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Prevalence of Juvenile Periodontitis in a School-Aged Population

Anthony Leron Neely

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PREVALENCE OF JUVENILE PERIODONTITIS IN A
SCHOOL-AGED POPULATION

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B.S.E., Arkansas State University, 1979
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at
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To Marva:

Words are simply inadequate to describe your contribution to the successful development, implementation and completion of this investigation.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF TABLES</td>
<td>vii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>ix</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>LITERATURE REVIEW</td>
<td>2</td>
</tr>
<tr>
<td>Historical Background</td>
<td>2</td>
</tr>
<tr>
<td>Descriptive Epidemiological Studies</td>
<td>9</td>
</tr>
<tr>
<td>Case Reports and Family Studies</td>
<td>25</td>
</tr>
<tr>
<td>Summary</td>
<td>45</td>
</tr>
<tr>
<td>Literature on the Use of Radiographs To Assess Bone Loss</td>
<td>49</td>
</tr>
<tr>
<td>Literature on the Correlation Between Clinical Attachment Level and Radiographic Bone Levels</td>
<td>53</td>
</tr>
<tr>
<td>Conclusions</td>
<td>58</td>
</tr>
<tr>
<td>SPECIFIC AIMS</td>
<td>61</td>
</tr>
<tr>
<td>RATIONALE FOR STUDY</td>
<td>62</td>
</tr>
<tr>
<td>METHODS AND MATERIALS</td>
<td>64</td>
</tr>
<tr>
<td>RESULTS</td>
<td>81</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>98</td>
</tr>
<tr>
<td>CONCLUSIONS</td>
<td>117</td>
</tr>
<tr>
<td>FUTURE STUDIES</td>
<td>119</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>121</td>
</tr>
<tr>
<td>APPENDICES</td>
<td>128</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Major Features of Descriptive Epidemiological Studies</td>
<td>143</td>
</tr>
<tr>
<td>2. Major Features of Case Reports</td>
<td>144</td>
</tr>
<tr>
<td>3. Interpretability (Readability) of Radiographic Sites From the 1819 Pairs of Bitewings in the Preliminary Radiographic Screening</td>
<td>146</td>
</tr>
<tr>
<td>4. Identification of Traceable Possible Cases: Subject Flow From the Preliminary Radiographic Screening to Non-traceable</td>
<td>147</td>
</tr>
<tr>
<td>5. Identification of Diagnosed Cases: Subject Flow From Requests Mailed Through the Clinical Examinations</td>
<td>148</td>
</tr>
<tr>
<td>6. Identification of Diagnosed Cases: Final Results Including Three Year Follow-up Radiographic Examination</td>
<td>149</td>
</tr>
<tr>
<td>7. Findings of the Radiographic Criteria Based on a 22% Sample of Non-case Radiographs Available at Year-Three</td>
<td>150</td>
</tr>
<tr>
<td>9. Radiographic Bone Level Measurements Versus Clinical Attachment Level Measurements for all Buccal Proximal Sites for the Adult Population</td>
<td>153</td>
</tr>
<tr>
<td>10. Radiographic Bone Level Measurements Versus Clinical Attachment Level Measurements for all Lingual Proximal Sites</td>
<td>154</td>
</tr>
<tr>
<td>11. Agreement Between Radiographic Bone Level and Attachment Level Measurements in the Adult Population</td>
<td>155</td>
</tr>
<tr>
<td>12. Percentage Agreement Between Radiographic and Attachment Level Measurements in the Adult Population</td>
<td>156</td>
</tr>
</tbody>
</table>
## LIST OF TABLES CONTINUED

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Prediction of Clinical Attachment Levels of &gt;3 mm From Radiographic Assessments (Measurements in Millimeters)</td>
<td>157</td>
</tr>
<tr>
<td>14. Intra-examiner Reliability Rates From the Radiographic Screenings as Validated by Millimeter Ruler Measurements</td>
<td>158</td>
</tr>
<tr>
<td>15. Intra-examiner and Inter-examiner Reliability Rates for Radiographic Measurements in the Adult Population</td>
<td>159</td>
</tr>
<tr>
<td>16. Validity of the Preliminary Radiographic Screening Based on Millimeter Measurements</td>
<td>160</td>
</tr>
<tr>
<td>17. Agreement Between the First and Third Year Radiographic Screening Examinations for 10-12 Year Olds Regarding Classification as Definite or Possible JP Cases</td>
<td>161</td>
</tr>
<tr>
<td>18. Agreement Between the Clinical Examination and the First Year Radiographic Screening Examination for 10-12 Year Olds Regarding Classification as Definite or Possible JP Cases</td>
<td>162</td>
</tr>
<tr>
<td>19. Agreement Between the Clinical Examination and Third Year Follow-up Radiographic Examination for 10-12 Year Olds Regarding Classification as Definite or Possible JP Cases</td>
<td>163</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Identification of JP Cases Based on First Year Radiographic and Clinical Examinations</td>
<td>164</td>
</tr>
<tr>
<td>2.</td>
<td>Identification of JP Cases Based on Three Year Radiographic Examinations</td>
<td>165</td>
</tr>
<tr>
<td>3.</td>
<td>Flow Chart of Informed Consent for the Adolescent Population</td>
<td>166</td>
</tr>
<tr>
<td>4.</td>
<td>Case 1: Bitewings From the Preliminary Screening and Follow-up Examination</td>
<td>167</td>
</tr>
<tr>
<td>5.</td>
<td>Case 1: Radiographic Series From the Third Year Examination Including Bitewings</td>
<td>168</td>
</tr>
<tr>
<td>6.</td>
<td>Case 1: Radiographic Series From the Third Year Examination Excluding Bitewings</td>
<td>169</td>
</tr>
<tr>
<td>7.</td>
<td>Case 2: Bitewing Radiographs From the Preliminary Radiographic Screening</td>
<td>170</td>
</tr>
<tr>
<td>8.</td>
<td>Case 3: Bitewing Radiographs From the Preliminary and Third Year Follow-up Radiographic Examinations</td>
<td>171</td>
</tr>
</tbody>
</table>
INTRODUCTION

The purpose of this research project is to determine the prevalence of juvenile periodontitis in a school-aged population. Despite the fact that not much is known about the prevalence of juvenile periodontitis (JP), much speculation has been given to the subject. The primary problem seems to be the lack of a universally accepted definition for a diagnosis of the disease. As a result of varied definitions used, it is difficult to directly compare existing research on this topic.

The following literature review presents the current state of the art of the epidemiologic research on JP. There will be four general sections composing the literature review. The first is the historical background which will present a chronological overview of studies (both epidemiological and non-epidemiological) related to juvenile periodontitis. The next two sections (case reports and descriptive epidemiological studies) will discuss the human data on juvenile periodontitis in detail. The final section will be a brief review of the literature on the use of radiographs to assess bone loss and clinical attachment loss.
LITERATURE REVIEW

Historical Background

The first recorded case of juvenile periodontitis (JP) was reported by Gottlieb (1923) who termed the condition "diffuse atrophy of the alveolar bone." Throughout the years, many other names have been given to this condition such as periodontosis, periodontoclasia, Gottlieb Syndrome and precocious periodontitis. Gottlieb thought that widening of the periodontal ligament space and atrophy of the alveolar bone were the major characteristics of the condition. He also thought that cementum resorption was possible, but the clinical observation of note was the migration of teeth affected. This concept as proposed by Gottlieb was based on the premise that a degenerative process affected the cementum allowing "downgrowth" of the (sulcular) epithelium leading to bone loss and pocket formation. Gottlieb also thought that systemic conditions could cause the condition, as the case described had epidemic influenza.

In 1938, Wannenmacher (according to Saxen 1980) stated that bone loss associated with JP appeared in the molars and incisors (the oldest periodontal tissues i.e. they erupt first). The terminology used to describe JP was "parodontitis marginalis progressiva". Saxen (1980) points out that this was the first reference to an inflammatory condition. This conclusion was based on the observation that the gingiva of some of these sites looked healthy in the presence of deep pockets, but showed bleeding on
probing with a blunt instrument. This was indeed a novel concept in 1938, for the dominant theory at that time was Gottlieb's degenerative condition of cementum theory.

In 1946, Gottlieb felt that the name of the condition, "diffuse atrophy of alveolar bone" should be changed to "deep cementopathia", to reflect the belief that the condition was due to a pathological condition of the cementum. It was called deep cementopathia to explain the presence of pathologic cementum on the root surface in his histologic and clinical observations. The author noted that bone loss in these areas was intrabony and usually quite extensive. These pockets could present with or without suppuration. Where the pockets were deep, he noted wandering (migration) of teeth. To support his deep cementopathia theory, Gottlieb (1946) made the observation that whenever cementum was absent on the root surface, alveolar bone was also absent. He felt that cementum must be vital to prevent the epithelial attachment from growing apically on the root surface, thereby, causing bone loss and development of pockets.

In 1940, Thoma et al. described clinical "wandering and elongation" of teeth as well as pocket formation in "parodontosis" (diffuse atrophy of the supporting structures of the teeth). The reasoning behind this terminology was unclear and was not addressed in the report. Based upon histological material, it was felt that proliferation of connective tissue (which replaced resorbed bone in the pocket) caused the tooth to wander (drift)
to the side opposite the connective tissue proliferation. If equal on all sides of the tooth, connective tissue would cause the tooth to extrude (become elongated) from the socket. Elongation was particularly common when connective tissue was found around the apex of the teeth.

Thoma et al. (1940) believed that pocket formation was caused by the downward growth of epithelium into areas where principal fibers of the periodontal ligament once existed. Epithelial downward growth, however, occurred only after breakdown of the principle fibers of the periodontal ligament. The principle fibers are connective tissue fibers that run obliquely from the cementum of the tooth to the alveolar bone (usually in a coronal, direction especially when the tooth is in function) and mainly resist apically directed forces on a tooth. They also thought malocclusion to be a factor in the formation of pockets, and would promote acceleration of the disease process.

In 1942, Orban et al. suggested the term "periodontosis" for the previous term "diffuse atrophy." They made post-mortum observations on two patients, one 55 years old and the other of unknown age. They thought that, on the initial stages, the disease progressed from degeneration of the principle fibers of the periodontal ligament with widening of the ligament due to bone resorption. Loose connective tissue, subsequently, replaced resorbed bone. At this initial stage, no inflammation or proliferation of epithelium was present. The second stage, following
the first rapidly, was marked by proliferation of the epithelial attachment along the root surface with a slight amount of inflammatory cell infiltration into the connective tissue. The final stage was separation of the epithelial attachment from the tooth with development of a deep crevice in which the tissues were irritated and infected as a result of the process. The basic argument was that if collagenous tissue could degenerate in other parts of the body, then it should be possible in the periodontal ligament.

Goldman (1949) examined microscopic sections of teeth affected with periodontosis with attached periodontium and reported that the disease initially affected the periodontal membrane and bone with the gingiva becoming involved later. He felt that these were the earliest changes that occurred in the condition and that they were specific to this disease.

In 1950, the Nomenclature Committee of the American Academy of Periodontology adopted the official name of "periodontosis" to resolve the confusion over the most appropriate terminology for this entity. It was described as a "degenerative non-inflammatory destruction of the periodontium originating in one or more of the periodontal structures, characterized by migration and loosening of the teeth in the presence or absence of secondary epithelial proliferation and pocket formation or secondary gingival disease."
In 1959, the Nomenclature and Classification Committee of the American Academy of Periodontology established that substantial evidence was lacking in human histologic material to establish conclusively the histopathologic changes that occurred in periodontosis. The committee also concluded that the condition was not caused by systemic factors, but be enhanced by occlusal trauma. To complete the circle of confusion, the World Workshop in Periodontics in 1966, suggested that the term periodontosis be deleted from the periodontal nomenclature due to lack of substantial data to support it as a separate or specific disease entity.

The term "juvenile periodontitis" was coined in France by Chaput et al 1967 (see Saxen 1980) and introduced in the United States by Butler in 1969. According to Saxen (1980), Bouyssou and Fourel (1973) stated their case based on their own studies and claimed that the term "juvenile periodontitis" was more appropriate than "periodontosis".

In 1977, the Committee of Nomenclature of the American Academy of Periodontology gave a definition for JP which stated, "Periodontosis: A degenerative disease of the periodontium, existence of which is not accepted universally." Further, they defined JP as follows: "Juvenile Periodontitis: see periodontosis." This suggested that only the name be changed, not the definition. Also in 1977, the International Conference on Research in the Biology of Periodontal Disease described the term "juvenile periodontitis" as "severe loss of attachment and destruction of bone
adjacent to permanent first molars and/or incisors in children, adolescents or young adults." This appears to be the name and definition that was accepted by most researchers at that time and is the name that is used most widely today by researchers and clinicians.

In a review of the literature and presentation of anecdotal case reports, Page et al. (1985) raised the older notion of defects in cementum formation (Gotlieb 1946) being partially responsible for the onset of JP. According to the concept, a tooth with abnormal cementum formation has an attachment apparatus that is more susceptible to breakdown by bacterial invasion. In support of this claim, cases of hypophosphatasia were cited as being a condition in which abnormal cementum formation was more common in certain teeth than others. It was suggested that the pattern of bone loss in some types of early-onset periodontitis (pre-pubertal, juvenile and rapidly progressive periodontitis) might be explained by these findings. The authors suggested that evaluation of root cementum and measurement of serum alkaline phosphatase and urinary phosphoethanolamine in JP patients were possible ways to assess the validity of this theory.

The etiology of this disease has not been established but an association has been linked with the organism *Actinobacillus actinomycetemcomitans* and *Capnocytophaga* species (Socransky 1979, Tanner et al. 1979, Ebersole et al. 1980, Listgarten et al. 1981). Evidence from several studies (Newman et al. 1973, Newman
et al. 1974, Slots 1976, Newman et al. 1976, Newman et al. 1977) found that the predominantly cultivable microflora in sites affected with juvenile periodontitis consisted of gram negative anaerobic rods and filaments. These organisms made up over 55% in one study (Newman et al. 1976) and 59.2% in another study (Slots 1976). These observations were different from microflora counts in healthy sites in the same individuals and in individuals unaffected with juvenile periodontitis. The normal flora in healthy individuals and in unaffected sites in those with juvenile periodontitis consists of gram positive rods and cocci. For a more thorough treatment of the large quantity of microbiologic information available on juvenile periodontitis, see the above references and the review articles by Saxen (1980) and Saxby (1982). For more recent reviews, see Davies et al. (1985) and Risom et al. (1985). Other concepts regarding the etiology of juvenile periodontitis are discussed in the review articles, but the significance of the microbiological studies is that the inflammatory nature of the disease has been associated with organisms capable of causing destruction of periodontal tissues.

This literature review section is devoted primarily to the literature on the epidemiology of juvenile periodontitis. Pertinent information concerning other theories and observations regarding juvenile periodontitis is beyond the focus of this review, and the reader is referred to the review articles cited in this text.
Descriptive Epidemiological Studies

Dawson (1948) reported a prevalence rate of 56.3/1000 for what he termed periodontosis syndrome in 994 Egyptian fleaheen (agricultural workers 15-55 years old) admitted to the Abbassia Fever Hospital, Cairo, Egypt (See Table 1 for a summary of major features of descriptive studies). (All prevalence percentages in this document will be presented as rates per 1000 subjects for ease of comparisons between studies). The fleaheen population represented a low income group with homogeneous living and sanitary conditions. Many of the fleaheen were reported to suffer from malnutrition and other chronic diseases common to the region. The criteria for selection of subjects to participate in the study were not specified.

In this study, clinical examinations were performed for caries, periodontal disease and calculus. Diagnosis of periodontosis syndrome (juvenile periodontitis today) was based on wandering (migration) of teeth without primary involvement of the gingiva, or when local conditions (unspecified) produced marginal gingivitis. Under this classification scheme, 56 cases were reported (32 from upper Egypt and 24 from lower Egypt). Pocket depths were charted and regarded as severe if they measured ≥ 3mm. All cases of periodontosis syndrome were considered to be severe. From this description of the methods it was unclear how the author distinguished these cases from adult periodontitis. No further analyses
of cases were performed because diagnostic equipment was unavailable.

The major shortcoming of this report was the lack of a specific definition for periodontosis syndrome (juvenile periodontitis). Wandering of teeth (used as the criterion for diagnosis of JP) can occur in many other types of periodontal disease, not just in periodontosis syndrome. The wandering of teeth combined with severity of periodontal disease, and absence of local factors (unspecified, but assumed to be plaque and calculus) may have been sufficient to make the diagnosis of periodontosis syndrome, and probably reflected the state of knowledge of the disease in 1948.

Marshall-Day et al. (1949) reported a 175.7/1000 prevalence rate for periodontosis in a radiographic survey of periodontal disease in India. The original group (aged 9-60 years) consisted of 538 males (civilians and police) and 30 females, however, analysis was done on only 443 individuals (370 of whom were reported to have some type of periodontal disease). These individuals were said to be representative of the population (selection criteria unspecified). Some members of the group had full mouth radiographic exposures, while others had only incisors and cuspid regions radiographed due to scarcity of x-ray film in India. A clinical examination was performed, including assessments of: gingival condition, pus formation, pocket formation, and tooth mobility. Bone resorption was assessed from radiographs of the
entire lower arch as well as the incisor and cuspid region of the maxilla. The scoring system for interproximal bone loss ranged from 0-10, 10 equaling total loss of bone, 5 equaling loss of half the bone and 1 being just visible loss. No criteria was given for diagnosing periodontosis as opposed to other forms of periodontal diseases.

In this study, the authors reported a prevalence rate of 175.7/1000 for periodontosis which was really the rate among cases with periodontosis of those people with some type of periodontal disease (n = 65/370). Calculating the rate of those analyzed for presence of disease (n= 443), however, yields a prevalence rate of 144.5/1000 (n= 65/443). The rate, regardless of how calculated, appears to be one of the highest ever reported for this disease. The major shortcoming of this article was that the authors did not specify specific criteria for diagnosing periodontosis. The authors did, however, state that it was difficult to differentiate between periodontosis and other forms of periodontal disease in some cases, suggesting that some errors in classification may have been committed.

Belting et al., in 1953, reported on the prevalence and incidence of alveolar bone disease in 5014 men who reported to a regional veterans administration dental clinic. The men were examined in the order that they presented to the clinic (no selection or exclusion of subjects). The group ranged in age from 20 to 80 years. According to the authors, these men represented the heal-
thy veteran population from Chicago, Illinois, (however, this was not verified by the authors). The criteria for selection of cases of periodontal disease was based on one or more teeth being affected by destruction of alveolar bone. Their criteria for categorizing types of periodontal disease is summarized below:

1) **Periodontitis simplex** - consisted of moderate to severe marginal gingivitis with abundant supra- and sub-gingival calculus, plus horizontal bone loss interproximally on x-rays, and gingival pockets exceeding 2mm and visible pus flow from the pockets on pressure.

2) **Periodontosis** (early periodontosis) - demonstrated an absence of or only mild marginal gingivitis with little calculus, but with vertical bone loss interproximally and pockets exceeding 2mm and no evidence of pus from the pocket with pressure application to the gingiva.

3) **Periodontitis complex** (late periodontosis) - demonstrated moderate to severe marginal gingivitis and abundant subgingival calculus, plus vertical bone loss interproximally on x-rays and pockets exceeding 2mm with visible pus from the pocket with pressure.

Because periodontosis and periodontitis complex were felt to be different stages of the same disease, the two categories were merged and became periodontosis with periodontitis, while periodontitis simplex remained a separate entity. Periodontosis with periodontitis was found to have a prevalence rate of 20/1000 among 20 to 24 year olds (n = 479) and a high prevalence rate of 220/1000 among 45 to 49 year olds (n = 159 in this category). The prevalence rates varied for each five year age range but these two values defined the range of the values.
The major complications with the type of classifications used by Belting et al (1953) was that similar features were found in patients with periodontosis as well as periodontitis. Categorizing the disease as periodontosis with periodontitis makes it difficult to separate out which disease might be the predominant one or which one started first. The authors felt that because of the similarity of the features it was impossible to distinguish one from the other. Perhaps this problem is one that was exacerbated due to the age of the population studied (aged 20 to 80), i.e. one would expect the level of periodontitis to increase with advancing age which might then be superimposed on pre-existing periodontosis. The data support this line of reasoning in that there was an increase in the combined condition of periodontosis with periodontitis with increasing age, as indicated by the 220/1000 prevalence rate in the 45 to 49 year old age group versus 20/1000 in the 20 to 29 year old age group. The questions raised were whether this was the best way to categorize the disease process, and whether the most appropriate study population was selected. Finally, since the study population consisted only of veterans presenting for treatment at a dental clinic, the likelihood of the sample being completely representative of healthy veterans in Chicago is small. Because of the self-selection, one must be cautious about making a generalized statements about the prevalence of periodontosis with periodontitis in the total population based on the sample in this study.
In a study of a military population of 3897 recruits aged 16-26 years old (a 50% sample of the total number available), Kaslick et al (1968a) reported a prevalence rate of 1.5/1000 for periodontosis with periodontitis. Mobility of greater than 1 degree (greater than 1mm movement of the tooth in its socket upon placing a mild force in a buccal and lingual direction) was used as an initial diagnostic criterion for periodontosis with periodontitis. Mobility was used as the primary criterion because it was thought that mobility occurred prior to pocket formation and inflammation. Six teeth were assessed for mobility; the upper right first molar, the upper left central incisor, the upper left first premolar, the lower right first premolar, the lower right central incisor and lower left first molar. Full mouth radiographs were taken on all men with mobility on any of the listed teeth above, and those with "appreciable radiographic bone loss" (undefined) were given a clinical examination with a periodontal probe. Those with bone loss associated with other periodontal conditions (stated as recurrent necrotizing ulcerative gingivitis or obvious primary occlusal trauma) were dropped from the study. It was not stated how much bone loss was necessary to make a final diagnosis of periodontosis with periodontitis.

