Invasive cervical resorption:
An analysis of potential predisposing factors

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Objective: An investigation was undertaken to assess potential predisposing factors to invasive cervical resorption. Method and materials: A group of 222 patients with a total of 257 teeth displaying varying degrees of invasive cervical resorption were analyzed. Potential predisposing factors, including trauma, intracoronal bleaching, surgery, orthodontics, periodontal root scaling or planing, bruxism, delayed eruption, developmental defects, and restorations were assessed from the patients' history and oral examination.

Results: Of the potential predisposing factors identified, orthodontics was the most common sole factor, constituting 21.2% of patients and 24.1% of teeth examined. Other factors were present in an additional 5.0% of orthodontically treated patients (4.3% of teeth), and these consisted principally of trauma and/or intracoronal bleaching. Trauma was the second most frequent sole factor (14.0% of patients and 15.1% of teeth). Trauma in combination with intracoronal bleaching, orthodontics, or delayed eruption constituted an additional 11.2% of patients (10.6% of teeth). Intracoronal bleaching was found to be the sole potential predisposing factor in 4.5% of patients and 3.9% of teeth, and an additional 10.4% of patients and 9.7% of teeth showed a combination of intracoronal bleaching with trauma and/or orthodontics. Surgery, particularly involving the cementoenamel junction area, was a sole potential predisposing factor in 6.3% of patients and 5.4% of teeth. Periodontal therapy, including deep root scaling and planing, showed a low incidence, as did other factors, such as bruxism and developmental defects. The presence of an intracoronal restoration was the only identifiable factor in 15.3% of patients and 14.4% of teeth, while 15.0% of patients and 16.4% of teeth showed no identifiable potential predisposing factors. Conclusion: These results indicated a strong association between invasive cervical resorption and orthodontic treatment, trauma, and intracoronal bleaching, either alone or in combination. (Quintessence Int 1999;30:83–95)

Key words: external resorption, invasive cervical resorption

CLINICAL RELEVANCE: Clinicians should be alert to the possibility of invasive cervical resorption, especially following trauma, intracoronal bleaching, or orthodontic treatment alone or in combination. Periodic radiographic checks are necessary for those teeth that might be considered to be at risk.

Invasive cervical resorption is an insidious and often aggressively destructive form of external root resorption that is characterized by invasion of the cervical region of the root by fibrovascular tissue derived from the periodontal ligament. This pathologic process progressively resorbs cementum, enamel, and dentin, to eventually involve the pulp space late in the process. Ectopic calcifications can also be observed in advanced lesions, both within the invading fibrous tissue and deposited on the resorbed dentin surface. The clinical and histopathologic features of this condition have been outlined in a previous publication.1

The etiology of invasive cervical resorption is unknown, but several potential predisposing factors have been suggested. Of these, intracoronal bleaching-related resorption has been the most widely documented factor, following the initial report by Harrington and Natkin in 19792 (for a review, see Heithersay et al3). Trauma has also been recognized as a potential cause of “late external root resorption,” the clinical description of invasive cervical resorption adopted by Cvek in 1981.4 Other potential predisposing factors that have also been explored include orthodontics, orthognathic and other dentoalveolar surgery, and periodontal treatment.5,6

The present investigation was undertaken to assess various potential predisposing factors in a relatively large group of patients presenting with varying degrees of invasive cervical resorption.
METHOD AND MATERIALS

The subject material consisted of 257 teeth displaying invasive cervical resorption in 222 patients who had been referred to the specialist endodontic practice of the author. Patients underwent a clinical and radiologic examination, and photographic records were taken where appropriate. Specific details of age, sex, and medical and dental history were recorded. Complete-mouth radiographic surveys were taken whenever multiple resorptions were deemed a possibility.

The potential predisposing factors were assessed from the patients' history and oral examination. Dates of specific incidents or treatments were also recorded.