As with the classification scheme of Belting et al. (1953), the problem remained as to whether periodontitis or periodontosis was observed. Use of mobility as the primary screening criterion for assessment of disease was another major concern. Mobility would most likely fail to detect cases of early disease, as it usually
occurs after severe attachment loss. The authors recognized this problem and suggested that there was an underestimation of disease prevalence based on this method of detection. It was also stated that Negroes, with a prevalence rate of 8.3/1000 were more prone to the condition than Caucasians (prevalence rate of 1.1/1000), based on a racial analysis of 241 Negroes and 3656 Caucasians. Both the overall prevalence rate and the prevalence rates for the two racial subgroups should not be interpreted as rates for the general population given that they were based on information about a specific group of individuals (namely, Armed Forces recruits).

Emslie in 1966 reported finding three cases of periodontosis among 995 people (a 3.02/1000 prevalence rate) in schools, technical colleges, teacher training colleges, and prisons (aged <10-60 years old) in the Republic of the Sudan. A few children under 12 years of age attending the Khartoum Hospital as out-patients with other than dental disease and the parents accompanying them were examined. The sex ratio was 2:1 female: male, with a sex breakdown of 489 females, 474 males and 8 for which sex was not stated. No radiographic assessments were made but a thorough clinical exam only was performed on all subjects in the study. Indices used for assessment of periodontal disease were the Periodontal Index (PI) (Russell, 1956) and the Oral Hygiene Index (Green and Vermillion, 1960). No mention was made of criteria used in the study for diagnosis of periodontosis. The authors did, however, mention that local factors (plaque and
calculus) did not seem sufficient to have caused the deep localized pockets.

As with other studies, the lack of standardized criteria for selection makes it difficult to interpret the results or to reproduce the study at another time. Also, whether the disease can be accurately diagnosed from clinical examinations alone has not been established in the literature to date. Interpretation of this study is difficult in view of these shortcomings.

Rao et al. (1968) reported an overall prevalence rate of 68.3/1000 for periodontitis in a study involving 1200 male and female Indians (15-30+ years old) from the Dental Institution in Bombay. These people had reported to this clinic for treatment of advanced periodontal disease. Eighty four cases were reported with a female: male ratio of 41:1. Given that males comprised 56% (670/1200) of the study population, the prevalence rate for males was extremely low (1.7/1000) compared to females (68.3/1000). Although preliminary data was obtained on all subjects, the two males were dropped from the final analysis, therefore, only data from the females were reported.

In this study, radiographs of molars and incisors only were selected for practical reasons. The authors further suggested a possible onset in the teens with advancement in the later years. Oral hygiene was reported as good or bad. Fifty five of 82 (67.1%) had good hygiene (mean PI of 4.724), while bad oral hygiene (mean PI of 6.816) was reported in the remaining 32.9% of
the patients. Family history of periodontosis was also positive for 49 of the 82 affected individuals (this represented 59.75% of those affected with the disease with a positive family history). Thirty three of the unaffected individuals (2.96%) gave a positive family history of periodontosis.

One of the major shortcomings of this investigation was the lack of a case definition for JP. The authors only stated that they selected cases that had the typical presentation of the disease, but this was undefined in the article. Further, the appropriateness of the age groups studied was a key question in this survey, as the majority of the cases (79%) were > 20 years of age. Given the older age groups examined, they might have been observing periodontitis superimposed on periodontosis in the older age groups. To solve this problem one would have to know the exact time of onset of the periodontosis, which is difficult for this type of study. The authors tried to assess the time of onset by asking subjects to recall when symptoms were first noticed, but this information was probably not very reliable since it was based on subject recall. Also, it is unlikely that symptoms were manifested until the disease became severe. Additionally, the familial tendency of JP reported by the authors must be interpreted cautiously since it was based only on family history of periodontal disease. It was also pointed out that periodontosis sufferers had better oral hygiene than those unaffected with the condition. No definition was given for either good or bad oral hygiene, therefore, it is not possible to interpret these re-
sults. General caution should be used in interpretation of results of this report given the number and magnitude of the shortcomings.

A prevalence rate of 1.0/1000 was reported for juvenile periodontitis by Saxen (1980b) who examined 8,096 pairs of bitewing radiographs of 16 year olds in Finland. This sample represented 56% of the total population of 16 year olds in Uusimaa county. These patients represented people reporting to 19/21 health service districts in the county. Radiographic examination screened out 28 possible cases for further clinical study based on the following criteria:

1) the patient must be in good general health;
2) radiographically detectable bone loss more than 2mm must be demonstrated around more than one tooth;
3) local irritants must not be commensurate with the bone loss.

Eight cases were confirmed (5 females; 3 males) from the 28 that were screened at the beginning of the study. Orthopantomograms were used on some patients not having full mouth x-rays. The final diagnosis was made six months to two years after the clinical exam. This lag in time of diagnosis was because the author wanted to be certain of the clinical diagnosis by examining more recently exposed radiographs (exposed after the initial diagnosis). A 5:3 female:male ratio was noted. The author also noted that all of the cases had at least two of the first molars involved.
This study was noteworthy in that it represented a prevalence study which involved over half of the total people available for the study. Nevertheless, the fact that there was self-selection of subjects makes it difficult to generalize the results to the entire population. Although 19/21 dental districts were represented in the survey, it is not clear whether those who chose to participate were representative of the entire population. In fact, since this sample represented those 16 year olds who volunteered to have radiographs taken, it is likely that they were different with respect to disease experience than non-participants, especially if the condition caused them to seek professional attention. Given the information above, the representativeness of the sample and whether it can be generalized to the general population is not known. Also of note was the fact that the author set millimeter limits (>2mm from CEJ) for bone loss which makes the design easier to replicate versus simply stating the criteria as bone loss on more than one tooth. Another interesting aspect of the study was the use of bite-wing radiographs as a screening tool for JP patients. This method, if reliable, might be useful in large epidemiological studies. Furthermore, since this appears to be a rare disease, it would be far less expensive and time consuming to screen in this way versus initially conducting a clinical exam on all prospective patients first. This represents one of the more rigorous epidemiological studies in the literature on the prevalence of juvenile periodontitis.
Barnett et al. (1982) reported a prevalence rate of 24.0/1000 for juvenile periodontitis in 2,167 subjects aged 13-30 in a dental school population in the United States. A sex prevalence of 2:1 females:males was also reported. The original cases were screened from radiographs categorized according to the ADA classification system for periodontal diseases. This system designates cases as Type I through Type IV, corresponding to Gingivitis, Early Periodontitis, Moderate Periodontitis and Advanced Periodontitis, respectively (for information on this classification system, see the Council on Dental Care Programs: Code on Dental Procedures and Nomenclature, JADA 92: 647-652, 1976). Of the total 2167 subjects, 1131 were in ADA types I and II combined. A total of 301 patients were in ADA type III, and 53 were in type IV. The criteria used for diagnosis of JP cases was as follows:

1) a negative medical history;
2) radiographic evidence of early-to-moderately-advanced bone loss either in a molar-incisor or generalized distribution in patients aged 13-20;
3) or generalized moderately-advanced-to-advanced bone loss (ranging from 40-100%) in patients 21-30.

This study had several shortcomings. First, the question of whether an accurate diagnosis of JP can be made based on radiographs alone has not been proven and, in fact is drawn into question by their own analyses. To determine if their diagnosis by radiographs was accurate, they took a random sample of 60 of the 301 young people in the study who had been initially classified as ADA type III, and found 10% to be affected on clinical exam. Based upon the findings on this 10% sample, they estimated
that 30 patients from the 301 in the type III classification would have JP. In addition, 23 patients from the type IV category were reported to have JP based on the x-rays and records. Again, no clinical examinations were performed on these patients. While the random selection process could give a projection of the number of JP cases, the author reports the prevalence rate as a true rate. Caution should be used in the interpretation of these results, as they represent estimates, not true rates.

Gjermo et al. (1984) reported finding 8 cases of juvenile periodontitis out of 214 patients (37.4/1000 prevalence rate) (101 M and 113 F) aged 13-16 years, examined from 2 primary schools in Brazil. A 2.67:1 male:female ratio was reported among the cases. Two posterior bitewing radiographs were taken on each child and bone loss was recorded when it exceeded 2mm from the CEJ. A compass adjusted to the exact magnification obtained in the x-ray viewer was used to measure bone loss. JP lesions were recorded when "cup-shaped" vertical lesions were diagnosed on at least 3 1st molars. They found that the most frequent location of bone loss was the mesial aspect of the maxillary 1st molars (25% of lesions found).

Although this was a relatively small study (214 participants), the results were surprising considering the stringent criteria used to be considered a case (mesial surface of at least 3 1st molars involved). Gjermo's prevalence rate was 37 times higher than Saxen's (1980b) rate of 1.0/1000 (using the criteria of 2
1st molars involved). Because of the apparent rarity of the disease, it is interesting to speculate why the cut off was placed at 3 teeth and not 2, or 1 which probably would have provided more cases. In fact, they reported that 17 people had vertical bone loss, apparently, nine of whom did not have the required 3 tooth minimum. If all 17 of those with vertical bone loss were included in the analysis, the prevalence rate would have been 58.0/1000. Thus, a slight change in the case definition would have resulted in an increase of approximately 1.5 times the prevalence rate. Finally, Gjermo's report of a 2.67:1 male:female ratio conflicts with other descriptive studies (Saxen 1980b, Barnett et al. 1982, Hansen et al. 1984, Saxby 1984 and Kronauer et al. 1986) and is further evidence that the prevalence rate of JP by sex, like the total population prevalence rate is not firmly established.

Hansen et al. (1984) reported a 5.0/1000 prevalence rate of juvenile periodontitis in 2,249 15 year old Norwegians. The breakdown by sex was 1137 females and 1112 males. A total of 12 cases of JP was reported, the sex ratio was 1:1 females:males. This ratio is different from other reports on sex prevalence (Benjamin et al. 1967, Manson et al. 1974, Saxen 1980b, Hormand et al. 1979, Barnett et al. 1982, Gjermo et al. 1984, Hansen et al. 1984). The criteria for screening of cases was based on two posterior bite-wings of each patient and was as follows: bone loss was recorded when the distance of at least 2mm from the CEJ to the alveolar
crest was noted. Overt infrabony pockets, detected clinically, were recorded separately because of suspicion of juvenile periodontitis. Bitewings were excluded if less than one mesial surface of one maxillary and one mandibular first molar could not be read and if no bone loss was recorded in other areas. Horizontal bone loss was recorded but not reported here. Radiographs were magnified 10x and a compass was adjusted to the exact magnification as the viewer and the readings taken. It was not clear whether a diagnosis of JP was based on clinical or radiographic evidence or both.

In this study, clinical examinations were done on 31 subjects with and without radiographic bone loss (selection criteria unspecified). The Plaque Index (Löe 1967), Gingival Bleeding Index (GBI) (Ainamo and Bay 1974) and interproximal pocket depths measured from the buccal surface to the nearest mm were assessed. Mean PII was 1.28 for subjects with bone loss and 1.32 for the others while GBI scores were 0.51 and 0.46 respectively. Periodontal pockets were similar in both groups, and 4mm readings were recorded commonly.

Hanson et al. (1984) cautions that the possibility of underestimation of bone loss exists. Non-standardization of radiographs and exclusion of unreadable films may have excluded some cases. The major concern was that only 31 patients were examined clinically (some with and without bone loss) but it was not stated whether all the cases of JP were included in that exam. Further,
the selection criteria might have excluded some cases of the disease because of the requirement of \( \geq 2 \text{mm} \) of bone loss on the mesial of at least one maxillary and mandibular first molar.

Kronauer et al. (1986) reported that the prevalence of juvenile periodontitis was 1.0/1000 among 16 year olds in Switzerland. The study population consisted of 7,142 randomly chosen adolescents, 16 years of age (17\% of the entire 16 year old age group) from all areas of Switzerland. A clinical and radiographic examination was performed on all subjects. The radiographic examination used was by the method of Schei et al. (1959). The criteria used for a radiographic diagnosis of JP is summarized as follows:

1) \( \geq 2 \text{mm} \) bone loss from the CEJ on more than one aspect of one maxillary and/or mandibular first molars;
2) subject must be in good health; and
3) no plaque retentive factors or calculus at sites with bone loss exceeding 2mm.

The clinical examination was performed on all subjects who screened positive for "incipient juvenile periodontitis" from the radiographic examination. Criteria for the clinical examination is summarized as follows:

1) subject and family history;
2) attachment loss from the CEJ on 6 sites on all teeth -- > one site on > 1 molar was considered positive;
3) full mouth x-rays (sites with subgingival calculus excluded from diagnosis);
4) measurement of oral hygiene (Løe and Silness 1964), calculus (Ennever et al. 1961) -- a PLI of 3 or CSI of 2 at the attachment loss site was excluded from analysis; and
5) measurement of iatrogenic factors (i.e. overhanging amalgams) -- these sites were excluded from the analysis.
The results showed that 8 patients had "incipient juvenile periodontitis", 4 males and 4 females. The prevalence was calculated as 1.12/1000 (8/7,142) or rounded to 1.0/1000. Three of the eight cases reported had loss of attachment around the central incisors. No race difference was noted in this group. The conclusions from the study were that bite-wings were successful in screening for early bone loss around first molars and that JP lesions were predominantly isolated in first molar regions.

This study was a well conducted prevalence survey of a representative (randomly selected) cross-section of the 16 year old Swiss population. Adequate attempts were made to exclude those individuals with obvious local factors (subgingival calculus, overhanging restorations, PI1 scores of 3 or CSI scores of 2) that were thought to confound the diagnosis of JP. Though the exclusion criteria tends to make the cases of JP appear more homogeneous, the real danger is that some cases which might appear similar to adult periodontitis (i.e., those with subgingival calculus or severe inflammation) could be misclassified. Therefore, the actual prevalence would be higher than that observed.

**Case Reports and Family Studies**

Benjamin et al (1967), reported on a series of 11 case reports, and noticed that a familial pattern emerged in regard to the occurrence of periodontosis (see Table 2 for a summary of the
The major features of case reports). The authors criteria for diagnosis of periodontosis was as follows:

1) a characteristic vertical pattern of bone loss must be present;
2) more than one tooth must be involved;
3) it must occur in an adolescent or young adult;
4) the patient must be free of systemic disease.

The 11 case reports varied in the number and types of individual family members affected with the disease. The severity of involvement varied among cases regarding both the number of teeth, and bone levels on those teeth. Though a familial pattern was suggested by the authors (Benjamin et al. 1967), they stated that their evidence was insufficient to draw conclusions about heredity. They reported a predilection for females who demonstrated a ratio of 3:1 over males. The evidence is inconclusive regarding hereditary factors; prevalence data cannot be derived from case report series.

The major strength of this report was the realization that evidence was lacking from which to draw a conclusion on heredity of periodontosis. Also, although the establishment of criteria for selection of cases was an improvement, an explanation of the use of the characteristic of vertical bone loss was lacking. The limitation of case reports is that an accurate assessment of prevalence cannot be obtained, nor can causation be demonstrated.

Butler (1969) presented a case report which is important because it is cited so frequently as supportive evidence for a familial
pattern of juvenile periodontitis (as is Benjamin et al. 1967, Sussman et al. 1978 and Saxen 1980c). The report was of a Negro family with five siblings, three boys and two girls. One brother (age 15) and a sister (age 12) had periodontosis. An aunt and grandfather had a history of early tooth loss as well as the mother who gave a history of loss of all her teeth in the late teens. No diagnostic criteria was given for assessment of periodontosis. Blood work-ups done on the brother were within normal limits. Bone loss was noted on the mesial surface of first molars of the brother and sister.

The major shortcomings of this report were: first, no mention was made of the criteria used in the diagnosis of periodontosis; and secondly, attention should be focused on the fact that this was a case report and as such has limited potential in determining familial patterns of occurrence of periodontosis. Finally, although common sense might suggest that a familial pattern or environmental factor could exist for periodontosis, it is difficult to support based solely on data from case reports.

Fourel (1972) reported on six cases in Algerians, ranging in age from five and one half to 32 years. The male to female ratio was 1:2. No specific criteria was given for diagnosis of periodontosis. Clinical and radiographic examinations were used in the diagnosis of periodontosis. The author did, however, state that he believed the only forms of periodontosis were that with the
molar-incisor pattern or the incisor only pattern. Whether this criteria was used for these cases was not mentioned.

The author reported that there was a high degree of consanguinity among the cases that had been reported in the periodontal literature and that the same existed in these reports. Three of the six cases were siblings of parents who were first cousins. Also of note was the observation that in one patient (a five and one half year old girl) the deciduous teeth had abnormal bone loss. At seven and one half, there was abnormal mobility and malposition of the permanent teeth. Whether bone loss was present was not reported.

Of note in this report was the fact that Fourel felt strongly that the evidence in the literature in general and from these cases made a strong argument for the possibility of an hereditary condition which manifests itself later in life, accounting for age differences seen among people affected. The author offered the following concepts to support this possibility:

1) the familial pattern;
2) the frequency of consanguinity;
3) the epidemiological frequency among groups where the proportion of consanguinous marriages was high.

The author summarizes, however, by stating that the theory of an hereditary pattern is difficult to prove, but that the evidence to date (1972) validated the possibility of an hereditary disease transmitted by a recessive gene.
The only real shortcoming of this report was a lack of specific criteria for diagnosing periodontosis which makes it difficult to apply the methods to future studies or to interpret his findings. There was also the factor of age which came into play when he reported that the primary dentition of one child was involved. The inclusion of the primary dentition creates some skepticism since for the majority of authors felt that the disease was isolated to the permanent dentition. Interpretation of this aspect of the report is difficult and left up to the reader in light of much opposition to this concept in the literature.

In a later study, Fourel (1974) reported on 4 cases of what he termed "Gottlieb Syndrome" (juvenile periodontitis). The age range was 3-24 years old with a 3:1 female: male ratio. The author proposed the new terminology because he felt that the microscopic evidence existing to that date was insufficient to allow analysis of the data. The entity as would be newly named, would be distinct and would take the name of the first person to describe it, Gottlieb (1923). The definition of the disease was as follows: "Gottlieb syndrome is a disease of the periodontium, occurring in an otherwise healthy child or adolescent, which is characterized by a quick loss of alveolar bone affecting, at the early stage, the first molars and incisors. The amount of destruction manifested is not commensurate with the amount of local irritants present." The author also stated that the periodontal lesions could be isolated or associated with cutaneous diseases, frequently manifesting as epithelial desquamation. Primary as well
as permanent teeth were thought to be affected as opposed to permanent teeth only.

This report raised numerous questions regarding the normally accepted belief that the condition affected only permanent teeth. It also stated that the condition was genetic in origin. As of 1974, however, the American Academy of Periodontology had not accepted the concept of a genetic basis to this condition and the terminology that was accepted was periodontosis. The case reports were presented to support the concept of a familial tendency in JP. To illustrate, two of the four cases had parents who were first cousins, the other two were not determined. This does not prove causation, however, the author felt that it was enough information, when taken with other reports in the literature, to justify a name change.

Manson et al. (1974) reported on the clinical features of juvenile periodontitis in 22 patients aged 14 to 21 years old. Initially, 22 patients comprised the study population; 9 more cases were added, aged 22–29 years old to capture what was termed the post-juvenile periodontitis group. For purposes of this discussion only the 22 original cases will be used.

The criteria used for selection of the original 22 patients was as follows:

1) patients were less than 22 years of age at the time of the examination;
2) on radiographic examination they showed the character-
istic pattern of advanced vertical bone destruction involving more than one tooth;
3) local etiological factors were not commensurate with the severity of bone loss; and
4) the patients were healthy and there was no relevant present or past general disease.

Eleven of 22 juvenile periodontitis patients examined gave a family history of periodontal disease (type of disease unspecified). The breakdown of the affected family members was: 7 siblings, 2 mothers, and 2 maternal relatives. Blood work-ups on the parents were within normal limits. No other follow-up was done on these family members. Bone destruction was separated into categories of typical localized and atypical localized. The typical group showed symmetrical incisor, first molar involvement in both jaws, including 2nd premolars, and/or 2nd molars (n = 13 patients), occasionally. The group with atypical bone loss consisted of 8 patients who exhibited assymmetrical patterns or had one jaw affected more often than another. In some individuals incisors were involved in one jaw only or on one side of an arch. Two of the patients showed diffuse involvement with most teeth in both jaws affected.

While the observations made by these authors are important and noteworthy, caution must be exercised in drawing too many conclusions from this report. As an example, the report of a 3.6:1 ratio of females to males which was based on case reports must be viewed as the ratios among the cases. Family history of periodontal disease in these patients was not verified, but was used to support the concept of a familial pattern of occurrence of JP as
reported by others (Benjamin et al. 1967, Rao et al. 1968, Butler 1969, Manson et al. 1974, Jorgenson et al. 1975, Sussman et al. 1978 and Saxen 1980c). Because of the limited number of cases and the vagueness of the selection criteria (especially the section on characteristic pattern of bone loss which was never described), the ability to interpret this data is somewhat limited.

Jorgenson et al. (1975) has suggested that periodontosis may be an autosomal recessive condition based on three cases of periodontosis in siblings. No diagnostic criteria was given for the determination of cases. The first case was of a Negro boy 10 years of age, who was also diagnosed as having ichthyosis. Ichthyosis is a condition characterized by dry and scaly skin on the body resembling fish scales, thus the name. His two sisters were also diagnosed as having periodontosis, one 16 years old and the other 15 years old. Radiographs of the panorex type were taken for each child. Each child was in different stages of eruption of their permanent teeth with different degrees of severity of the disease.

Limitations of this report are numerous, but a major one was the lack of diagnostic information for the assessment of the disease. Further, the inference about an hereditary pattern of periodontosis can only be suggested by this article because of the limitations of case reports. The discussion of this paper was under-
taken primarily because of its numerous citations by other authors as supportive evidence for a familial occurrence of JP.

Melnick et al (1976) reported on the phenotypic and genetic findings of two families with periodontosis taken from the University of Indiana School of Dentistry and the University of Louisville School of Dentistry. The ages ranged from 11-22 years across both families. There were a total of 88 people in the analysis of both families, 44 of whom were affected with periodontosis. Thirty one females and 13 males were affected, a 2.38:1 female:male ratio. The diagnosis was based on the following:

1) family pedigree;
2) health questionnaire;
3) complete series of intraoral radiographs;
4) hand x-ray of the carpal bones of the left hand;
5) serum calcium, phosphate and alkaline phosphate determination;
6) serum alkaline phosphatase isozyme fractions; and
7) a clinical exam using standard periodontal charting and evaluation of oral hygiene.

The inclusion criteria required that all families have full pedigree charts mapped and a complete description of all individuals affected with periodontosis. No criteria was given for final diagnosis of periodontosis even though all of the above tests were performed.

The authors performed a genetic analysis and concluded that the disease was inherited as a dominant trait, and was more common among females. The authors stated that the nature of the develop-
mental defect was not known but was likely inherited as a sex linked dominant trait with 78% penetrance.

This study showed clearly that the disease appears to be present in families more often than would be expected by chance alone, however, the limitations of case reports restricts the ability of the results to be generalized to the entire population.

Sugarman et al (1977) reported on five cases of "precocious periodontitis" (periodontosis) ranging in age from 12-21 years old. The sex ratio was 4:1 female:male. The subjects in this report represented patients treated by standard periodontal techniques for this condition. The criteria for diagnosis was not given in the report. The authors stated, however, that all patients treated had pocket depths of 6mm or more with concurrent bone loss and no tissue enlargement. None of the patients had more than eight teeth involved, and the other non-involved teeth had pocket depths <2mm. In addition, all subjects were in good health and none were over 22 years old.

The authors suggested that the name periodontosis be changed to "precocious periodontitis" because microbiological studies had begun to show that anaerobic, gram-negative rods predominated in the pockets of individuals with periodontosis. These organisms were shown to be capable of marked bone resorption in germ free rats (Newman et al. 1974). They also cited Newman et al. (1976) who studied diseased and healthy sites of cases and controls. Their observations showed that the control sites had primarily
gram positive organisms and diseased sites had gram-negative rods. The authors (Sugarman et al. 1977) probably cited these papers because gram-negative organisms had been associated with disease and gram-positive organisms with periodontal health. They felt that the name, periodontosis, was inappropriate because it described a degenerative process, while the evidence pointed to an inflammatory condition with a bacterial component. "Precocious periodontitis", they thought, would separate this entity from adult periodontitis because of its early onset and its localization to certain teeth.

This was an informative report which made a strong case for a change in the periodontal nomenclature to reflect the knowledge that was available in the literature as of 1977. The shortcoming of the report was the inability to determine from the methods, whether diagnostic criteria was established prior to, or after case selection, the cases were selected or were selected.

Another case report frequently cited as supportive evidence for a familial pattern of juvenile periodontitis is that by Sussman et al (1978). This was a report of a 30 year old black woman presenting with an x-ray pattern and probings consistent with periodontosis. Her 17 year old daughter and 50 year old mother had clinical and x-ray probings consistent with periodontosis. No mention, however, was made of diagnostic criteria for periodontosis. The most significant point was that the authors suggested a familial influence in periodontosis. While it was appropriate
that the authors suggested a familial pattern, the reader should avoid the temptation of assuming that this proves causation. Although there appeared to be a familial occurrence of juvenile periodontitis, the evidence was not conclusive.

In 1979, Hormand et al. studied a total of 156 Danish patients aged 12-32 years with juvenile periodontitis lesions referred or reporting to the Department of Periodontology over a 10 year period. They definition of a diagnosis for juvenile periodontitis (JP) was made in accordance with that of Baer (1971) and read as follows:

"a disease of the periodontium occurring in an otherwise healthy adolescent, which is characterized by a rapid loss of alveolar bone about more than one tooth of the permanent dentition."

Bitewing and full mouth radiographs were available for all patients. "Rapid loss of alveolar bone" was described as vertical or horizontal bone loss of more than 1/3 the root length on x-rays. Patients were placed into three groups; type I - 1st molars and/or incisors, type II - 1st molars, incisors, and a few additional teeth (<14 total) and type III - the generalized type (≥ 14 teeth).

A total of 111/156 cases were female (71%), with a 5.3:1 female: male ratio in the 12-18 year old group, a 2.4:1 female: male ratio in the 19-26 year old age group and a 1.5:1 female: male ratio in the 26-32 year old group. The mean number of involved teeth were 5.3 in the young and 11.6 in the oldest group. As for
bone loss types, the males predominated in type I in the 12-18 year old group, and no type II bone was loss seen in this age group. In the 19-25 year old group, all three types were represented. In the 26-32 year old group, no type I patterns were seen, and more females than males had types II and III. No tests of significance were reported for these results. The general suggestion was that females tended to be more involved throughout all groups. Finally, the conclusions drawn by the authors were as follows:

1) juvenile periodontitis constitutes a clinical entity different from the usual form of adult periodontitis;
2) it affects more females than males, possibly because of an earlier onset among females;
3) the typical pathogenesis comprises an initial involvement of first molars and/or incisors and subsequent involvement of other teeth (other teeth not described); and
4) the majority of juvenile periodontitis cases exhibit symmetrical involvement of first molars, incisors and a few additional teeth.

Saxen (1980c) reported on the pattern of JP in 31 families and concluded that the results were consistent with the hypothesis that JP is inherited in an autosomal recessive mode. The study entailed the first degree relatives of the 31 cases who had had radiographs taken (mostly orthopantomographs). Also included were 60 parents, and 64 siblings who were all affected with JP. The criteria for diagnosis of JP was given in Saxen (1980b), and is listed above. The only difference was that people up to age 30 were included to admit the cases of post-juvenile periodontitis.
In this study, 8 families had JP diagnosed in one or more siblings, giving a total of 11 affected siblings. The sex ratio for the propositi (subjects affected on whom the study was based) was 1.8:1 females:males. The sex ratio among all siblings was 1.06:1 (n = 33/31) females:males and that of the affected siblings was 1.75:1 (n = 7/4). The genetic ratio was calculated and found to be close to the theoretical expected value consistent with an autosomal recessive trait. This study presented evidence that supports an observed inheritance pattern of JP which was consistent with an autosomal recessive phenomenon. This, however, as she points out is not conclusive, and the mechanism of the inheritance remains unanswered. Indeed, the author was correct to make the important statement above, for no one study of this type can prove a cause and effect relationship. A piece of information that was left out was the method of selection of the original 31 cases. The question is critical, for if these cases were selected because they gave a family history of JP versus those who gave no such history, there may have been bias in case selection.

Additional evidence in support of the hereditary nature of JP was reported in the clinical and x-ray findings of a family with JP (Ohtonen et al. 1983). Initially, 5 subjects (probands) aged 12-18 years with suspected JP were examined clinically and radiographically (orthopantomographs). Bone loss was measured from the CEJ on mesial and distal sites of all teeth. Serum analysis was also performed to determine HL-A antigens. A total of 29 addi-
tional family members, including siblings and 8 parents were examined.

Results indicated that 6/29 family members had either JP or post-JP. Nine of 11 JP or post-JP subjects were siblings of the probands (6 female and 3 male), while two were parents. A female preponderance was reported in the young age, however, the sex ratio equalized with increasing age. The general observation was that a molar-incisor pattern of JP was present in the young with additional teeth affected in older individuals (more generalized disease). The age range of the affected siblings (up to age 43), however, makes it difficult to determine whether the authors examined JP or adult periodontitis that resembled JP.

As a result of the occurrence pattern in these families, the authors suggested that JP was inherited as a dominant trait, linked with HL-A antigens. This report is in discordance with Saxen et al. (1984) who reported a possible autosomal recessive mode of transmission. The report also differed from those of Spektor et al. (1985), Page et al. (1985) and Vandesteen et al. (1984) who all indicated that their results were consistent with an x-linked dominant mode of inheritance.

Burmeister et al. (1984) studied the periodontal conditions of 46 subjects with JP and 57 with severe periodontitis (SP) and reported that the plaque accumulations and gingival inflammation was greater in the sites affected with the disease conditions
than non-affected sites. Classification of JP and SP were as follows:

**JP** - destruction limited to first molar and/or incisor teeth with up to two additional teeth involved;

**SP** - > 5mm attachment loss on > 8 teeth, at least three of which were not first molars.

The clinical examination consisted of PII (Silness & Løe 1964), GI (Løe & Silness 1963), probing depths in millimeters and measurement of the CEJ from the gingival margin on the mesial, buccal, distal and lingual surfaces on all teeth. Any interproximal site with 2mm or more of attachment loss was considered affected.

Results showed that the mean PII score was significantly worse for the sites affected with JP (1.51±0.01) versus unaffected sites (0.95±0.01). The plaque index was also greater for affected SP sites (1.72±0.01) than unaffected SP sites (1.20±0.01). The gingival condition was also worse in affected JP sites (1.53±0.01) versus unaffected sites (1.04±0.02). Similarly, the GI was significantly worse in SP affected sites (1.48±0.02) versus unaffected sites (1.16±0.02).

The amount of attachment loss measured on first molars in JP and SP patients were virtually equal (4.68±0.22mm and 5.40±0.20mm, respectively). Pocket depths were not significantly different on first molars between JP and SP patients (6.04±0.24mm and 5.83±0.19mm, respectively). A sex ratio of 2:1 F:M in JP and SP subjects was reported. Primary analysis on race breakdown re-
vealed a 3.1:1 black:white ratio in JP but when analyzed for age and race combined, the race difference disappeared. Further, age was found to be a more significant factor in predicting whether a subject had JP or SP (SP patients were older). No relationship was detected between age and extent or severity of involvement in JP, but age versus severity was significant in SP subjects. Finally, the authors concluded that though a racial distribution might exist, no sex-age-race correlation was noted.

This study was noteworthy in that it presented evidence that was contrary to the commonly held belief that JP sites harbored less plaque than normal sites. Whether this phenomenon is consistent for all cases of JP will require further investigation to substantiate.

The possibility of an autosomal recessive mode of inheritance for JP was reported by Saxen et al. (1984) who studied 30 patients (14-30 years old) with JP. Their siblings and parents were also examined for signs of previous or present JP. A total of 52 siblings and 60 parents were examined. Nine of 52 siblings had JP, while none of the parents had evidence of the disease.

Based on the above findings, it was concluded that the evidence did not contradict a recessive mode of inheritance, and that the method of ascertainment was between complete and very incomplete. Finally, the authors suggested that follow-up studies be performed on the offspring of children presently affected with JP.
Risom et al. (1985) reported on a black family with JP in three of seven siblings. The sibship consisted of three males and four females with ages that ranged from 16-26 years. The three females comprised the case group. Further, the authors emphasized the fact that each of the females had different fathers, a factor which suggested an X-linked mode of inheritance with maternal transmission. Additionally, it was reported that the mother and great-grandmother both lost their teeth at an early age; the mother at age 22 (from "pyorrhea"), while the great-grandmother was in her early twenties when the loss occurred. The authors felt that the mother's history was suggestive of JP.

The major shortcoming of this report was the fact that no criteria was given for the diagnosis of JP, thus, it was not possible to compare their results to those of other authors. A strength of the study was that the author's noted that the primary etiology of JP remained unclear (bacterial or immunodeficiencies of white cells), but the neutrophil defects often associated with the disease were probably genetically determined for most JP patients.

Another interesting point was that the authors (Risom et al. 1985) suggested that families be counseled about the genetic transmission of the disease. Whether the counseling recommendation is indicated is unclear, since the genetic transmission of JP has not been adequately established. To illustrate, Saxen (1980c), Saxen et al. (1984) and Jorgenson et al. (1975) all felt
that the mode of transmission was autosomal recessive, while others (Spektor et al. 1985, Page et al. 1985, and Vandesteen et al. 1984) have suggested an X-linked dominant mode of inheritance.

In a study of a black family with three forms of periodontal disease (early-onset periodontitis) in one generation, it was reported that the pattern of JP presentation was consistent with, but not conclusive of an X-linked, dominantly inherited trait (Spektor et al., 1985). In the family of 13, 5 had JP while 2 had pre-pubertal periodontitis (PP) and 1 had rapidly progressive periodontitis (RP). The mother lost all her teeth by age 27 (presumably due to RP) but the father was periodontally sound. The maternal grandparents had lost their teeth early in life while this finding was not observed in the paternal grandparents or the father's siblings. Of the mother's siblings (10 living) at least three (2 sisters and 1 brother) had early-onset periodontitis.

A pedigree analysis was performed and the results were reported to be consistent with an X-linked dominant mode of transmission. Also, a high caries rate was reported in this family which is contrary to the popularly held notion that children with JP have a low caries rate.

The problem with assessing JP by history of tooth loss is that without sufficient evidence (clinical and/or radiographic examination) it is difficult to prove that the disease existed.
Further, when key diagnostic teeth (permanent first molars) are absent (as was the case for some subjects in this study) the diagnosis becomes virtually impossible. Therefore, caution must be used in interpreting the results of this investigation since early loss of teeth could result from a multitude of causes, JP being only one.

The actual age of onset of JP is not known, however, it has been shown that the condition becomes more severe and generalized throughout the mouth with increasing age (Saxen et al 1985). Eighty eight untreated patients with JP were studied (1,079 teeth total) and it was determined that with an increase in age there was an increased number of teeth involved. The severity of inflammation was also reported to increase with age. The entrance criteria for the study are summarized as follows:

1) more than one tooth involved;
2) good health;
3) few local irritants not commensurate with bone loss; and
4) less than 30 years old.

Panoramic radiographs were used to detect bone loss and the Gingival Bleeding Index (GBI) (Ainamo and Bay 1975) was used to detect bleeding in all patients. Bone loss was categorized by the criteria of Baer and Socransky (1979) as follows:

I) the localized form - limited to first molars and/or incisors;
II) the chronic disseminated form - which was slowly progressive and fairly generalized; and
III) the acute disseminated form - which was rapidly progressive and generalized.
The results of the investigation revealed that in the 13-18 year old age group (n = 32), approximately 16% had type III bone loss versus nearly 66% who had type I loss. Corresponding data in the 19-25 year old age group (n = 37) was 57% and 14%, respectively. In the 26-30 year old age group (n = 19), the differences reached their greatest disparity at 68% and 5%, respectively. From this data it is easily observed that the older groups had a greater proportion of severely involved (type III) sites than the younger groups.

Linear regression analysis was used to test the association between age and severity of JP. An $r^2$ value of 0.31 was obtained from this analysis. It was estimated that approximately one additional tooth became involved with JP each year. These results supported the conclusion that the severity of the disease in this group of individuals increased with increasing age. These results support the idea that if JP is untreated in some individuals, it becomes progressively worse (increased attachment loss) and can involve increasing numbers of teeth.

**Summary**

Summation of the data that has been presented in this literature review, reveals that controversy still exists regarding the prevalence of juvenile periodontitis. Prevalence rates of over 170.0/1000 and under 1.0/1000 have been reported for JP. Based on the literature to date, it is not clear what the real preva-
alence of JP is, but most evidence suggests that it is near the
low end of the range presented above (Tables 1 and 2).

One of the recurrent shortcomings associated with some descrip-
tive studies and/or case reports is that diagnostic criteria was
missing or only partially listed. This deficiency limits the
ability to interpret the findings as well as the ability to
replicate the study. The absence of a universally accepted case
definition of JP may have led to ranging, if unstated, case
definition of JP being used which may serve to explain the vast
differences in prevalence reports in the literature. Another
tendency noted was that females were reported to be affected with
JP more often than males in case reports (Benjamin et al. 1967,
Fourel et al. 1972, Manson et al. 1974, Saxen 1980c and
Vandesteen et al. 1984) (see Table 2 for additional references).
However, this trend was not reported as frequently in descriptive
Although one descriptive study reported a higher male:female
ratio for JP (Gjermo et al. 1984), little evidence exists in the
literature to support this finding. To complete the cycle of
confusion regarding sex prevalence, other case reports (Butler et
al. 1969 and Page et al. 1985) and descriptive studies (Hansen et
al. 1984, Saxby 1984 and Kronauer et al. 1986) have found no
difference in the sex ratio for JP. Although the majority of case
studies have reported a higher female:male ratio for JP, too few
descriptive studies have been conducted to establish a true sex
prevalence rate for JP. In addition, descriptive studies per-
formed on JP have found varying sex prevalence rates. Additional descriptive studies are needed to establish the true sex prevalence rate for JP.

A familial occurrence of juvenile periodontitis has been observed in case reports by many authors. They describe a high rate of consanguanous marriages among those families with affected siblings. While this pattern has been reported by many authors, who often strongly suggest a familial pattern, most will point out that their reports cannot prove that genetics play a role in the etiology of the disease. Most of the populations studied were either selected because of a high rate of disease in a particular family or the reason for selection was not specified. This type of selection could lead to a spurious association between the disease and family history. In fact much confusion exists regarding the possible genetic transmission of the condition. To illustrate, some authors have reported an autosomal recessive mode of inheritance while others have reported an X-linked dominant pattern. Since there appears to be no consistent pattern of reporting, it is difficult to determine which pattern, if any, adequately explains the familial patterns noted. One explanation for the varied findings is that many of the authors rely on family history (rarely radiographic or clinical) of periodontal disease to assess whether parents or siblings had JP. As is well known in epidemiological research, subject recall can be extremely unreliable, and could result in subject misclassification. This could in turn, lead to differences observed in inheritance
patterns. Clearly, the definitive answer on a genetic etiology is still pending.

The choice of study design will lead to different capabilities to show causation and to allow calculation of risk for a disease. The most powerful design is the experimental study, in which one has greater control over the independent variables and the confounding variables. The studies described above are descriptive in nature, and as such, have the least capacity of all epidemiologic study types to show causation. While these types of studies are the most logical first step, it must be realized that they have limitations. In short, this review has described the past and current methodologies used to assess juvenile periodontitis and illustrates the need for more well designed descriptive epidemiological studies of JP.

Although epidemiologic studies have been performed and have been reported, too few have been done to establish conclusively the true prevalence rate of or etiology of JP. It should be stated that the microbiological and immunological components of JP have been advancing and changing rapidly but this has not been true for the epidemiology of the disease. In fact, little more is known now about the true prevalence rate of JP than when it was described by Gottlieb in 1923. Additional, rigorously conducted, large descriptive studies, with well defined diagnostic criteria for the diagnosis of JP, are needed to establish the true prevalence rate of JP.
Literature On the Use Of Radiographs To Assess Bone Loss

In a longitudinal radiographic study of alveolar bone loss, Rohner et al. (1983) studied 105 patients (45 male, 60 female), 18-71 years old from the University of Geneva for up to 14 years. Complete periodontal, restorative and prosthetic treatment was rendered on all patients. Radiographs were taken (long cone and bisecting angle techniques) at intervals of 4-14 years and bone loss was measured by the method of Schei et al. (1959). Briefly, this method entailed placing a plastic ruler graduated with horizontal lines which were aligned with the root and crown tips. Bone loss was measured as a function of the total length of the root. Normal bone loss was considered as 1mm from the CEJ and was measured from this point. The average rate of interproximal bone resorption was determined to be 0.51% (0.07 mm) per year. Age, sex, professional status, type of periodontal treatment and state of health (systemic) did not change the rate of resorption, although, crowned teeth had a greater rate than uncrowned teeth.

In another study using similar measurement techniques, Jenkins and Mason (1984) assessed orthopantomographs of 800 untreated patients > 16 years old reporting to the Glasgow Dental Hospital and School in England over a four month period. In contrast to the ruler used by Rohner et al. (1983), a plastic ruler calibrated in quartiles (1 = 0-25% loss and 4 = 75-100% loss) was used to measure the x-rays. The entire tooth length was used to assess bone loss (bone height < 65% of root length was considered
bone loss) versus bone loss from the CEJ. A total of 84.5% of 16-19 year olds, 95-100% of all older individuals and 81% of individuals over 45 years old had marginal bone loss. One major problem inherent in this method was that bone loss was measured as a percentage of root length, a variable that changes readily with changes in x-ray beam angulation. Further, since 65% of the tooth length was considered the cut-off level for normal bone height, any resorption of the root tip would result in increased bone resorption even when none had occurred. Additionally, orthopantomographs tend to distort all radiographic images (including teeth and bone), thus, the accuracy of the measurements must be questioned.