Fig 1 Clinical classification of invasive cervical resorption.
The following factors were categorized and described:

1. Trauma. The age at the time of trauma along with severity of trauma. Details of nonsurgical root canal treatment or adjunctive treatment, eg, intracoronal bleaching.

2. Intracoronal bleaching. In patients with a history of intracoronal bleaching, details of previous injuries or treatment, and the number and timing of intracoronal bleaching treatments.

3. Surgery. The type of surgery in the related area, eg, surgical removal of unerupted or partially erupted teeth, or transplantation.

4. Orthodontic treatment. The ages at the commencement and completion of orthodontics, and the orthodontic method employed.

5. Periodontal root scaling or planing. The severity of periodontal involvement and the duration of treatment.

6. Bruxism. The approximate duration of bruxing and the degree of tooth wear.

7. Delayed eruption.

8. Developmental defects.

9. Other potential factors. Any other treatments or incidences that may be considered to be related to this condition.

10. Intracoronal restorations. When no other potential predisposing factor was identifiable, the presence of coronal restoration was recorded.

The degree of invasive cervical resorption for each tooth was recorded according to the following clinical classification (Fig 1):

1. Class 1. Denotes a small invasive resorptive lesion near the cervical area with shallow penetration into dentin.

2. Class 2. Denotes a well-defined invasive resorptive lesion that has penetrated close to the coronal pulp chamber but shows little or no extension into the radicular dentin.

3. Class 3. Denotes a deeper invasion of dentin by resorbing tissue, not only involving the coronal dentin but also extending at least to the coronal third of the root.

4. Class 4. Denotes a large invasive resorptive process that has extended beyond the coronal third of the root canal.

The data were subjected to frequency analysis, which was the only statistical method deemed applicable to this study.

RESULTS

Of the 222 patients, 114 were females and 108 were males. The sex and age distribution at the time of diagnosis is shown in Fig 2. The ages varied from 11 to 75 years; the mean age was 37 years. Figure 3 indicates the severity of invasive cervical resorption, as defined in Fig 1, by age group. The total number of teeth from this patient sample was 257; and their distribution is outlined in Table 1.

The analysis of potential predisposing factors for the patients is summarized in Fig 4.
### Table 1: Distribution of teeth showing invasive cervical resorption

<table>
<thead>
<tr>
<th>Tooth</th>
<th>Maxillary</th>
<th>Mandibular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central incisor</td>
<td>75</td>
<td>12</td>
</tr>
<tr>
<td>Lateral incisor</td>
<td>23</td>
<td>13</td>
</tr>
<tr>
<td>Canine</td>
<td>34</td>
<td>13</td>
</tr>
<tr>
<td>First premolar</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Second premolar</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>First molar</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>Second molar</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>Third molar</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

### Table 2: Distribution of patients and teeth associated with trauma alone or in combination with other factors

<table>
<thead>
<tr>
<th>Potential predisposing factors</th>
<th>No. of patients (%)</th>
<th>No. of teeth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trauma as a sole factor</td>
<td>31 (14.0%)</td>
<td>39 (15.1%)</td>
</tr>
<tr>
<td>Trauma and bleaching</td>
<td>17 (7.7%)</td>
<td>19 (7.4%)</td>
</tr>
<tr>
<td>Trauma and orthodontics</td>
<td>3 (1.4%)</td>
<td>3 (1.2%)</td>
</tr>
<tr>
<td>Trauma, bleaching, and orthodontics</td>
<td>4 (1.8%)</td>
<td>4 (1.6%)</td>
</tr>
<tr>
<td>Trauma and delayed eruption</td>
<td>1 (0.5%)</td>
<td>1 (0.4%)</td>
</tr>
<tr>
<td>Total</td>
<td>56 (25.2%)</td>
<td>66 (25.7%)</td>
</tr>
</tbody>
</table>

**Intracoronal bleaching**

The distribution of patients and teeth showing intracoronal bleaching and related factors is shown in Table 3. The teeth most frequently affected by a sole history of intracoronal bleaching were the (1) maxillary central incisors (3.1%) and (2) maxillary lateral incisors (0.3%).