Rosling et al. (1975) studied the effects of periodontal therapy on alveolar bone loss in a pilot study of five patients. The technique involved construction of maxillary and mandibular acrylic splints which extended across-arch from premolar to premolar region. Five orientation slots were placed on the lingual surface of the splints to facilitate standardized film position. The x-ray tube was fixed to the apparatus via quadrangular metal slots placed in the occlusal portion of the splint. Measurements were assessed twice in a 14 day period, then at 2 months post-surgery. A stereocomparator was used to compare all duplicate measurements and test reliability of the method. A mean decrease of 0.69mm (S.E. 0.07) was noted for interproximal bone height (measured to the nearest 1/100mm). They found differences of
approximately 0.033mm for a single measurement, thus, it was determined to be quite accurate. Finally, the authors concluded that the technique was adequate for measuring small changes in bone height since the measurement error was minimum. It is unlikely that this method would be practical for large scale epidemiological investigations because of the time and expense involved.

Ryden and Elisasson (1982) used radiographs to study 10 patients (37-49 years old) with advanced periodontal disease (including tipping and flaring of teeth). Radiographs were exposed after periodontal treatment, and again, two years later. Steel balls (0.8mm in diameter) were fixed to the facial and lingual surfaces of the incisors to assist in orientation. Three of the radiographs were copied and measurements compared in a stereocomparator. Bone loss was measured from the apex to the crest. Radiographs were magnified 7x with a Bausch-Lomb magnifier and measured to 0.1mm with a compass and a transverse scale. Variations between repeat assessments on the same radiographs and over time were between 0.12 and 0.36mm. Thus, the authors concluded, as did Rosling et al. (1975), that the method showed good precision in measuring bone height on the same radiograph over time and radiographs taken at different points in time.

Although the method worked well with this small number of patients, further studies of larger numbers of individuals would
be needed to confirm the accuracy and usefulness of the technique.

Gratt et al (1980) used a new radiographic technique called xeroradiography, to assess bone loss in periodontal disease. They studied 96 volunteer patients needing periapical and bite-wing radiographs for diagnostic purposes. A total of 550 sets of paired films (xeroradiographs and conventional radiographs) were examined for clarity of selected items, including: height of gingival contour, contour of gingival soft tissue, heavy and light calculus, supra- and subgingival calculus, trabecular pattern, height of alveolar crest, density of alveolar crest, pattern and location of bone loss, apical extent of osseous defects in bi- and trifurcations and interproximal areas, PDL and root morphology. All assessments were made by the same radiologist. A normal x-ray machine was used to make all exposures. Exposures were made using 75-100 kVp and 10mA. The exposure times varied from 1/2 second (30 pulses) for conventional film and 1/6 seconds (10 pulses) for xeroradiographic film. The authors stated that xeroradiographic images were superior to those generated on conventional film, primarily due to what was termed edge enhancement, a property that accentuates the differences between areas of great contrast, i.e. the crest of alveolar bone versus the PDL. Notable differences were reported for detection of calculus and bone loss patterns which were often missed by conventional radiographs. Although overall quality was better for xeroradiographs, wide area contrast was reported to be better with conven-
tional radiographs. The stated practical advantages of this new system were: 1) the images generated were dry and ready for viewing in 20 seconds, thus, multiple exposures could be made readily; 2) the equipment was small in size and lightweight; and 3) developing materials were less expensive than those used in conventional radiology. This technique appears to hold some promise for epidemiologic research because of the advantages stated, however, further studies must be conducted to determine the usefulness of the technique in clinical application.

Literature on the Correlation Between Clinical Attachment Level and Radiographic Bone Levels

Radiographic measurements have been used routinely to assess bone levels, estimate attachment loss and make diagnoses of JP in clinical practice and in studies. This method has been chosen as a screening tool for use in this study. The following section summarizes representative reports that have utilized this method. Only those studies that focus on radiographic bone levels and its ability to predict clinical attachment levels are described below.

Kelly et al. (1975) studied 58 patients undergoing various forms of periodontal therapy utilizing the long cone technique for radiographic assessment. They reported that a high positive correlation existed for measurements of radiographic bone height and attachment levels before and up to four years after periodon-
tal treatment. The pre-treatment correlation coefficient was 0.64 and 0.69 for clinical attachment level and radiographic bone height on the mesial and distal surfaces respectively. Post-treatment correlation coefficients for both mesial and distal surfaces for the above two parameters were 0.68, 0.66, 0.68 and 0.71 for years one through four, respectively. All correlation coefficient values were statistically significant ($p < 0.001$).

Their radiographic viewing technique involved projecting a 5x magnified periapical radiographic image onto a screen labelled with parallel grids arranged in equal increments off which a percentage reading of crestal bone height from the crown tip to the apex could be obtained (from the method of Bjorn et al. 1969). They felt that this method was preferable to that of Schei et al (1959) (measured bone loss from the CEJ), because the CEJ is often difficult to determine.

The shortcoming of this method was that percentage bone loss did not register exact millimeter increments of bone loss from a fixed point such as the CEJ. Their method measured percentage of bone loss from the crown tip and apex, a relationship that varies with the angulation of the central x-ray beam. To illustrate, Bassiouny and Grant (1976) demonstrated this point in dried human mandibles (number unspecified) by observing the movement of images of soft wire placed on the buccal and lingual plates as the angle of the x-ray beam was varied from +20, 0 and -20 degrees. It was noted that greater changes occurred with infra-
bony defects on the buccal and lingual crests than with horizontal bone loss. It must be pointed out that while these findings concur with the general principles of radiographic imaging, neither the number of jaws studied, nor statistical tests, if performed, were reported. Because the results were not quantifiable, they must be viewed in light of their descriptive nature.

Renvert et al. (1981) studied 13 patients with a total of 33 defects and reported that radiographic bone height did not correlate well with either probing attachment level, probing bone level (see also Isidor et al. 1984) or re-entry bone height measurements ($r = 0.45, 0.46$ and $0.47$ respectively). Standardized radiographs were taken before and 32 weeks after intraosseous surgery during which full thickness mucoperiosteal flaps were elevated, but no bone was removed during the procedure. Clinical attachment level, pocket depths, probing bone level and re-entry bone height were all measured to the nearest millimeter by utilizing specially designed onlays with buccal and lingual steering grooves to orient the periodontal probe to the deepest portion of the pocket. This technique was similar to that used by Isidor et al (1984) who used plastic splints with orientation grooves to guide the periodontal probe into the sulcus. In this study, the authors found the technique to be reproducible with respect to determining probing bone levels and attachment levels.

While the methods utilized by Renvert et al. (1981) to measure attachment and bone loss appeared to be adequate, there were no
control (non-surgery) patients to compare with the surgically treated patients. Though pre-surgical measurements were obtained, it is difficult to determine whether these results are comparable in patients not requiring intraosseous surgery. In short, it was not certain what effect the surgical procedures had on the measurement parameters.

Goodson et al (1984) measured 231 radiographic sites from standardized periapical radiographs (taken at 0, 6 and 12 months) and clinical attachment loss in 146 of those sites. They concluded that radiographic bone loss failed to predict clinical attachment loss. It was also concluded that attachment loss preceded bone loss by 6 to 8 months. The technique for the radiographic assessment involved projecting the radiographic image onto a digitized computer screen. Points were plotted at the CEJ, crest of the alveolar bone and the apex. Bone loss measurements were calculated from the CEJ to the alveolar crest (in millimeters). The average of four repeated measurements was taken as the measure of bone loss.

A significant finding in support of the authors conclusion was that when they measured attachment change of 4 mm, subsequent bone loss was predicted in 60% of the cases with a false positive error rate of 0.05. In contrast, 4 mm of attachment change occurring during the radiographic monitoring period predicted bone loss only 20% of the time with a false positive rate of 0.15. An attachment loss of 5 mm predicted subsequent bone loss in 80% of
the cases. They reported that these values indicated that attachment loss predicted bone loss, but only when it occurs prior to the bone loss.

In a study of 70 students aged 12-16 years old (35 with and 35 without clinical attachment loss), Mann et al. (1985) examined clinical attachment loss and radiographic bone loss and reported that bitewing were a poor screening or diagnostic tool for assessment of early periodontal destruction in adolescents. The criteria used to assess bone loss on radiographs was as follows:

1) a distance > 1.0mm between CEJ and alveolar crest;
2) widening of the PDL space;
3) diffuseness or absence of crestal cortical plate;
4) thinning or absence of the trabeculae of the crestal portion of the alveolar bone.

The mesial and distal surfaces were examined on maxillary and mandibular first molars, the mesial of maxillary second molars and distal surfaces of the lower incisors. All radiographs were exposed immediately prior to clinical assessments. While three calibrated examiners (two dental radiologists and one generalist) independently examined each radiograph, clinical assessments were made by only one examiner.

The results of this investigation indicated that 19.5% of sites examined had clinical attachment loss (classified as a pathologic site) while bone loss measured between 23.9% to 39.0% among the three examiners. Agreement between the clinical and radiographic measurements for all three examiners was minimal and all differences were reported to be highly significant for all four of the
criteria listed above. Although not presented in this article, the authors stated that the intra-examiner reliability was high. Because of this fact they concluded that the lack of agreement between clinical and radiographic readings indicated a failure of radiographs to adequately detect early changes needed for screening or diagnosis.

Conclusions

Although radiographs have been used extensively to assess bone loss associated with periodontal disease, no standard methodology has been developed for accurately quantitating bone loss. A number of authors have measured bone loss as a function of total tooth root length, using grids with horizontal lines graduated in 1/20 increments (Bjorn et al. 1969, Kelly et al. 1975 and Rohner et al. 1983). Jenkins and Mason (1984) used a similar method, but the horizontal lines were graduated in quartiles. A variation of this technique was used by Goodson et al. (1984) who plotted the CEJ, alveolar crest and apex from a radiographic image projected onto a digitized screen. Other authors have observed magnified radiographic images in a stereocomparator and measured bone loss using a compass and transverse scale (Rosling et al. 1975 and Ryden and Elisasson 1982). From this brief review, it appears that reproducibility of measurements has been variable but tends to be better with the increasing complexity of the methodology. The use of some of these methods require expensive equipment and
is time consuming (Rosling et al. 1975 and Ryden and Elisasson 1982). While these factors may not be extremely critical in relatively small studies, they can be a major factor in the success or failure of large epidemiological studies involving thousands of subjects.

Another issue addressed in this review was the use of radiographs to predict clinical attachment loss. From the few reports listed above (Kelly et al. 1975, Renvert et al. 1981, Goodson et al. 1984 and Mann et al. 1985), there appears to be disagreement concerning the subject. Although some authors have reported that radiographic bone levels correlate well with clinical attachment loss measurements (Kelly et al. 1975 and Renvert et al. 1981), others have reported contrary evidence (Goodson et al. 1984 and Mann et al. 1985). It is conceivable that the differences in reports were due to the varying methods utilized.

Whether radiographic bone levels can accurately predict clinical attachment levels has not been established conclusively. However, the most recent evidence indicates that the method may not be sensitive for detecting small changes in attachment levels. While most studies of this type have focused on chronic adult periodontal disease, it might be useful to apply these methods to the study of JP in adolescents. Juvenile periodontitis seems particularly suitable for these types of investigations, since there are often rapid changes in radiographic bone levels and clinical attachment levels over short periods of time in individuals with
Evidence from such a study would provide needed, additional information on the appropriateness of the use of these methods in the study of JP.
SPECIFIC AIMS

The primary objective of this study was to establish the prevalence of juvenile periodontitis (JP) in 10-12 year old school children using bite-wing radiographs to screen for possible cases followed by thorough clinical examinations to determine definite cases.

Secondary objectives of this study were to:

1) establish the false positive rate for x-ray screening for JP by comparing x-ray diagnoses with clinical diagnoses using the study population.
2) test the validity of x-ray screening for periodontal attachment loss by comparing clinical and x-ray measurements on a population of periodontal patients;
3) compare the prevalence and severity of JP by race, sex, and socioeconomic status (SES); and
4) establish a protocol for radiographic and clinical diagnoses of JP that can be used quickly, easily and consistently.
RATIONALE FOR STUDY

The rationale for this proposed research is that the prevalence of JP in pre-teen and teenage children has not been established. While the clinical observations suggest that the circumpubertal period seems to be the point of onset, no specific prevalence rates have been established for various ages of this life period. The availability of a radiographic data bank on 10-12 year old school children suggested the feasibility of establishing the prevalence rate of JP for this subset of circumpubertal children, the 10-12 year olds. Determination of the prevalence rate of JP in this age group would indicate whether it would be appropriate to target this group for public health screening on a larger scale.

The rationale for testing the validity of the radiographic screening by comparing x-ray bone loss measurements with clinical attachment loss measurements in patients with periodontitis is to establish the accuracy of radiographic measures in detecting clinical attachment loss. By determining the correlation between the two measures, the ability to detect clinical attachment loss from radiographic screening of 10-12 year old children could be estimated.

The rationale for the methods proposed is that an efficient, inexpensive and accurate method of screening radiographs for JP would facilitate large scale examinations. Such examinations could provide prevalence rate estimates of JP in various age
groups. In addition, establishing a set of criteria by which to diagnose JP should enhance the reproducibility of findings among different investigators.
METHODS AND MATERIALS

I. Assessment of The Prevalence of JP in 10-12 Year Old Children

A total of 1872 volunteer 10-12 year old public school children from the greater Worcester, Massachusetts area, who were enrolled in a dentifrice clinical trial were selected as the study population. This sample represented approximately 50% of the total number of children in the Worcester area in this age group. Only 50% of the population was represented because, although, there was a 60% enrollment rate into the fluoride dentifrice trial, some subjects were ineligible because they had no radiographs. Figures 1 and 2 present flow charts describing the outline of this investigation and traces subjects flow from start to completion.

A. Radiographic Screening

All radiographs were examined on a standard viewbox covered with black paper to a dimension that facilitated placement of the bite-wings (BW's) so they could be viewed in their entirety. The light in this room was totally darkened during screening sessions to ensure a standard lighting condition during all radiographic readings.

The radiographic screening took place in two stages, the first, was a preliminary screening (Figure 1), or visual inspection, to
determine the interpretability (here defined as the CEJ and PIL clearly visible and unobstructed by each other on the radiograph) of the radiographs. This exam also determined whether the radiographs would be considered for a second, more detailed radiographic examination. The second, was considered the final radiographic screening (Figure 1) and used a plastic see-through ruler calibrated in millimeters was used to measure those x-rays selected from the preliminary screening. During both the preliminary screening and final radiographic exam, subject's names were masked from the records to blind the reader to the identity of individual subjects. Blinding was done to facilitate assessment of reliability checks, especially given the rareness of the disease. The following sections describe the methods in detail.

1) **Preliminary Radiographic Screening**

The preliminary screening was a technique employed to accelerate the process of reading large numbers of radiographs. The technique involved visually examining the mesial and distal surfaces of all four permanent first molars on a total of 1872 pairs of bite-wing radiographs to determine the location of the crest of alveolar bone. If the bone levels at any interproximal site on any first molar(s) did not appear normal (normal described as bone levels \( \leq 1 \text{mm from the cementoenamel junction} \)), the x-rays were placed in a re-examination category to be screened in the final radiographic screening process. If bone levels appeared normal the radiographs were placed in a "noncase" category. All
radiographs (mesial and distal sites of permanent first molar teeth) were categorized regarding their interpretability. The specific criteria used to determine interpretability of radiographs was as follows:

1) **Readable Radiographs** --

   all radiographs for which the cementoenamel junction (CEJ), and periodontal ligament space (PDL) was visible and unobstructed by other radiographic structures;

2) **Periodontal ligament space (PDL) missing on x-ray** --

   (a) apical extent of PDL space cut off the film,
   (b) eruption of a tooth adjacent to a permanent 1st molar obscuring the PDL space;

3) **Blurred films/unreadable films** --

   an unreadable site because of motion error;

4) **Extensive vertical angulation (VA) of x-ray beam** --

   the CEJ was obscured by the crestal bone (i.e. they were superimposed upon each other);

5) **Excessive horizontal angulation (HA) of the x-ray beam** --

   the CEJ of a 1st molar tooth was obscured by an overlapped adjacent tooth or restoration;

6) **Orthodontic bands or appliances** --

   orthodontic bands and/or appliances obscured the CEJ or PDL space;

7) **Extensive restoration(s) or caries** --

   restorations or caries that obliterated or obscured the CEJ;

8) **Other** --

   those sites unreadable for reasons unspecified in the above categories;
9) Missing tooth --

included those cases that had missing teeth or data.

An intra-examiner reliability check of the preliminary screening process was performed daily. This was accomplished by utilizing a research assistant to include in each day's set of radiographs a random 5% of all x-rays from the previous day's examinations. The intra-examiner reliability check represented 5% of those radiographs excluded and an equal percentage of those included in the more detailed examination.

2) Final Radiographic Screening

Radiographs selected for the final radiographic examination were measured by using a transparent ruler calibrated in millimeter increments. The ruler was constructed with a handle for ease of manipulation and placement on the x-rays. The classification criteria used for determining a radiographic JP case in this screening was:

all subjects with at least one permanent first molar site with bone loss from the CEP >2mm was considered a possible radiographic case.

Two millimeters was selected because preliminary data collected prior to the start of the study indicated that it was the smallest value measurable with this technique that allowed the inclusion of all abnormal bone levels regardless of bone loss patterns (i.e. vertical versus horizontal bone loss).
3) Methods For Obtaining Informed Consent

This section outlines the steps involved in obtaining informed consent for permission to conduct examinations in either children's schools or homes from school officials and parents of children with evidence of radiographic JP (Figure 3).

School officials were contacted by telephone informing them of the study and the need to examine certain children in their schools for signs of periodontal disease. This telephone contact was followed by a letter that clearly explained that, based upon preliminary evidence, the identified child could have JP, a condition that required dental treatment. Additionally, a packet to be forwarded to the child's parent(s) was included in the mailing to the principal. The parental package included a brief summary of the periodontal findings of the child as observed on radiographs and recommended that the child obtain a more detailed periodontal examination by a dentist to establish a more definitive diagnosis. One option offered to the parents was to have the candidate examine their child; the other was to have the examination conducted by their own dentist. Phone contact was made with school officials one week of the postdate of the original letters for purposes of clarifying specific details of the study.

Two weeks were allowed for officials to send information packets home to children's parents and for a reply to be received by the candidate. If no responses were received from parents within that time, the school officials were contacted regarding the receipt
of and dispersement of the information packets. An additional period of two weeks was allowed for parents to respond to the examination request forms. Those not returning the consent forms at this stage were considered refusals and were classified as non-participants. No additional follow-up letters were sent at this time, but were mailed to all non-respondents at the completion of all clinical examinations. All letters and request forms can be found in the Appendix A.

Clinical examinations were scheduled if parents indicated that they wanted examinations performed on their children. Examinations were performed at each school after all requests were received from that school to maximize the number of examinations performed on a given scheduled visit to school. Those children who were absent or who could not be located at the time of the scheduled examination were examined on a subsequent visit to the school. The methods of the clinical examination are described in detail below.

B. Methods and Materials of the Clinical Examination

Prior to the clinical examinations, all subjects completed a brief medical history questionnaire to ascertain whether antibiotic premedication was appropriate (Appendix A-6). No child was examined without a completed medical history questionnaire.

All examinations were performed using a portable dental chair, headlight, standard mouth mirrors and gloves. Periodontal
charting was performed with Michigan "O" probes with Williams markings. Cassette tape recorders were used to record all indices which were later transcribed onto data sheets. Two recorders were used to prevent accidental loss of data due to equipment malfunction.

The Plaque Index (PI I) was performed on all teeth by the method of Silness and Løe (1964), followed by the Gingival Index (GI) performed by the method of Løe and Silness (1963). Probing depths were performed at 4 sites on each tooth, the mesio-buccal, mid-buccal, disto-buccal and mid-lingual surfaces. Attachment loss measurements were recorded from the CEJ to the depth of the pocket. The difference between measurements from the gingival margin to the bottom of the pocket and from the margin of the gingiva to the CEJ, i.e. net attachment loss, the measurement from the CEJ to the bottom of the pocket. This reference point was chosen because the CEJ is a fixed point from which accurate measurements of the attachment loss can be taken repeatedly. Measurement of attachment loss from the CEJ was performed on only the four permanent first molar teeth while pocket depths from the gingival margin was determined on the remaining teeth. Attachment loss was measured where possible on teeth other than first molars with pocket depths exceeding 4mm. Attachment loss was not measured on all teeth routinely because the four permanent first molar teeth were the only teeth used for diagnosis of JP. While attachment loss measurements on all teeth would have provided valuable information on each site, time constraints, however,
prohibited these measurements (i.e. each child could be kept out of class only 15-20 minutes). In addition, it is unlikely that the yield from such measurements would have contributed significantly to the diagnosis of the disease. The diagnostic criteria for clinically defining JP in this study was as follows:

attachment loss \(> 3\text{mm} \) from the CEJ on one or more permanent first molar teeth with an absence of local factors to explain the extent of the loss.

Surfaces that were obstructed by orthodontic appliances, carious lesions, or large restorations were excluded from the clinical attachment loss examination and data analysis.

Upon completion of the clinical examinations, letters were sent to parents informing them of the diagnostic results and recommended that the child see his/her dentist for appropriate treatment as indicated. All letters and forms can be found in Appendix A.

During the examinations the local Worcester Dental Society received calls from a few parents who were concerned that their children had developed a serious dental condition. After conversations with members of the dental society, letters of further explanation were sent to the dental society and to all parents of children not participating in the clinical examination. The letter emphasized that the radiographic examination only suggested that their child might have a periodontal disease problem and that an examination by their dentist was important to
C. **Worst-Case Scenario for False Negatives Based on the Preliminary Screening**

The availability of three-year follow-up radiographs on children in the Worcester fluoride dentifrice clinical trial made it possible to estimate the worst case scenario (maximum number projection) for false negatives based on the visual prescreening. To accomplish this estimation, a 20-25% random sample (n = 221-278) of radiographs of children who were included in the preliminary screening and who were currently participating (n = 1106) in the fluoride dentifrice trial were selected (by an assistant) for measurement of bone loss on first molar sites with a transparent ruler. As a masking procedure, some proportion (known only to the assistant) of radiographs of children designated as possible cases (three-year follow-up radiographs) were mixed in with the non-cases. All names were masked on the radiographs and the packets containing them to blind the examiner.

The benefit of this analysis was that it allowed an estimation of the maximum number of false negatives based on the preliminary screening. It is a worst case estimation because some children who developed bone loss after the original radiographs were exposed (3 years prior) were categorized as "missed cases." Therefore, these individuals artificially inflate the number of

rule out the possibility of such a condition. This letter is included as Appendix A-7.
truly misclassified cases, and thus represent a "worst-case" estimate of false negatives.

D. Three Year Follow-up Radiographic Examination on 10-12 Year Old Children

Three year follow-up radiographs of children who were identified as a possible radiographic case based on the first year radiographs were examined for signs of continued bone loss. Bitewing radiographs were available for 76.5% (n = 75) of the 98 children who were originally identified as possible radiographic cases. A duplicate full mouth series of radiographs were available for one subject (1.5%) who was examined clinically at Boston University, but radiographically by the candidate. The other 22% were either absent from school the day 3rd year radiographs were taken or were no longer part of the ongoing fluoride dentifrice trial. The procedures followed for x-ray examinations were the same as for the detailed x-ray examination described above. The only change made was that an age-sex matched control child from the same school was selected for each possible case, thus a total of 150 radiographs were assessed (Figure 2). Controls were chosen to mask the identity of previously chosen possible radiographic cases. The controls were chosen by selecting the next age-sex matched child from the record file containing radiographs of all children (by school and grade) in the fluoride dentifrice trial. All measurements from this assessment were compared to those from
the initial screening to determine whether there was progression of bone destruction during the three year interval.

E. Determination of Accuracy of Radiographic Bone Loss Measurements in Detecting Clinical Attachment Loss in Adult Patients

To assess the precision of radiographs as diagnostic tools in the assessment of periodontal diseases, the correlation between clinical attachment levels and radiographic bone levels was determined by measuring these two parameters on adult patients with existing bite-wing radiographs. These patients were chosen randomly from patients receiving treatment in the Dental Clinics at the University of Connecticut School of Dental Medicine. Oral consent was obtained from all subjects before clinical examinations were performed (see Appendix A-11). Clinical attachment level measurements were assessed for each patient by measuring from the cemento-enamel junction (CEJ) to the base of the pocket. This measurement was obtained indirectly by measuring pocket depths from the free gingival margin (FGM), then measuring from the FGM to the CEJ. The distance from the FGM to the CEJ was then subtracted from the pocket depth, the resultant measurement was net attachment loss. If the FGM was apical to the CEJ it was assigned a negative value, then added to the pocket depth to yield net attachment loss. The mesio-buccal, mesio-lingual, disto-buccal and disto-lingual sites of all permanent molar teeth were measured. A Michigan "O" probe with Williams markings was used to make the clinical assessments.
A six digit code number present on all patient records and radiographs was used to retrieve all bite-wings at least one day after the clinical examination was completed. The reading lag time was designed to decrease the chance of bias inherent in assessing radiographs immediately after the clinical assessments, i.e., the observer could remember the attachment loss measurement for an individual patient, thus, the radiographic assessment would not be an independent and blind assessment. The bite-wing radiographs (all of which were less than one year old) were assessed for bone loss by the candidate and an independent investigator as described below.

1) Procedures for Bone Loss Measurements in the Adult Population

Two examiners, the candidate and a second, volunteer investigator blindly and independently assessed all radiographs. No calibrations were performed between the two examiners to assess the ease with which the technique could be applied to radiographs without training. While no calibrations were performed, differences between measurements were noted and resolved by discussion of the discrepancy by the examiners. Blindness was assured by the use of a six digit code number on all x-rays and attachment level measurement forms as mentioned above. Additionally, names were not used on any data forms to assure that the investigators would remain blinded to individual subjects. As a further measure, all radiographs were assessed at least one day after the clinical
measurements. Also, at least two radiographs were assessed at each reading to further mask the identity of the last clinical examination performed.

2. Procedures for Radiographic Interpretation in the Adult Population

Radiographic bone loss was measured from the CEJ to the apical extent of the defect (defined as the area where the periodontal ligament remained constant in width) on the mesial and distal of all permanent molars. A clear plastic ruler calibrated in millimeter increments was used to make the radiographic assessments. All measurements were rounded up to the nearest millimeter to avoid the difficulty and uncertainty of measuring fractions of millimeters which were beyond the scope of the instrument used. For example, a reading that exceeded 2mm but did not reach 3mm was recorded as 3mm instead of 2.5mm. Disagreements of ≥1mm were discussed by both examiners and a single measurement determined.

II. Reliability Checks

A. Intra-examiner Reliability of the Preliminary Screening

An intra-examiner reliability check of the preliminary screening process was performed daily. This was accomplished by a research assistant who included in each day's set of visually screened radiographs, a random 5% of all x-rays from the previous day's examinations. The intra-examiner reliability check represented a
5% sample of those radiographs excluded and a equal percentage of those included in the more detailed examination.

B. Intra-examiner Reliability of the Final Radiographic Screening

To assess the intra-examiner reliability of the final radiographic screening, a randomly selected 51% (n = 52) of the radiographs identified as possible cases (based on bone loss of < 2mm from the CEJ) on at least one first molar site) were reassessed. As a masking procedure, an equal number of radiographs determined to be non-cases (bone loss < 2mm from the CEJ) were randomly selected and reassessed. Agreement was based on classification as a possible case and not on a site by site comparison. For example, if a possible case originally had bone loss on one tooth > 2mm, but on re-examination had a different tooth that was > 2mm, it was still classified as a possible case.

C. Intra-examiner Reliability Check For the Follow-up Radiographic Assessments on Children Remaining in the Study

To assess the intra-examiner reliability of the follow-up radiographic examination on the adolescent population, a randomly chosen 51% sample of x-rays (possible cases and controls) were reassessed. An equal number of randomly chosen non-cases (based on the preliminary radiographic screening) from the three-year set of radiographs were mixed in as masks. Unlike the reliability check of the preliminary screening, all measurements were
compared on a site by site basis because the site was the unit of concern rather than case classification (possible or definite cases). This was done to assess the reliability of the method in detecting radiographic bone loss in the same group of adolescents three years later.

D. **Intra-examiner Reliability of Radiographic Assessments on the Adult Population**

To assess the intra-examiner reliability of the radiographic assessments on the adult population, a total of 7 patient records were chosen randomly by an assistant and reassessment were performed. This resulted in the reassessment of 41% (n = 68) of the sites originally measured. This skewed distribution of sites among these few patients resulted from the fact that some subjects had more interpretable sites than others. The same methods of assessment for bone loss as used in the adolescent population was used. All sites were compared on a site to assess the reliability of the method in detecting bone loss in an adult population.

E. **Inter-examiner Reliability of the Radiographic Assessments on the Adult Population**

To assess the reliability of the method of measuring radiographic bone loss between independent examiners, the same patients reassessed in the intra-examiner reliability check (41% of sites) were reassessed by both examiners. All measurements were based on
III. Validity Check

A. Validity of the Preliminary screening as Measured by Millimeter Ruler

To calculate intra-examiner reliability of the preliminary screening, a 3-5% sample (n = 53-88) of those radiographs designated as non-cases (n = 1755) were randomly selected by an assistant for measurement with a transparent ruler calibrated in millimeters. As a masking procedure, some proportion (known only to the assistant) of those radiographs designated as possible cases in the preliminary screening were mixed in with the non-cases. Further, to ensure that all measurements were assessed blindly, names were masked on all radiographs and packets containing them. Determination of possible or non-cases was the same as described in the methods section above. To briefly reiterate, all radiographs with bone levels ≥ 2mm on at least one first molar site was designated a possible case. Those radiographs with bone levels on all sites measuring < 2mm were designated as non-cases.

IV. Statistical Analyses

The agreement rates between the clinical examinations with both the final radiographic examination and the three-year follow-up examination was determined by the Kappa Coefficient of agreement (Landis and Koch 1977) which measures the agreement between two
imperfect measures. Kappa can be calculated using the following formula:

\[
\text{Kappa} = \frac{N(a + d) - (n_1 f_1 + n_2 f_2)}{N^2 - (n_1 f_1 + n_2 f_2)}
\]

\(N\) is the total study population, \(a\) is the number of true positives, \(d\) is the number of true negatives identified, \(n_1\) is the number of positives identified by method 1, \(n_2\) is the number of negatives identified by method 1, \(f_1\) is the number of positives identified by method 2 and \(f_2\) is the number of negatives identified by method 2.

Kappa estimates the proportion of agreement between two measures due to chance alone. Landis and Koch (1977) outlined the following guidelines for Kappa value interpretation:

1) \(<0.00 = \text{poor agreement [i.e. difference due to chance]};
2) 0.00-0.20 = \text{slight agreement};
3) 0.21-0.40 = \text{fair agreement};
4) 0.41-0.60 = \text{moderate agreement};
5) 0.61-0.80 = \text{substantial agreement}; and
6) 0.81-1.00 = \text{almost perfect agreement}.

Kappa estimates were contrasted with false positive rates for selecting possible and definite cases of JP from the first and third year follow-up radiographic examinations as well as from the clinical examinations. While the false negative rate could not be calculated directly in this investigation, worst-case estimates of false negatives were calculated on a 22% sample of non-case subjects remaining in the study at year-three.
RESULTS

I. Prevalence Rate Results

A. Overall Prevalence Rate Based on Diagnosed Cases

A total of 1,872 10-12 year old children were evaluated for the presence of juvenile periodontitis using a two-stage radiographic screening technique combined with follow-up clinical examinations. A total of 3 cases were detected, yielding a prevalence rate for juvenile periodontitis of 1.6/1000. While all were based on radiographic evidence, only two cases were confirmed by clinical examinations.

A total of 98 requests were mailed to parents of possible cases and 45 parents (46% of the mailing) returned consent forms, and of those, 42 (93% of returned forms) consented to permit their children to be examined clinically. All 42 (100%) of the children for whom requests were available were examined clinically by the candidate. An additional child (female) was examined by members of the Department of Periodontology at Boston University School of Dental Medicine (BU), thus a total of 43 clinical examinations were performed (hereafter, the total examinations performed will equal 43). The sex breakdown was 23 females and 20 males, a ratio of 1.1:1 female:male. Of those examined, two subjects (1 male and 1 female) (4.7%) had clinical presentations
consistent with JP. The method of detection of the three cases is discussed in detail below:

**Case 1:** This individual (a 14 year old white female) was 12 years old when classified as a possible case based upon the preliminary radiographic screening examination (Figure 4). Complete clinical and radiographic examinations were performed by members of Boston University's Department of Periodontology, who confirmed the diagnosis of JP. Details of the examination and the diagnosis was fully discussed by the candidate and the Boston University staff. No clinical examination could be performed by the candidate because of complications concerning legal guardianship of the child. However, duplicates of the original radiographs examined by the Boston University staff (full mouth series) were examined by the candidate for signs of JP (Figures 5 and 6). The radiographic diagnosis of JP was confirmed by the presence of infrabony defects on the mesial surfaces of the lower right and upper left permanent first molars (Figure 4).

**Case 2:** This individual (a 14 year old hispanic male) was 12 years old when classified as a possible case during the preliminary screening (Figure 7). He was later classified as a definite case based on clinical and three-year follow-up radiographic examinations. During the clinical examination, pocket depths on the lower first molars were measured up to 10mm, the limit to which probing depths could be measured
accurately. Attachment loss on the lower first molar sites reached 6-7mm. It would be truer to estimate that the actual attachment loss was closer to 9mm since the periodontal probe penetrated into the sulcus past the 10mm calibrated limit. This finding indicates that massive attachment loss had occurred in this individual. Of note also was that during the final radiographic examination, this subject was selected only as a possible radiographic case instead of a definite case. Therefore, the massive bone destruction noted on the three-year follow-up radiographs had taken place during the interval between the first and second set of radiographs. Whether the great majority of the attachment loss noted occurred prior to or after the first radiographs were exposed was not clear. It would seem more likely that attachment loss occurred after the first radiographs due to the extent of the loss which probably would have been detected as a radiolucency radiographically.

Case 3: This case (a 15 year old white male) was 12 years old when classified as a possible case during the preliminary radiographic screening. Although lacking a clinical examination, this individual was classified as a definite case based on the strength of the radiographic evidence observed in the three-year follow-up radiographs (Figure 8). No clinical examination was performed because the parents did not return the request form indicating a desire for their child to participate in the study. Bone loss on one
first molar site appeared vertical in nature and approached 6mm. Note the progression of bone loss on the lower right and left and upper left first molar teeth. A follow-up letter was sent to the parents of this child informing them that the radiographic evidence suggested that the child had JP and that an examination by their dentist was recommended.

Race Prevalence - Two of the three JP cases were Caucasian, while the remaining case was Hispanic. However, because so few cases were detected, race prevalence could not be accurately determined from this investigation. Further, the racial distribution among the population was not diverse enough to make a statement about the general population adequately address the race prevalence of JP.

Sex Prevalence - The sex ratio was found to be 2:1 male to female (2 males and 1 female). However, because only three cases of JP were detected, inadequate information existed, to make a general statement on sex prevalence.

Socioeconomic Status - Although census tract data was available for individuals who participated in this investigation, the data is not presented here because too few cases (n = 3) were detected to yield any useful information about the SES of children with JP.
B. Preliminary Radiographic Screenings

Of the 1872 individuals entered into the preliminary screening, radiographic interpretability measurements were available for 1819 (97.2%). The interpretability was calculated for each site and is presented in Table 3. These results indicate that approximately 68% of all mesial and 38% of distal sites were available for measurement in the study. Overall, 53% of the 14,552 sites (8 sites per 1819 subjects) were interpretable (readable). It appeared that distal sites of upper molars were most often not interpretable, while distal sites of lower first molars were visible more often. The obvious implication of these findings was that some potential possible cases might have been eliminated because sites with bone loss were not interpretable. Lack of interpretability was due mainly to: blurred images, eruption of second premolars and second molars and excessive vertical angulation.

A total of 117 (6%) individuals were selected as possible cases and entered the final radiographic screening (Table 4). The individuals were chosen based on visual inspection of permanent first molars on bitewing radiographs for signs of bone loss ≥ 1mm from the CEJ. The results of the final radiographic screening are presented below.
C. Final Radiographic Screening Examination

Of the original 117 possible cases (from the preliminary screening) selected to have a final radiographic exam, 103 (88%) were selected for further clinical examinations (all subjects had at least one permanent first molar site \( \geq 2\)mm) (Table 4). Of the 103 possible cases identified, 98 (95%) had addresses to which requests for clinical examinations could be mailed (Table 5). Fourteen possible cases (12%) were classified as non-cases (<1mm bone loss from the CEJ) based on measurements with the millimeter ruler. This result indicates that preliminary screening was not as accurate as measurements using the transparent ruler.

One definite case was detected by the final radiographic screening (case 3 in section I A.) This case was classified as JP due to radiographic bone level measurements of up to 6mm from the CEJ on at least one first molar site (Figure 4). The remaining 102 individuals were classified as possible cases since none had a radiographic appearance similar to this case.

D. Three Year Follow-up Radiographic Examinations

Of the 98 traceable possible cases from the preliminary radiographic screening, only 75 (78%) had radiographs present at the three year follow-up radiographic examination. To blind the examiner to radiographic measurements, age, sex and school matched control children (n = 75) were measured along with the 75 children remaining from the preliminary radiographic screening.
(Table 6). A total of three cases of JP were confirmed by this process. Two of these cases were previously confirmed by clinical examinations. The final case was not examined clinically because no request form was returned by the parents. However, based on the strength of the radiographic presentation (Figure 8), it was clear that the child had JP. Table 6 traces the detection of the three JP cases from the preliminary screening through the third year radiographic examination.

E. Results of the Assessment of the Highest Estimate (i.e., Worst-case Scenario) for False Negatives Based on Theoretical Projections From the Preliminary Screening

To determine the worst-case scenario for false negatives from the preliminary screening, a 21.4% (n = 221) random sample of all non-case radiographs (n = 1031 non-cases based on the preliminary screening) available for children on the three-year follow-up were selected and measured for bone loss. As a masking procedure, 44 pairs of radiographs of children identified as possible cases on the final radiographic examination were added.

Table 7 shows that (at year-three) one hundred and twenty-four of the 221 non-cases (from the preliminary screening), or 56% exhibited at least one site with bone loss \( \geq 2 \text{mm} \), while in the remaining 44% (n = 97), all interpretable sites were \(< 2 \text{mm} \). Correcting for the 10% error rate from the preliminary screening (as validated by millimeter measurements) (see section III below), approximately 46% of children with interpretable sites \(<
2mm at 10-12 years old, had at least one site that measured > 2mm on three-year follow-up radiographs. The correction was necessary because up to 10% of the radiographs sampled were estimated to be possible cases from the original (visual) preliminary screening, thus, their inclusion in the three-year follow-up assessment would increase the false negative rate by an equal percentage. Table 8 presents a theoretical projection of the highest realistic number and maximum number of possible and definite JP cases. Based on the 46% estimate above, the highest realistic projection would be 474 possible cases among the non-cases (n = 1031) remaining in the study at three years. Further, the expected number of JP cases would equal 22, based on a yield rate of 2/43 clinical examinations performed. The estimated prevalence rate for JP cases would be 24.0/1000 for the three-year follow-up period. These rates include the two JP cases detected by clinical examinations as well as the additional estimated cases.

The estimate above represents the maximum number of cases expected based on a case yield rate of 2/43 clinical examinations. This estimate does not reflect the fact that cases could develop during the three-year interval in children who exhibited no detectable bony changes radiographically at the preliminary screening. Thus, if accurate, the worse-case scenario would represent a crude period prevalence, i.e. all cases present at three years, regardless of whether they developed at the start (time of the screening) or end of the three-year follow-up.
Table 8 also presents the maximum number of projected possible and definite cases based on the assumption of no loss of subjects to follow-up. The estimates reveal that 807 possible and 38 definite cases would have been expected. These estimates are 1.7x greater than the highest realistic estimates of 474 possible and 22 definite cases based on the actual number of subjects lost to follow-up. Therefore, the highest estimated rate of cases of JP would be 40.0/1000. The differences between complete retention of subjects and a 58% loss (actual percent lost to follow-up) graphically illustrate the effects of subject withdrawal.

While no definite cases were found during these radiographic assessments, one pair of radiographs exhibited bone loss that was strongly suggestive of JP but was not extensive enough to be classified as definite JP. To adequately describe this situation (different from both possible and definite cases), a "probable" case category was established. Based on this finding, approximately 5 probable cases would have been detected had all the previous non-case radiographs from the follow-up period been examined (estimated from a yield rate of 1 probable case per 221 non-cases measured). Extending this estimate to complete subject retention would have yielded approximately 9 probable cases.

A letter was sent to the parents of the child with probable JP explaining that there was a strong possibility that their child might have JP. It was also suggested that the child have an examination by their dentist (Appendix A-10).
F. Progression of Radiographic Bone Loss Over A Three-year Period in the Adolescent Population

Progression of bone loss among children identified as possible cases during the prescreening (n = 98) was determined by measuring the bone levels on BW for those children remaining in the study at three years (n = 75) (Table 7). Of the total sites examined, only 34.3% were interpretable (hereafter referred to as sites). Results indicate that 14.4% of sites measured less, 32.3% measured greater and 53.3% measured the same at three years. Because it was determined that approximately 25% of radiographic sites (determined from the intra-examiner reliability check of the three-year radiographs) (section III. C. below) were within ±1mm of the observed measurement, recalculation of the percentage of sites that changed was necessary (Table 7). The 25% adjustment resulted in values of 10.6%, 24.2% and 65.2% for sites that decreased, increased and remained constant, respectively, during the three year interval. This result indicates that approximately 24% (nearly 1/4) of sites in the remaining 78% of 10-12 year old children selected as possible JP cases from the original prescreening, increased in measurement over a three year period.

II. Results of the Agreement Between Radiographic Bone Level and Clinical Attachment Level Measurements

A total of 26 randomly selected adults presenting for dental treatment at the University of Connecticut School of Dental Medicine, were examined for signs of clinical attachment loss and
radiographic bone loss. A total of 158 molar sites were available for comparison of both radiographic and clinical attachment level measurements. Tables 9 and 10 present the results of these paired assessments. All radiographic measurements were assessed by two examiners, who independently measured all sites and resolved all differences >1 mm. Table 11 reveals that the percentage agreement between radiographic and attachment level measurements was 34.2% for buccal and 34.8% for lingual sites. Within a range of ±1 mm, the agreement increased to 76.6% and 75.9% for buccal and lingual sites, respectively. When a range of ±2 mm was used, the agreement rates increased dramatically to 94.3% and 96.2% for buccal and lingual sites, respectively. These values indicate that radiographic bone levels predicted clinical attachment level poorly on an exact millimeter comparison basis, but was excellent within a range of ±2 mm.

Table 12 shows the agreement rates between radiographic measurements by various millimeter ranges of attachment level. These results illustrate that agreement decreased for each millimeter increment of radiographic bone level measurements, but on a site by site comparison, showed consistently high agreement for all levels when a range of ±2 mm of attachment loss was used (from 96% at 1 mm to approximately 90% at ≥ 5 mm).

Table 13 presents data on the percentage of times radiographic bone level measurements predicted a clinical attachment level measurement of ≥ 3 mm. Note that at a radiographic bone level
measurement of 1mm from the CEJ, clinical attachment level was observed 24.1% and 22.2% of the time for buccal and lingual surfaces, respectively. At a radiographic measurement of 2mm (the cut-off level for screening of possible cases in this study), the corresponding values were 32.1% and 39.2% for buccal and lingual sites, respectively. Even at a radiographic reading of ≥ 5mm, clinical attachment level measurements of ≥ 3mm was observed only 84.2% and 89.2% of the time for buccal and lingual sites, respectively. These results indicate that approximately 12%-16% of the time, a radiographic reading of ≥ 5mm would correspond to clinical attachment level measurements of < 3mm.

III. Reliability Checks

A. Intra-examiner Reliability of the Preliminary Screening

A 5% intra-examiner reliability re-check of the preliminary screening yielded an intra-examiner reliability rate of 83.3% (Table 14) (based on 1872 pairs of radiographs examined in the prescreening). Therefore, the error rate for selecting possible cases based on visual screening alone was 16.7%. This result indicates that up to approximately 17% of those individuals examined radiographically may have been misclassified. The implication of this result is that potential possible cases may have been omitted by the use of the preliminary screening process. The result also indicated that the preliminary screening has limitations (using the criteria of bone loss ≥ 2mm from the CEJ) in
selecting previously selected possible cases. Therefore, a visual prescreening is not advocated for future investigations of this

B. **Intra-examiner Reliability of the Final Radiographic Screening**

An intra-examiner reliability check was performed on a randomly selected 51% (n = 52) of the 103 radiographs screened as possible cases from the final radiographic examination. The intra-examiner reliability agreement rate was found to be 100% based on bone loss > 2mm from the CEJ on at least one interproximal site on one first molar (Table 14). As stated in the methods and re-emphasized here, the agreement rate was based on case classification and not a site by site comparison. This result indicates that the ruler measurements were reliable with respect to classification of possible cases.

C. **Intra-examiner Reliability Check for the Follow-up Radiographic Assessments on Children Remaining in the Study**

A 51% recheck (n = 38) of the 75 pairs of radiographs assessed for bone levels at the three year follow-up period revealed an overall intra-examiner reliability rate of 74.4% based on a site by site comparison (Table 14). The remaining 25.6% of repeated measures were either above or below the original assessments. However, a 99.5% intra-examiner reliability rate was obtained when a range of ± 1mm was used to assess the duplicate measurements. This indicates that one fourth of the sites reassessed
were measured correctly to within $\pm 1$ mm. These results indicate nearly perfect agreement since the results fall within the measurement range (measured to the nearest millimeter) set forth in the methods section.

D. Intra-examiner Reliability of Radiographic Assessments on the Adult Population

Results of the 41% intra-examiner reliability check was performed by both examiners and are presented in Table 15. Examiner 1 (independent investigator) had an overall intra-examiner agreement rate of 55.1%. This value increased to 91.3% within a range of $\pm 1$ mm. Corresponding values for Examiner 2 (candidate) were found to be 69.1% and 94.1%. While these results indicate poor agreement for both examiners on a site by site comparison, they show excellent agreement (reliability) within a range of $\pm 1$ mm.

E. Inter-examiner Reliability Rate of Radiographic Assessment on the Adult Population

The inter-examiner reliability rate was calculated for radiographic assessments on the adult population and was found to be 51.2% on a site by site basis and was 87.9% within a measurement range of $\pm 1$ mm (Table 15). These results indicate good agreement within a range of $\pm 1$ mm, but poor agreement between examiners on a site by site comparison.
IV. Validity Check

A. Results of the Test of Validity of the Preliminary Screening as Measured by a Millimeter Ruler

A total of 100 pairs of bite-wing radiographs (70 non-cases and 30 possible cases) were measured with a transparent ruler. This sample (n = 70) represented a 3.7% random selection of those subjects classified as non-cases in the preliminary screening. Of the 70 non-cases (based on the preliminary screening), 63 were classified as non-cases (bone levels < 2mm from the CEJ) based on measurements with the transparent ruler, thus, the validity (accuracy) was 90%. This result indicates that 10% (n = 170) of non-cases from the preliminary screening were misclassified (see Table 16). The significance of this finding is that an additional (estimated) 170 subjects would have been contacted, requesting a clinical examination, if all radiographs had been measured with the ruler. Furthermore, applying the case yield rate of 2/43 clinical examinations to these subjects, 8 additional cases would have been expected. The actual number of cases was probably lower than that projected, however, the range of 2-10 defined the upper and lower limits for expected cases (based on the worse-case estimates above). The range described represents the two cases detected from the actual clinical examinations plus the 8 estimated cases.
V. Agreement Between Clinical and Radiographic Examinations in the Adolescent Population

The Kappa coefficient of agreement (coefficient of agreement between two imperfect measures) between the first-year and follow-up radiographic screening examinations regarding the classification of children as possible or definite JP cases was determined to be 0.49 (see Table 17). According to the criteria of Landis and Koch (1977) (< 0 = poor agreement and 1 = perfect agreement) for interpretation of Kappa, this value indicates moderate agreement between the two measures. Further, the result suggests that part of the agreement noted between the first year and follow-up radiographic measures resulted from chance alone. Kappa was also calculated for the association between the clinical examinations versus the first-year and follow-up radiographic assessments regarding their ability to detect possible or definite JP cases, and was found to be 0.66 and 0.78, respectively (Tables 18 and 19). These results indicate substantial agreement (less likely due to chance alone) between both the first-year and follow-up radiographic examinations with the clinical examination. The strongest agreement, however, was noted between the clinical examinations and the follow-up radiographs which were exposed approximately one to four weeks after the clinical examinations. This finding was consistent with the notion that clinical attachment loss precedes radiographic bone loss. Further, radiographic detection of bone loss appears to be dependent on the length of time between attachment loss and
radiographic exposures. Thus, it appears that radiographic bone loss reflects clinical attachment loss more accurately when radiographs are exposed several years subsequent to the finding of attachment loss. The exact length of time between attachment loss and bone loss could not be assessed in this investigation because both clinical and radiographic examinations were performed nearly cross-sectionally (approximately 1-4 weeks apart).

In contrast to the high agreement rate as indicated by Kappa values above, false positive rates for classification as possible or definite cases of JP for first and third year radiographs was high (98.7%) (Table 17). Corresponding values for both first and third year radiographs with clinical examinations were 95.3% (Table 18) and 94.1%, (Table 19), respectively. While these values do not represent a highly sensitive test, they do indicate that approximately 1/20 children presenting with radiographic bone loss interproximally on first molars >2mm from the CEJ on >1 tooth (classified as a possible case) would be expected to have clinical signs consistent with JP. Although this is not a high yield, given the seriousness of the disease process, the approach used in this investigation appears to be reasonable.
I. Prevalence Rate Based on Diagnosed Cases

A. Overall Prevalence

The present investigation was a prevalence study of juvenile periodontitis which consisted of examination of 1872 pairs of bite-wing radiographs of 10-12 year old children from the greater Worcester, Massachusetts area, followed by clinical examinations and follow-up radiographs three years later. Three cases of JP were observed (2 males and 1 female); thus, a prevalence rate of 1.6/1000 was detected. This finding represents the first reported JP prevalence rate for children of this age range. The result is in agreement with Kaslick et al. (1968a) who reported a rate of 1.5/1000 (0.15%) among 3897 military recruits 16-26 years old. Similar prevalence rates (1.0/1000) have been reported in descriptive studies by Saxen (1980b), Saxby (1984) and Kronauer et al. (1986). Although other authors have reported higher prevalence rates (Marshall-Day et al. 1949, Rao et al. 1968 and Barnett et al. 1982) (Table 1), the methodology used in these studies was not as rigorous as those with the lower prevalence rates. Thus, the observed prevalence rate of JP in this investigation was consistent with the most current and rigorously designed descriptive studies of JP.

A major concern that might have affected the prevalence of JP in this investigation was the fact that 57% (n = 55) of possible
cases identified from the preliminary radiographic screening were not examined. The parents either did not return the request forms or they refused to allow their child to be examined. Thus, if the case yield rate of 2/43 clinical examinations was applied to those not examined, approximately, three (2.6) additional cases of JP would have been expected. Although this is only an estimate, it illustrates the potential loss of cases of JP and the need for vigorous subject follow-up. While strenuous efforts were made to follow-up possible cases in this study, caution was exercised to minimize the possibility of subject harassment which could have jeopardized other ongoing investigations.

Another factor that may have affected the prevalence rate of JP was the young age range studied (10-12 year olds). Although it has been suggested that JP occurs sometime in the circumpubertal period, no prevalence information exists regarding this age range. Since it has been suggested that the severity of JP increases with age (Saxen 1985), it is probable that many individuals affected with the disease at this age would not yet manifest clinical or radiographic signs of the disease. Whether this is a real phenomenon cannot be substantiated by the current literature or the present investigation. Much larger longitudinal studies of JP beginning prior to the onset of puberty are needed to adequately address whether this is a real phenomenon or an isolated finding.
B. Race Prevalence, Sex Prevalence and Socioeconomic Status

1) Race Prevalence

Because only three cases of JP were detected in this study (2 whites and 1 Hispanic), it was not possible to make a statement about race prevalence that could be generalized to the entire population. Further, racial distribution of the population studied prohibited an adequately discussion of race prevalence. Additionally, since the population was predominantly white (>90%) the probability of detecting a case among non-whites was small. Therefore, a larger population base with a greater proportion of non-whites would be necessary to adequately address the issue of race prevalence rate of JP.

2) Sex Prevalence

The sex ratio for JP in this investigation was found to be 2:1 male to female (2 males and 1 female). While this finding was interesting, given that the ratio of males to females examined (n = 43) was 1:1.15 (23 females and 20 males), no sex analysis could be performed because too few cases were detected. As with race prevalence, a larger population base would be necessary to adequately discuss sex prevalence.
3) **Socioeconomic Status**

While it was possible to analyze data on SES, the fact that only three cases were detected in this investigation would provide little useful information about SES in the general population. A much larger population base with an SES distribution more representative of the general population would be necessary to address the issue of SES among JP cases. Perhaps one way to achieve this goal would be to design a multi-center study in which thousands of children are examined from different regions of the country. This method would increase the number of cases of JP detected and could provide a more diverse population base from which to generalize about the prevalence of JP by SES.

**II. The Method**

**A. Radiographic Examinations**

The two stage screening process used in this study (preliminary and final radiographic examinations) provided a useful way to quickly screen large numbers of radiographs for bone loss consistent with a diagnosis of JP. The details of the two radiographic examinations are discussed below.

1) **Preliminary Radiographic Screening**

The preliminary screening (visual examination only), though rapid, proved to be less reliable and accurate than the ruler
measurements in the final radiographic screening. Table 4 shows that the accuracy (validity) of the preliminary screening in detecting possible cases was 88% based on bone loss of ≥ 2mm from the CEJ. This finding indicates that 12% of all radiographs selected by this method were actually non-cases, thus, their inclusion in the clinical examinations would have increased the number of examinations necessary to detect a case of JP. Further, the result indicates that the preliminary radiographic screening (visual examination) tended to overestimate the amount of bone loss. The obvious effect of this type of error would be to increase the number of false positives examined. Since the effort in this investigation was to be more liberal in the classification of possible cases (including those with a small amount of bone loss), the examination of additional non-cases may not have been an unacceptable compromise if all the JP cases present were also included. Although the inclusion of false positives was never the goal of this investigation, it seemed to be a less important source of error than the exclusion of a single case of JP.

2) **Final Radiographic Screening**

In the final radiographic screening, a cut-off level of 2mm was selected for possible case inclusions because it has been suggested that the normal position of the crest of alveolar bone from the CEJ is 1mm in individuals without bone loss (Schei et al. 1959 and Rohner et al. 1983). In addition, other authors have
used a similar cut-off level (Saxen 1980a and 1980c, Gjermo et al. 1983 and Kronauer et al. 1986) for classification of JP. The measurement was not made directly from the crest of bone in this investigation because bone loss often presents as infrabony defects, thus, the crest may be several millimeters away from the most apical extent of the defect. Instead, measurements were made from the area of the PDL which remained constant in width throughout the remaining apical extent of its length. The rationale for the use of this technique in the present investigation was that it appeared to be less ambiguous than the alveolar crest measurement, thus, had the potential to yield more consistent results. The 2mm cut-off level was also selected because it was determined from the validity check of the preliminary screening that this was the smallest measurements from which consistent assessments could be made. Bone loss pattern (vertical versus horizontal) was purposely ignored in this assessment and all possible cases were determined solely on the presence or absence of bone loss > 2mm from the CEJ on at least one interproximal site of one permanent first molar. This was done to decrease the potential bias inherent in selecting radiographs for signs of JP based on the type of bone loss pattern. As an example, a site with 2mm of bone loss interproximally with a vertical component would more readily be considered consistent with a diagnosis of possible JP than a similar defect with no vertical component. Although it was not possible to totally eliminate this
type of error, it was probably lessened by strictly relying on actual measurements for classification.

3) **Highest Estimate (i.e. Worst-case scenario) For False Negatives Based on Theoretical Projections**

Table 8 presents the highest realistic and maximum projection of possible and JP cases based on the number of misclassified non-cases from the three year radiographic follow-up and preliminary radiographic screening. The maximum projection of JP cases \(n = 36\) represents the maximum number of cases expected based on the assumption that no non-cases (from the preliminary screening) were lost to follow-up. The highest realistic projection of cases \(n = 22\), as well as the maximum projection of cases were based on the results of measurement of a 22% sample of the actual number of non-cases available for follow-up \(n = 1031\) (Table 7). It should be noted that the projections for the maximum number of cases were also based on the same 22% sample, using the assumption that those who withdrew from the study were similar, with respect to radiographic and clinical findings at three years, to those remaining. Although this is generally not a safe assumption, for illustrative purposes, these theoretical projections were made. As can be seen in Table 8, the expected number of JP cases in the two projections vary from 22-36 (both with rates of 21.3/1000). This indicates that approximately 43% of the theoretically projected JP cases would have been lost to follow-up at three years.
Although it is useful to compare these two theoretical values, the highest realistic projection probably reflects more closely, the true withdrawal rate of subjects from epidemiological studies. These results graphically illustrate the potential loss of cases through subject withdrawal, therefore, it is crucial that elaborate mechanisms be designed to enhance subject retention. These could include such things as: offering subjects a monetary incentive for completion of the study, raffling off a gift at the end of the study, or providing some free service (i.e. dental care) at the end of the study.

B. Clinical Examinations

The cut-off level for the diagnosis of JP in the present investigation was set at 3mm of attachment loss (from the CEJ) on at least one interproximal first molar site. Three millimeters was selected because it was felt that this was abnormal attachment loss for a child in this age group. Other studies have noted pocket depths of > 5mm (Saxen 1980b and Saxby 1983) but this measurement is more difficult to reproduce than attachment levels.

A minimum of one tooth involved with attachment loss was selected because no good evidence exists to suggest that a minimum of more teeth was necessary for a diagnosis of JP. Although others have used as one criterion, the presence of at least two teeth to be diagnosed as JP (Homand and Frandsen 1979, Saxen 1980b and 1980c
and Saxby 1983), a one tooth minimum was used in the present study to avoid missing potential cases.

The results of this study revealed that the original selection criterion of $> 3$ mm of attachment loss was inadequate for the clinical diagnosis of JP. To illustrate, some of the children examined had sites with attachment loss measurements of $> 3$ mm, however, the amount of plaque and/or calculus and inflammation present appeared to be sufficient to cause the readings observed. In fact, those individuals with clinical JP, had interproximal probing depths on some sites (first molars) that ranged up to 10 mm, with 6-7 mm of attachment loss (attachment loss was measured on only one subject with JP). These results were clearly consistent with a diagnosis of JP and were different from all other sites examined. Therefore, in future studies, it might be more appropriate to change the criterion from $> 3$ mm to $> 5$ mm, including only those sites without overt inflammation (GI $> 2$). This change is significant because probing depths can increase with the increasing severity of tissue inflammation, thus, increasing the apparent attachment loss. Although changing the criterion would not have affected the results of this investigation, additional studies are needed to determine whether the change is appropriate.
C. Agreement Between Radiographic Bone Level and Clinical Attachment Level in the Adult Population

The exact millimeter agreement between the clinical attachment level and radiographic bone level was found to be 34.2% and 34.8% for buccal and lingual sites, respectively (Tables 9 and 10). This result indicates that radiographic bone level measurements are not good predictors of clinical attachment on an exact millimeter comparison, whether measured from the buccal or lingual sites. The agreement was fair at a measurement range of ± 1mm (76.6% and 75.9% for buccal and lingual sites, respectively), but was excellent at a range of ± 2mm (94.3% and 96.2% for buccal and lingual proximal sites, respectively) (Table 11). This result implies that a range exists within which radiographs can predict clinical attachment loss. As an example, Table 12 illustrates that at a radiographic bone level of 3mm, the attachment level was within ± 2mm 100% of the time. The significance of this observation is that ±2mm is the best measurement range. Thus, it appears that a range of < 2mm is inadequate to describe the difference in measurements observed between radiographic bone levels and clinical attachment levels. Further, it appears that radiographs underestimate the attachment level.

Applying these approximations to the adolescent population, a cut-off level of 2mm would be estimated to detect a clinical case of JP (originally set at 3mm loss of attachment) only 22%-24% of the time (Table 13). Thus, it appears that the potential for misclassification (i.e. increased false positive rate) of possi-
ble cases exists. A 1mm increase in the radiographic cut-off level (up to 3mm) would increase the potential to find individuals with clinical attachment loss to 60% (Table 13). While the potential yield of cases would be increased by the increased cut-off level, the number of children in this age range could meet this criteria is likely to be small. Therefore, larger populations would be necessary to find adequate numbers of subjects to study. In fact, one of the cases detected in this study (Figure 7) would have been missed using this cut-off level. The potential omission of this case using a higher cut-off level, strongly argues against a change in the present cut-off of level \( \geq 2\) mm of bone radiographically.

III. Sources of Measurement Error

A. Reliability Checks

1) Intra-examiner Reliability of the Preliminary Radiographic Screening

The intra-examiner reliability of the preliminary screening (visual examinations only) was calculated and found to be 83%, (Table 14). Although this value is not excellent, it is a good intra-examiner agreement rate. However, this result does indicate that potential possible cases (up to approximately 17%) of those determined to be non-cases, may have been misclassified and omitted from observation in the final radiographic screening. Misclassification is always of concern since it implies that a
few cases of JP may have also gone undetected. A possible explanation could be that visual measurements are imprecise and subject to change with repeated attempts. This error could have been enhanced by the fact that some radiographs had better contrast and overall film quality than others. Fatigue could have also played a role, as up to 200 sites of bitewings were sometimes assessed in a single measurement period. Finally, the overall implication of this assessment is that visual inspections alone is not reliable enough to assess bone loss.

While the intra-examiner reliability rate of the preliminary screening was not excellent (83%), the methodology of investigation was unaltered because it was not certain whether the intra-examiner reliability rate of the final radiographic screening would be higher. Thus, the study continued as designed with the recognition of the fact that some limitations would exist regarding ability to interpret the results because of the potential misclassification of 17% of the possible cases.

2) Intra-examiner Reliability of Final Radiographic Screening

The final radiographic screening was based on the criteria of $>2$ mm as measured with a transparent ruler calibrated in millimeters. A random 5% sample ($n = 52$) of the 103 possible cases and an equal number of non-cases (as masks) were re-examined and the intra-examiner reliability rate was found to be 100% (Table 14). The interpretation of this finding is that standard criteria of $>
2mm as measured by a ruler to determine possible and non-cases yielded consistent results in classification. As stated in the methods and re-emphasized here, the agreement rate was based on case classification and not on an exact millimeter site by site basis. Although 100% agreement on an exact millimeter measurement comparison would have been the ideal result, a range of ± 1mm seems practical since it is nearly impossible to be in 100% agreement on all sites when exact millimeter measurements are required. The intra-examiner reliability rate of the three year follow-up radiographic screening was also assessed by millimeter ruler measurements and is discussed below.

3) Intra-examiner Reliability for the Three-Year Follow-up Radiographs

The overall intra-examiner reliability for measuring the follow-up radiographs was found to be 74.4% (Table 14) based on an exact millimeter comparison, but was 99.5% when measured within a range of ± 1mm. This result indicates that the method had excellent reproducibility within a range of ± 1mm but was less accurate on an exact millimeter basis. Although smaller differences in intra-examiner reliability have been reported (Rosling et al 1975, and Ryden and Eliasson 1982), the instruments used were more complex and cumbersome and measured bone loss to within 1/10 to 1/100mm (versus to the nearest millimeter as in this investigation).
The results of this investigation were within the error range of the method, i.e., all assessments were determined to the next highest millimeter. Therefore, small errors in the placement of the ruler from one measurement to the next could have easily resulted in the measurement error observed. Further, since all measurements were rounded up to the nearest millimeter to avoid fractions of millimeters, a small change in a measurement in either direction would mean the addition or loss of 1 mm. As an example, a measurement that was slightly less than 3 mm (rounded up to 3 mm) would be rounded to 4 mm if the placement error caused a reading of slightly greater than 3 mm. Conversely, a 2 mm reading could be obtained if the ruler was positioned at 2 mm or slightly less.

The problems stated above appear to be inherent in radiographic assessments, since small fluctuations in exposure or development technique could change the quality of the image. These changes could complicate the placement of the ruler in a reproducible position. Standardization of the exposure and developing techniques would decrease the amount of variability between each radiograph, but would not correct for differences in radiographic density associated with varying degrees of alveolar bone loss. For example, infrabony defects located infraapproximately, would appear less radiodense than similar areas with horizontal bone loss. Because strict standardization of radiographic techniques is difficult to accomplish under the best of circumstances (Bassiouny and Grant 1976 and Rosling et al. 1975), i.e., requir-
ing splints or precision instruments to assist in film placement (leading to increased time and expense), it would probably not be feasible in large epidemiological investigations including thousands of subjects. Pilot studies may be necessary to estimate the additional time and expense necessary to incorporate these types of changes into radiographic surveys.

An alternative to the above suggestions would be to examine a large group of individuals radiographically, followed by a clinical examination to assess the level of disease. Comparison of the results of the two separate examinations would give an indication of the usefulness of radiographs in assessing periodontal disease levels. Additional methods, such as precision instruments and custom designed splints could be compared to the technique outlined in this manuscript. The usefulness of the alternative methods could then be determined by whether there was a significantly decreased measurement error when compared to current techniques. This must also be weighed against the relative cost for the increase in precision or yield of additional cases of disease. These are difficult problems to address, but offer new areas for further research.

4) Intra-examiner Reliability For the Adult Radiographic Assessments

Table 15 shows that the intra-examiner reliability rate for the assessments of radiographs of the adult population was poor on exact millimeter comparison for both examiners (55% for examiner
1 and 69% for examiner 2). However, the agreement was excellent for both examiners when a range of ± 1mm (91% and 94%, for examiner 1 and 2, respectively). This result indicates that the measurement error was confined to the range set forth in the methods section (measurements were rounded up to the nearest millimeter).

The finding that both examiners were reliable to within ±1mm indicates that the measurement technique was easy to use and required little training. In fact, no calibration or training sessions were held for examiner 1 (independent investigator) who was given only the measurement and exclusion criteria listed in the methods section.

5) **Inter-examiner Reliability for the Adult Radiographic Assessments**

The inter-examiner reliability for radiographic assessments on the adult population, like the intra-examiner reliability was found to be poor (51%) on an exact millimeter comparison. However, approximately 88% of all sites measured were within a range of ±1mm. This result was surprising since no calibration or training sessions were held between the examiners. This further indicates that the radiographic technique used in this investigation was reliable between examiners. Thus, it appears that with training, investigators could achieve and maintain even higher inter-examiner agreement rates.
B. Validity of the Preliminary Radiographic Screening

The validity of the preliminary radiographic examination in selecting non-cases (based on all sites $\leq 1\text{mm}$) was found to be 90% (Table 16), thus, up to 10% of the non-cases ($n = 1702$) selected by this method were actually possible cases. Based on this estimate, 170 possible cases were misclassified, resulting in an additional 8 expected JP cases (based on a case yield rate of 2/43 clinical examinations performed). However, since evidence shows that approximately 50% of subjects would not have consented to clinical examinations, only 4 cases would have been expected. Thus, the magnitude of the 10% error in misclassification was great, considering that the number of cases expected exceeds the number actually observed in this investigation ($n = 3$). Although the actual number of cases was probably smaller than that projected, the potential cases lost due to the 10% error rate is too great given the apparent rarity of JP. Further, since the intra-examiner error rate for the final radiographic screening (radiographs measured) was 100%, the actual time saved by performing the preliminary screening appeared to be insignificant compared to the number of potential cases lost by this technique. Thus, it appears that all radiographs should be measured to minimize the number of potential cases lost due to the error inherent in visual radiographic assessments. Additionally, the amount of time actually saved by an initial visual screening (preliminary screening) seems trivial (approximately 10-12 BW sets per hour faster) compared to the potential loss of a single case of JP.
To facilitate the assessment of large numbers of radiographs, an assistant could be trained and calibrated by the investigator. The assistant and investigator could then, independently, assess a proportion of the total number of radiographs with provisions made to periodically assess intra-examiner and inter-examiner reliability. Intra-examiner reliability could be facilitated by each investigator re-measuring 5% of the radiographs that they previously assessed. The inter-examiner reliability check could be determined by the assistant and investigator independently assessing the same 5% random sample of radiographs. Finally, the error in misclassification would become even more important in large epidemiological studies, as the number of missed cases could escalate rapidly.

C. Summary of the Methodology of Radiographic and Clinical Examinations of the Adolescent Population

The major improvement of the present investigation over most of those reported to date is that subjects exhibiting incipient bone loss (bone loss $\geq 2$mm from the CEJ) were followed cross-sectionally for three years and examined at the end of that period. The advantage of this technique was obvious from the fact that two of the three cases of JP detected were classified only as possible JP cases during the preliminary and final radiographic screening at year one. Although, both cases were classified as definite JP radiographically (at year three) only one of them was confirmed clinically. This technique is not unique,
since Saxen (1980b) used a waiting period of from six months to two years to confirm the radiographic and clinical diagnosis of JP. However, Saxen (1980b) but did not report the development of new cases within that time period. Whether the two cases detected during the three-year follow-up period had clinically detectable JP at the time of the preliminary screening cannot be answered by this investigation, since no clinical examinations were performed at that time. It is clear, however, that these two cases (designated as possible cases in the preliminary and final radiographic screenings) would not have been confirmed had the follow-up radiographic and/or clinical examination not been performed. While the three year delay between radiographic exposure and clinical examinations resulted from unexpected logistic difficulties in organization and implementation of the investigation, it was fortuitous since it allowed confirmation of suspected cases. Thus, it appears that children in this age range (10-12 year olds) who exhibit incipient bone loss on first molar sites should be followed closely for development of radiographic and clinical signs consistent with a diagnosis of JP.

The high false positive rates found for classification of definite and non-cases based on radiographic and clinical examinations (Tables 17-19) reveal that approximately 1/20 possible JP cases examined would be expected to have clinical JP. While this is not a high yield, the seriousness of the sequelae of the disease, i.e. loss of teeth, indicates that the criteria and methods used in this investigation were reasonable.
CONCLUSIONS

1) In a population of 1872 volunteer 10-12 year old children, the prevalence rate for juvenile periodontitis was found to be 1.6/1000 (3 cases).

2) The false positive rates for determining possible and definite cases of JP by comparing x-ray (first and third year) and clinical (year-three) diagnoses were found to be high.

3) The high agreement between radiographic and clinical assessments in the adult population indicates that the method is suitable for screening children for juvenile periodontitis.

4) The ability of radiographic bone levels to predict clinical attachment levels was found to be poor on an exact millimeter measurement comparison, but was excellent within a range of ± 2mm.

5) The intra-examiner reliability rate for measuring ≥ 2mm of bone loss from the CEJ with a millimeter ruler was high within a range of ± 1mm for both a trained and untrained examiner.

6) The inter-examiner reliability rate for measuring ≥ 2mm of bone loss from the CEJ was found to be high within a range of ± 1mm.

7) The prevalence of juvenile periodontitis by race, sex and socioeconomic status could not be determined in this investigation due to an inadequate number of cases.

8) Based on the results of this investigation and reports from the literature, the following protocol for a diagnosis of juvenile periodontitis in 10-12 year children is recommended:

   1. disease present in a systemically healthy adolescent, less than 21 years of age;
   2. ≥ 1 permanent first molar involved;
   3. radiographic bone loss ≥2mm from the CEJ, measured to the area of the PDL that remains constant in width throughout its apical extent; and
   4. clinical attachment loss of ≥ 5mm with no local factors, i.e. overhanging restorations, orthodontic appliances or trauma to explain the findings.
9) Adolescents in the 10-12 year age range who exhibit minimal bone loss radiographically (bone levels \( \geq 2 \text{mm} \) from the CEJ) can progress to juvenile periodontitis and should be monitored for development of radiographic and clinical signs consistent with a diagnosis of juvenile periodontitis.
FUTURE STUDIES

Because of the lack of good epidemiological data on the prevalence of juvenile periodontitis, additional descriptive studies on large populations of adolescents should be conducted. The results of the present investigation indicate that an appropriate target population is the 10-12 year old age group. Further, information from follow-up assessments of these children show that progression of bone loss can occur in some children with incipient bone loss. Prior to this investigation the literature has focused primarily on JP in the 13-16 year old age range. While prevalence rates could be established for this age range, massive bone and attachment loss may have already occurred prior to detection. Thus, it would be interesting to follow large groups of 10-12 year olds for 5-10 years with yearly examinations to assess the incidence of juvenile periodontitis. It might be necessary to establish multiple study centers to obtain adequate numbers of children of the appropriate age group.

Another appropriate age group for future study appears to be 6-10 year olds. Since the present investigation has demonstrated the presence of JP in 10-12 year olds at similar prevalence rates (1.6/1000) as in 13-16 year olds (approximately 1.0/1000), it would seem logical to study even younger children to establish the youngest age range in which JP can be detected. As with 10-12 year old children, the population size requirement for study
would be extremely large due to the apparently low prevalence rate of the disease process. Multiple study sites nation-wide may need to be established to obtain a large, diverse population with respect to race, sex and socioeconomic status.

Future investigations should be of the case-control type to assess whether race, sex and socioeconomic status are risk factors for the development of juvenile periodontitis. These studies are preferable to descriptive studies for establishing causation because the investigator can obtain better control of the independent variables which might affect disease outcome. These studies might also shed light on the theory that hereditary factors play a role in the susceptibility of individuals to juvenile periodontitis. Additionally, the microbiological and immunological aspects of the disease could be more adequately addressed.

While case-control studies are preferable to descriptive studies for testing hypotheses, they are probably not the next logical step for studying JP since the epidemiological data base at present is confusing and incomplete. The results of this study and the supporting strength provided by the literature cited in this manuscript, suggests that the next logical step is to conduct more thorough descriptive epidemiological studies based upon a universally applied case-definition focused on pre-pubertal and post-pubertal adolescent age groups.
REFERENCES


World Workshop in Periodontics, Ann Arbor, Michigan 1966
Dear [Name]:

Examination of the x-rays taken in 1984 on children in your school as part of the Worcester Preventive Dentifrice Study, revealed that [Name] had signs of periodontal disease (gum disease). This type of disease is called Juvenile Periodontitis because it affects young children and adolescents. This finding can only be confirmed by a clinical examination. The disease is not life threatening but can lead to the rapid loss of teeth if left untreated. The cause of the disease is unknown at this time.

To determine whether this child has Juvenile Periodontitis or one of the other forms of periodontal disease, it is important that he/she be examined by a dentist. I am suggesting to the parent that they be examined either by their own dentist or by one of us. The parent will let you know which option they prefer. I am requesting permission to examine [Name] in your school should the parent agree. The examination would take approximately 20 minutes and pose no disruption to the operation of normal school activity beyond the 20 minute examination for the student. The clinical examination will be conducted by a graduate student in the field of periodontology (Dr. Neely) under my (Dr. Ralph Katz) direct supervision.

All equipment, supplies and personnel needed for the examination will be supplied by me. No cost will be incurred by your school, the student or his/her family. A request has been enclosed in this packet as well as letters and request forms to be sent to the child's parent(s). Because the data from the dentifrice trial originated in your school system, I would like to: a) inform you of my preliminary findings; b) receive permission to examine the child in school after obtaining parental permission to examine their child.

Please send one copy of the enclosed letter (labelled A), consent form (labelled B) and the self-addressed stamped envelope provided, home to the child's parent(s) in the yellow folder.
Appendix A-1 Continued

provided (labelled C). Please note that items A and B have already been placed in the envelope (C) to facilitate ease of distribution.

If you have any specific questions regarding any aspects of the disease or the study please contact me at (203) 674-2363 or write to the address on the envelope.

Thank you for your kind assistance in this important matter.

Sincerely,

Ralph V. Katz, D.M.D., Ph.D.
Form For Consent to Conduct Examinations in the Child's School

I __________________________ grant Dr. Ralph Katz and associates permission to conduct a study on the prevalence of Juvenile Periodontitis in ____________ School. I understand that the study involves examining children suspected of having Juvenile Periodontitis. I also understand that all exams will be performed by Dr. Katz and associates and involves none of the school's staff or officials. I further understand that there will be no cost to either the school, parent or child.

I understand that all information obtained in this study will be kept in the strictest of confidence and reported in aggregate form only in any publications which result from this study. No individuals will be identified in any publications.

I the undersigned have read and understand all aspects of this study and freely grant permission.

NAME __________________________ DATE __________________________
Dear __________________________

It has come to my attention during an examination of x-rays from children in the Worcester fluoride toothpaste study being conducted by the School of Dental Medicine at the University of Connecticut, in Farmington, Connecticut, that _______ has evidence of periodontal disease (gum disease). One form of the disease is called Juvenile Periodontitis because it affects young children and adolescents. Since a diagnosis cannot be made from x-rays alone, a clinical examination is required for a definitive diagnosis. The disease, if left untreated, often leads to the premature loss of the affected teeth.

Presently, we are conducting a study to try to find out how many children are affected with this disease and why. The study is being conducted by the University of Connecticut School of Dental Medicine in Farmington, Connecticut. Attached is a consent form requesting permission to examine ______________ for Juvenile Periodontitis in your child's school.

Treatment methods are available for this disease even though the cause is still unknown. The best chance to treat this disease successfully is to detect it early and begin appropriate therapy. The results of this examination will be made available to you immediately following the examination. At your request I will make the results of this examination known to your dentist. Please read the permission form, sign it and return it to me in the enclosed, self-addressed, stamped envelope. There will be no charge to you for this examination.

While I would be pleased to provide your child with this examination in your child's school and to immediately inform you of the results, you may, of course, elect to have your child examined by your own family dentist. If you do prefer to have your family dentist examine your child, would you please indicate that preference in the appropriate space on the enclosed form and return this form to me.
If you have any questions about the disease or wish to confer with me, please feel free to contact me at (203) 674-2649 or at the address on the envelope.

Thank you for your kind attention to this very important matter.

Sincerely,

Ralph V. Katz, D.M.D., Ph.D.
Appendix A-4

Initial Contact Letter Sent To Parents of Children Who were not Presently in the Fluoride Dentifrice Trial

Dear _______________________

It has come to my attention during an examination of x-rays taken on your child approximately two years ago during the screening examination for the fluoride toothpaste study conducted by the University of Connecticut School of Dental Medicine in Farmington, Connecticut, that has evidence of periodontal disease (gum disease). One form of the disease is called Juvenile Periodontitis because it affects young children and adolescents. Since a diagnosis cannot be made from x-rays alone, a clinical examination is required for a definitive diagnosis. The disease, if left untreated, often leads to the premature loss of the affected teeth. Therefore, an examination by a dentist is essential.

Presently, we are conducting a study to try to find out how many children are affected with this disease and why. The study is being conducted by the University of Connecticut School of Dental Medicine in Farmington, Connecticut. Attached is a consent form requesting permission to examine _______________ for Juvenile Periodontitis in your child's school.

Treatment methods are available for this disease even though the cause is still unknown. The best chance to treat this disease successfully is to detect it early and begin appropriate therapy. The results of this examination will be made available to you immediately following the examination. At your request I will make the results of this examination known to your dentist. Please read the permission form, sign it and return it to me in the enclosed, self-addressed, stamped envelope. There will be no charge to you for this examination.
Appendix A-4 Continued

Though your child is not a participant in the fluoride toothpaste study I would be pleased to provide your child with this examination in your child's school and to immediately inform you of the results. You may, of course, elect to have your child examined by your own family dentist. If you do prefer to have your family dentist examine your child, would you please indicate that preference in the appropriate space on the enclosed form and return this form to me.

If you have any questions about the disease or wish to confer with me, please feel free to contact me at (203) 674-2649 or at the address on the envelope.

Thank you for your kind attention to this very important matter.

Sincerely,

Ralph V. Katz, D.M.D., Ph.D.
Appendix A-5

Form For Informed Consent Sent to Parents For Performing a Clinical Exam

I/we __________________________ give permission to Dr. Ralph Katz and associates to examine ______________________ at _________ at no cost to me/us for possible Juvenile Periodontitis. I/we realize that the exam consists of examining the oral cavity, teeth and gums and that no treatment of any kind will be performed. I/we also realize that questions regarding __________________ medical and dental history, as well as dental histories of other family members will be asked. Furthermore, all information will be held in the strictest of confidence and no names will be mentioned in any publication resulting from information obtained from this study.

I/we understand that no obligations to have any treatment performed exists if I/we allow ______________ to participate in this study. I/we also understand that participation in this examination is voluntary and refusal in no way affects my/our child's participation in the fluoride dentifrice trial.

Signature of parent __________________________ Date ______________

Signature of child __________________________ Date ______________

NOTE: SIGNATURE OF CHILD AND PARENT IS REQUIRED FOR US TO CONDUCT OUR EXAMINATION.
Appendix A-6

Health Questionnaire Mailed to Parents Of Child With Possible JP

Health Questionnaire

Name
Home address
Phone number

Does your child have a history of rheumatic fever

Does your child have a history of rheumatic heart disease

Does your child have a history of arterio-venous shunts

Does your child have a history of false joints or limbs

Does your child have a history of delayed or prolonged bleeding

Does your child have a history of healing problems

Does your child have a history of diabetes

If yes, what was the age at first diagnosis

What type of diabetes does your child have

What medications are being taken to control it

How well controlled is the diabetes

Is there a family history of diabetes

Relationship of affected person to child

Age of first diagnosis

Type of diabetes this person has

How well controlled is the condition

Does your child currently take medications

What are the medications

Does your child have a history of past medications

What were these medications

Is there a history of past hospitalizations

What were the hospitalization(s) for

Is there a history of antibiotic use greater than two weeks/year in any one year

Is there a history of treatment for gum disease

If yes, what was the treatment rendered

Was the problem resolved

Is there a history of permanent tooth loss in child

Was the loss due to decay (cavities)

Was the loss due to gum disease

At what age did the loss occur

Is there a history of parental permanent tooth loss

Is there a history of parental permanent tooth removal for gum disease

If yes, at what age did loss occur

If not, what was the reason for the loss
Appendix A-6 Continued

Is there a history of parental treatment for gum disease Y N
  If yes, at what age did treatment occur ________________
  What type of treatment was rendered ________________

Is there a history of sibling treatment for gum disease Y N
  If yes, at what age ________________
  Type of procedure rendered ________________

Is there a history of sibling permanent tooth loss Y N
  If yes, at what age did loss occur ________________
  What was the reason for the tooth loss ________________
Dear ____________________________

Recently you received a letter informing you that x-ray evidence from x-rays taken on ___________________ approximately two years ago for entrance into the fluoride dentifrice trial conducted by the University of Connecticut School of Dental Medicine, showed some bone loss around at least one permanent first molar. That letter also mentioned that the x-ray evidence only suggested the possible presence of Juvenile Periodontitis. Please understand that the letter did not indicate the presence of the condition, but stated only that some bone loss was noted and that a thorough dental examination was recommended.

Since we did not receive a request from you to examine your child in his/her school, we trust that you have sought this examination with your private dentist.

Thank you for your attention to this matter.

Sincerely,

Anthony L. Neely, D.D.S.

Ralph V. Katz, D.M.D., Ph.D.
Appendix A-8

Letter Sent to Parents of Child Clinically Diagnosed With JP

Dear ____________________:

We have examined ______________ carefully and found evidence to confirm that ______________ does have Juvenile Periodontitis. Both x-ray and clinical examination confirm the diagnosis.

This disease is not life threatening but can lead to loss of the teeth that are affected with the disease. There are treatments available, but it is important that this treatment begin immediately. If treatment is not received, early loss of teeth may result. It is for this reason that we are recommending that ______________ see your dentist as soon as possible. The sooner treatment begins the better the chances of curing the disease.

We hope that this information is helpful for you. We would like to send these findings to your dentist so that he can assist you in obtaining treatment for this disease. At your request we will inform your dentist of these findings.

We would like to take this time to thank you for your kind participation and cooperation in this study. Your assistance has been extremely valuable in making this study a success. Please remember that you may contact us at any time at (203) 674-2363 or 674-2469 or at the address on this envelope.

Thank you for your kind participation and cooperation.

Sincerely,

__________________________

Anthony L. Neely D.D.S.

__________________________

Ralph V. Katz, D.M.D., Ph.D.
Letter Sent to Parent of Unaffected Child

Dear __________________:

We have examined __________________ carefully and found no evidence to indicate that __________________ has Juvenile Periodontitis. The evidence seen on the x-rays was not confirmed by the clinical examination.

Though __________________ did not have Juvenile Periodontitis, we recommend that he/she see your dentist for the treatment of __________________ that was noted on examination.

We would like to take this time to thank you for allowing your child to participate in this important study.

Thank you again for your kind participation and cooperation.

Sincerely,

______________________________
Anthony L. Neely D.D.S.

______________________________
Ralph V. Katz, D.M.D., Ph.D.
Appendix A-10

Letter Sent to Parent of Child Diagnosed With Radiographic JP

Dear___________________:

We have carefully examined the three-year follow-up x-rays taken on____________ for the fluoride dentifrice trial and found evidence to strongly suggest that ______________ may have Juvenile Periodontitis. A clinical examination by a dentist is necessary to confirm the diagnosis.

This disease is not life threatening but can lead to loss of the teeth that are affected with the disease. There are treatments available, but it is important that this treatment begin immediately. If treatment is not received, early loss of teeth may result. It is for this reason that we are recommending that ______________ see your dentist as soon as possible. The sooner treatment begins the better the chances of curing the disease.

We hope that this information is helpful for you. We would like to send these findings to your dentist so that he can assist you in obtaining appropriate treatment for this condition. At your request we will inform your dentist of these findings.

We would like to take this time to thank you for your kind participation and cooperation in this study. Your assistance has been extremely valuable in making this study a success. Please remember that you may contact us at any time at (203) 674-2363 or 674-2469 or at the address on this envelope.

Thank you for your kind participation and cooperation.

Sincerely,

Anthony L. Neely D.D.S.

Ralph V. Katz, D.M.D., Ph.D.
Appendix A-II

Verbal Consent Form Asked Patients Treated in the Periodontology Clinic

A study is being conducted by Dr. Anthony Neely to find out how well x-ray findings and clinical findings correlate to each other in measuring the progression of periodontal disease.

We would like you to participate in this study. There is nothing special for you to do, or forms for you to fill out. The examination consists of measuring the pocket depths around your four first molar teeth, then examining your x-rays to compare them with the clinical measurements. Both these procedures are done routinely as part of normal treatment and poses no health risks to you.

Participation in this study is completely voluntary. Refusal to participate in no way affects the rendering of treatment to you here or in any other clinic in this institution.

Any information derived from this study that may be published will not contain any names of individuals. The information from this study will be used for statistical analysis only.
### Table 1

**Major Features of Descriptive Epidemiological Studies**

<table>
<thead>
<tr>
<th>Prevalence Rate/1000</th>
<th>Sample Size</th>
<th># Cases</th>
<th>M:F Ratio</th>
<th>Familial Pattern</th>
<th>Age Range</th>
<th>Minimum # Pocket Depth</th>
<th>Minimum # Teeth</th>
<th>Clinical Diagnosis</th>
<th>Radiographic Diagnosis</th>
<th>Reference</th>
<th>Year</th>
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<td>&quot;</td>
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<td>+</td>
<td>+</td>
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Table 2

Major Features of Case Reports

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<th>Minimum Pocket Depth</th>
<th>Minimum # Teeth for Diagnosis</th>
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<th>Year</th>
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<td>Age Range</td>
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<td>Minimum # Teeth for Diagnosis</td>
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<td>16-26</td>
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<td>-</td>
<td>-</td>
<td>+</td>
<td>Risom et al 1985</td>
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Table 3

Interpretability (Readability) of Radiographic Sites From the 1819 Pairs of Bitewings in the Preliminary Radiographic Screening

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<thead>
<tr>
<th>Tooth</th>
<th>Surface</th>
<th>Mesial (n)</th>
<th>Distal (n)</th>
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<tr>
<td>All</td>
<td></td>
<td>67.6% (4916)</td>
<td>38.4% (2797)</td>
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<tr>
<td>16</td>
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<td>69.2% (1259)</td>
<td>26.6% (484)</td>
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<td>26</td>
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<td>63.3% (1152)</td>
<td>24.9% (453)</td>
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<td>36</td>
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<td>68.3% (1243)</td>
<td>50.1% (912)</td>
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<td>46</td>
<td></td>
<td>69.4% (1262)</td>
<td>52.1% (948)</td>
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Percentages were based on a total of 14,552 sites, with 1819 measurements observed for each of the 8 sites.
Table 4

Identification of Traceable Possible Cases: Subject Flow From the Preliminary Radiographic Screening to Non-traceable

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<thead>
<tr>
<th>Status of Radiographs</th>
<th>Number of Subjects (%)</th>
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<tr>
<td>Preliminary Radiographic Screening (visual only)</td>
<td>1872</td>
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<tr>
<td>Not Entering the Final Radiographic Screening</td>
<td>1755 (94)</td>
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<td>Entered Final Radiographic Screening</td>
<td>117 (6)</td>
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<tr>
<td>Non-cases</td>
<td>14 (12)</td>
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<td>Possible Cases</td>
<td>103 (88)</td>
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<td>Non-traceable Subjects</td>
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<td>Traceable Subjects</td>
<td>99 (96)</td>
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Table 5

Identification of Diagnosed Cases: Flow From Requests Mailed Through the Clinical Examinations

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<th>Subject Status</th>
<th>Number of Subjects (%)</th>
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</tr>
<tr>
<td>Non-respondents</td>
<td>53 (54)</td>
</tr>
<tr>
<td>Respondents</td>
<td>46 (46)</td>
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<tr>
<td>Positive Respondents</td>
<td>43* (93)</td>
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<tr>
<td>Negative Respondents</td>
<td>3 (7)</td>
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<tr>
<td>Examined Clinically</td>
<td>43* (100)</td>
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<tr>
<td>Non-cases</td>
<td>41 (98)</td>
</tr>
<tr>
<td>Juvenile Periodontitis</td>
<td>2 (2)</td>
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* Response of one child was received through Boston University School of Dental Medicine, not the parent. The diagnosis of clinical JP was made during that examination and confirmed radiographically at the University of Connecticut School of Dental Medicine.
Table 6

Identification of Diagnosed Cases: Final Results Including Three-year Follow-up Radiographic Examination

<table>
<thead>
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<th>Status of Radiographs</th>
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<td>Prescreened Possible Cases with Traceable Addresses</td>
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<tr>
<td>Radiographs Available for 3 Year Follow-up</td>
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<td>Age, Sex, School Matched Control Children</td>
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<td>Final Diagnosed Cases of JP</td>
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<td>Confirmation of Previously Diagnosed Cases</td>
<td>2</td>
</tr>
<tr>
<td>Newly Diagnosed Radiographic Cases</td>
<td>1</td>
</tr>
</tbody>
</table>

* The percentage was based on the total number of subjects in the preliminary radiographic screening (n = 1872).
Table 7

Findings of the Radiographic Criteria Based on a 22% Sample of Non-case Radiographs available at Year-three

<table>
<thead>
<tr>
<th>Status of Radiographs</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Radiographs Present at Three Years</td>
<td>1106 (59%)</td>
</tr>
<tr>
<td>Possible Cases at Three Years</td>
<td>75 (7%)</td>
</tr>
<tr>
<td>Non-cases at Three Years</td>
<td>1031 (93%)</td>
</tr>
<tr>
<td>II. Randomly selected Non-cases</td>
<td>221 (22%)</td>
</tr>
<tr>
<td>Exhibiting Bone Loss ≥ 2mm</td>
<td>124 (56%)</td>
</tr>
<tr>
<td>Exhibiting Bone Loss &lt; 2mm</td>
<td>97 (44%)</td>
</tr>
<tr>
<td>III. Adjustment of Possible Cases</td>
<td>112 (46%)</td>
</tr>
<tr>
<td>(10% error correction from prescreening)</td>
<td></td>
</tr>
<tr>
<td>IV. Estimated Possible Cases at Three Years</td>
<td>474</td>
</tr>
<tr>
<td>V. Estimated JP Cases</td>
<td>22</td>
</tr>
<tr>
<td>VI. Estimated JP Cases/1000</td>
<td>21.3</td>
</tr>
</tbody>
</table>

Note: For further explanations of the derivation of these estimates, see Legend next page.
### Table 7 Continued

#### Legend

1. **I** = The number of radiographs from the initial prescreening that were present at the three-year follow-up period.

2. **II** = Those radiographs determined to be non-cases (based on the preliminary screening) that were randomly selected to be measured with a ruler.

3. **III** = Adjustment made for the 10% intra-examiner error rate determined from the preliminary radiographic screening (see Table 16). Ten percent of the non-cases were estimated to be possible cases, therefore, they were eliminated from the analysis.

4. **IV** = The estimated number of possible cases based on a sample of the population remaining in the study at the follow-up.

5. **V** = The estimated number of JP cases missed based on a case yield rate of 2/43 clinical examinations performed.

6. **VI** = The estimated number of JP cases missed expressed as a rate/1000 non-case subjects present in the study at three years.
Table 8

Maximum and Realistic Estimate of JP Cases: A Theoretical Projection

<table>
<thead>
<tr>
<th>Theoretical Diagnosis</th>
<th>Highest Realistic Projection*</th>
<th>Maximum Projection**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Possible JP Cases</td>
<td>474</td>
<td>783</td>
</tr>
<tr>
<td>Estimated JP Cases</td>
<td>22</td>
<td>36</td>
</tr>
<tr>
<td>Estimated JP Cases/1000</td>
<td>21.3</td>
<td>21.3</td>
</tr>
</tbody>
</table>

* Based on the 1031 previously determined non-case subjects who had radiographs present at the three-year point (incorporating the actual loss of subjects over three years).

** Based on the 1755 non-case subjects in the preliminary radiographic screening (assuming no loss to follow-up).
Table 9

Radiographic Bone Level Measurements Versus Clinical Attachment Level Measurements For All Buccal Proximal Sites For the Adult Population

<table>
<thead>
<tr>
<th>Radiographic Measurements</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>&gt;5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>(56.0)</td>
<td>(20.0)</td>
<td>(20.0)</td>
<td>(0)</td>
<td>(4.0)</td>
<td>(15.8)</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>20</td>
<td>10</td>
<td>4</td>
<td>3</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>(30.2)</td>
<td>(37.7)</td>
<td>(18.9)</td>
<td>(7.5)</td>
<td>(5.7)</td>
<td>(33.5)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>13</td>
<td>4</td>
<td>6</td>
<td>11</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>(2.9)</td>
<td>(37.1)</td>
<td>(11.4)</td>
<td>(17.1)</td>
<td>(31.4)</td>
<td>(22.2)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>6</td>
<td>1</td>
<td>5</td>
<td>12</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>(7.7)</td>
<td>(23.1)</td>
<td>(3.8)</td>
<td>(19.2)</td>
<td>(46.2)</td>
<td>(16.5)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>11</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>(5.3)</td>
<td>(10.5)</td>
<td>(5.3)</td>
<td>(21.1)</td>
<td>(57.9)</td>
<td>(12.0)</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>44</td>
<td>29</td>
<td>11</td>
<td>46</td>
<td>158</td>
</tr>
<tr>
<td></td>
<td>(21.5)</td>
<td>(29.1)</td>
<td>(13.3)</td>
<td>(12.0)</td>
<td>(24.1)</td>
<td>(100)</td>
</tr>
</tbody>
</table>
Table 10

Radiographic Bone Level Measurements Versus Clinical Attachment Level Measurements For All Lingual Proximal Sites In the Adult Population

<table>
<thead>
<tr>
<th>Radiographic Measurements</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>&gt;5 Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11</td>
<td>10</td>
<td>5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(40.7)</td>
<td>(37.0)</td>
<td>(18.5)</td>
<td>(0)</td>
<td>(3.7)</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>22</td>
<td>11</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>(17.6)</td>
<td>(43.1)</td>
<td>(21.6)</td>
<td>(3.9)</td>
<td>(13.7)</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>(17.1)</td>
<td>(22.9)</td>
<td>(17.1)</td>
<td>(20.0)</td>
<td>(22.9)</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>(7.7)</td>
<td>(7.7)</td>
<td>(15.4)</td>
<td>(7.7)</td>
<td>(61.5)</td>
</tr>
<tr>
<td>&gt;5</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>(0)</td>
<td>(10.5)</td>
<td>(15.8)</td>
<td>(0)</td>
<td>(73.7)</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>44</td>
<td>29</td>
<td>11</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>(17.7)</td>
<td>(27.8)</td>
<td>(18.4)</td>
<td>(7.0)</td>
<td>(29.1)</td>
</tr>
</tbody>
</table>
Table 11

Agreement Between Radiographic Bone Level and Attachment Level Measurements In the Adult Population

<table>
<thead>
<tr>
<th>Range Between Two Measurements</th>
<th>% Agreement By Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Buccal Proximal</td>
</tr>
<tr>
<td>None</td>
<td>34.2%</td>
</tr>
<tr>
<td>± 1mm</td>
<td>76.6%</td>
</tr>
<tr>
<td>± 2mm</td>
<td>94.3%</td>
</tr>
</tbody>
</table>
Table 12

Percentage Agreement Between Radiographic and Attachment Level Measurements In the Adult Population

<table>
<thead>
<tr>
<th>Radiographic Measurements</th>
<th>Percent Agreement</th>
<th>Percent Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Buccal Proximal</td>
<td>Lingual Proximal</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>+1mm</td>
</tr>
<tr>
<td>1</td>
<td>56.0%</td>
<td>76.0%</td>
</tr>
<tr>
<td>2</td>
<td>37.7%</td>
<td>86.8%</td>
</tr>
<tr>
<td>3</td>
<td>11.4%</td>
<td>65.6%</td>
</tr>
<tr>
<td>4</td>
<td>19.2%</td>
<td>73.1%</td>
</tr>
<tr>
<td>≥5</td>
<td>7.9%</td>
<td>79.0%</td>
</tr>
</tbody>
</table>
Table 13

Prediction of Clinical Attachment Levels of >3mm From Radiographic Assessments (Measurements in Millimeters) in the Adult Population

<table>
<thead>
<tr>
<th>Radiographic Measurement</th>
<th>Buccal Proximal (n)</th>
<th>Lingual Proximal (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24.1% (25)</td>
<td>22.2% (27)</td>
</tr>
<tr>
<td>2</td>
<td>32.1% (53)</td>
<td>39.2% (51)</td>
</tr>
<tr>
<td>3</td>
<td>60.0% (35)</td>
<td>60.0% (35)</td>
</tr>
<tr>
<td>4</td>
<td>69.2% (26)</td>
<td>84.6% (26)</td>
</tr>
<tr>
<td>&gt;5</td>
<td>84.2% (19)</td>
<td>89.5% (19)</td>
</tr>
</tbody>
</table>
Table 14

Intra-examiner Reliability Rates From the Radiographic Screenings as Validated by Millimeter Ruler Measurements in the Adult Population

<table>
<thead>
<tr>
<th>Screening Event</th>
<th>Subjects Examined</th>
<th>Intra-examiner Reliability Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary Radiographic Screening (visual only)</td>
<td>5% 94</td>
<td>83%</td>
</tr>
<tr>
<td>Final Radiographic Examination</td>
<td>51% 52</td>
<td>100%</td>
</tr>
<tr>
<td>Follow-Up Radiographic Examination</td>
<td>51% 38</td>
<td>74.4%</td>
</tr>
</tbody>
</table>
Table 15

Intra-examiner and Inter-examiner Reliability Rates For Radiographic Measurements In the Adult Population

<table>
<thead>
<tr>
<th>Type of Assessment</th>
<th>% Agreement By Range of Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
</tr>
</tbody>
</table>

I. Intra-examiner Reliability Check

- Examiner 1* 55.1% 91.3%
- Examiner 2** 69.1% 94.1%

II. Inter-examiner Reliability Check***

- Examiners 1 and 2 51.2% 87.9%

* Independent investigator's intra-examiner reliability rate.
** Candidates's intra-examiner reliability rate. Intra-examiner reliability rates were calculated based on reassessment of 41% (n = 68/166) of radiographic sites.
*** Inter-examiner reliability rates were calculated based on a total of 166 sites for which both examiner's measurements were present.
### Table 16

**Validity of the Preliminary Radiographic Screening Based on Millimeter Measurements**

<table>
<thead>
<tr>
<th>Screening Event</th>
<th>%</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Randomly selected Non-cases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-cases</td>
<td>3.7%</td>
<td>70</td>
</tr>
<tr>
<td>Possible cases</td>
<td>90%</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>10%</td>
<td>7</td>
</tr>
<tr>
<td>Estimated Misclassified Possible Cases</td>
<td></td>
<td>170</td>
</tr>
<tr>
<td>Estimated Missed Cases</td>
<td></td>
<td>8</td>
</tr>
</tbody>
</table>

* All estimates based on the 1702 identified non-cases from the preliminary screening and a JP case yield rate of clinical examinations performed.
Table 17

Agreement Between the First and Third Year Radiographic Screening Examinations for 10-12 Year Olds Regarding Classification as Definite or Possible JP Cases

<table>
<thead>
<tr>
<th></th>
<th>first year examination</th>
<th>3-year follow-up examination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>definite</td>
<td>possible</td>
</tr>
<tr>
<td>3-year follow-up</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>examination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>definite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>possible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>totals</td>
<td>1</td>
<td>74</td>
</tr>
</tbody>
</table>

Kappa = 0.49, p<0.0001 indicating moderate agreement.
False Positive Rate = 98.7%.
Table 18

Agreement Between the Clinical Examination and the First Year Radiographic Screening Examination for 10-12 Year Olds Regarding Classification as Definite or Possible JP Cases

<table>
<thead>
<tr>
<th></th>
<th>Clinical Examination</th>
<th>First Year Radiographic Examination</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>definite</td>
<td>possible</td>
<td>totals</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Definite</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Possible</td>
<td>1</td>
<td>41</td>
<td>42</td>
</tr>
<tr>
<td>Totals</td>
<td>2</td>
<td>41</td>
<td>43</td>
</tr>
</tbody>
</table>

Kappa = 0.66, p<0.0001 indicating substantial agreement. False Positive Rate = 95.3%.
Table 19

Agreement Between the Clinical Examination and Third Year Follow-up Radiographic Examination for 10-12 Year Olds regarding Classification as Definite or Possible JP Cases

<table>
<thead>
<tr>
<th></th>
<th>Clinical examination</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>definite</td>
<td>possible</td>
<td>totals</td>
</tr>
<tr>
<td>3-year follow-up</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>examination</td>
<td>definite</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>possible</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>totals</td>
<td></td>
<td>2</td>
<td>32</td>
</tr>
</tbody>
</table>

Kappa = 0.78, p<0.0001 indicating substantial agreement. False Positive Rate = 94.1%.
Appendix C

Figure 1

Identification of JP Cases Based on First Year Radiographic and Clinical Examinations

I
- Preliminary Radiographic Screening (Visual Only) (n = 1872)
- 5% Intra-examiner Reliability Check (n = 94)

II
- 3.7% Validity Check (n = 70)
  - Identification of Non-cases (n = 1702)
  - Final Radiographic Screening of Possible Cases (n = 117)
  - Lost to Analysis Due to Data Collection Error (n = 53)

III
- Identification of Non-cases (n = 14)
- Identification of Possible Cases (n = 103)
- 51% Intra-examiner Reliability Check (n = 52)

IV
- All Possible Cases with 3rd Year Radiographs (n = 75)
- Subjects with Addresses (n = 99)
  - Respondents (n = 46)
  - Non-respondents (n = 52)

V
- All Possible Cases with no 3rd Year Radiographs (n = 23)
- Non-traceable Subjects (n = 5)

VI
- Positive Responses (n = 43)
- Negative Responses (n = 3)
- Follow-up Letters Mailed

VII
- Clinical Identification of JP Cases (n = 2)
- Clinical Identification of Non-cases (n = 41)

VIII
- Follow-up Letters Mailed
- Follow-up Letters Mailed
Figure 2

Identification of JP Cases Based on Three Year Radiographic Examinations

From Flow Chart

Previous Page

All Possible Cases With 3rd Year Radiographs (N = 75)

75 Age, Sex and School Matched Non-case Controls

Final Radiographic Screening of 3rd Year Radiographs (measured) (n = 150)

Identification of Radiographic JP Cases (n = 3)

Identification of Non-cases (n = 147)

51% Intra-examiner Reliability Check

51% Intra-examiner Reliability Check
Figure 3

Flow Chart of Informed Consent For the Adolescent Population
Figure 4

Case 1: Bitewings From the Preliminary Screening and Follow-up Examination

A. Right bitewing from the preliminary radiographic screening.
B. Left bitewing from the preliminary radiographic screening.
C. Right bitewing from the third year radiographic examination.
D. Left bitewing radiograph from the third year radiographic examination.

Vertical bone was loss present on maxillary left and mandibular right first molars at the preliminary radiographic screening.
Figure 5

Case 1: Radiographic Series From the Third Year Examination Including Bitewings

Note the classical presentation of vertical bone loss on the mesial surfaces of the maxillary left first molar and lower left mandibular molar. None of the other teeth were affected with JP.
Case 1: Radiographic Series From the Third Year Examination Excluding Bitewings

Note the classical presentation of vertical bone loss on the mesial surfaces of the maxillary right and mandibular left first molars. Pocket depths at these sites measured 7-9mm. All other teeth appear normal.
Figure 7

Case 2: Bitewing Radiographs From the Preliminary Radiographic Screening

A. Right bitewing from the preliminary radiographic screening. B. Left bitewing from the preliminary radiographic screening.

Note bone loss on the mesial surfaces of the mandibular first molars. Probing depths at these sites measured 9-10mm during the three-year follow-up examination, with 7-9mm of attachment loss. While this individual was classified as a possible case on the basis of this radiograph, the clinical examination confirmed the presence of JP.
Figure 8

Case 3: Bitewing Radiographs From the Preliminary and Third Year Follow-up Radiographic Examinations

A. Right bitewing from the preliminary screening.
B. Left bitewing from the preliminary screening.
C. Right bitewing from the three-year follow-up examination.
D. Left bitewing from the three-year follow-up examination.

Note bone loss on the mesial surfaces of all first molars during the preliminary screening which showed progression three years later to include distal surfaces of the mandibular molars.