**Illustrative case report.** The patient, a 42-year-old man, noticed an irregularity on the palatal aspect of his maxillary left lateral incisor. Examination revealed an erosive defect containing soft tissue on the palatal surface of the incisor (Fig 6a); the labial surface was intact (Fig 6b). No symptoms were associated with this lesion. The patient had received fixed orthodontic treatment at 20 years of age, when he was a dental student.

When he was 23 years old, his lateral incisor was luxated palatally while playing soccer. It was repositioned within 30 minutes and splinted. Nonsurgical root canal treatment proved necessary. This was followed by intracoronal bleaching with 30% hydrogen peroxide activated thermocatalytically by an ultraviolet lamp applied intermittently for 5 minutes.

This was followed by a “walking bleach,” in which a cotton pellet, saturated with 30% hydrogen peroxide, was sealed into the pulp chamber with Cavit (ESPE) for 6 days. The procedure was repeated, and 8 days later the access cavity was restored. The tooth was reassessed 2 and 7 years later, at which times there was no radiographic evidence of invasive cervical resorption or periapical pathosis (Fig 6c).
Intracoronal bleaching using the same procedure was repeated at the 7-year recall. The subsequent radiographic records suggest that, during the rebleaching procedure, additional gutta-percha had been removed and replaced with another material within the canal, presumably as an additional seal.

The patient presented 12 years after the second intracoronal bleaching procedure, when he noticed an irregularity on the palatal aspect of the same left lateral incisor. Evidence of an extensive resorptive process in the previously root-filled incisor was shown radiographically by the presence of a radiolucent area at the mesiocervical region of the left lateral incisor, extending 3 to 4 mm into radicular dentin and cementum (Fig 6d). In addition, a periapical radiolucency could be observed, indicative of a periapical inflammatory response probably resulting from microbial leakage of the root canal filling via the resorptive defect. The lesion was classified as a class 3 invasive cervical resorption.

**Surgery**

The distribution of patients and teeth showing surgery and related factors is shown in Table 4. The type of surgery varied. The removal of adjacent partially or fully unerupted third molars or supernumerary teeth
Fig 6a Palatal view of the anterior teeth of a 42-year-old man whose maxillary left incisor tooth had been luxated 19 years earlier, 2 years after receiving orthodontic treatment. Nonsurgical root canal treatment and intracoronal bleaching proved necessary, and intracoronal bleaching was repeated 7 years later. Note the erosive defect at the mesiogingival surface, evident 12 years after the second intracoronal bleaching procedure.

Fig 6b The labial surface of the maxillary left lateral incisor shows some discoloration near the gingival margin but is otherwise intact.

Fig 6c A radiograph taken 7 years after trauma, nonsurgical root canal treatment, and intracoronal bleaching shows no evidence of resorption or periradicular pathosis.

Fig 6d A radiograph of the maxillary left lateral incisor taken 12 years after a second intracoronal bleaching procedure shows evidence of extensive invasive cervical resorption extending into the radicular and coronal tooth structure. A periapical radiolucency, indicative of periradicular pathosis, is also evident.
Fig 7a  Labial surface of the maxillary left canine of a 28-year-old woman who had surgery to expose an unerupted canine at the age of 14 years. Protracted orthodontic treatment followed. Note the irregularity at the distogingival surface with an associated soft tissue ulceration.

Fig 7b  The palatal surface of the maxillary left canine is intact and shows no clinical signs of resorption.

Fig 7c  (left) The radiographic appearance of the maxillary left canine reveals an irregular radiolucency extending to the radicular third of the tooth and to the coronal tooth structure in a crescental pattern.

TABLE 4  Distribution of patients and teeth associated with surgery alone or in combination with other factors

<table>
<thead>
<tr>
<th>Potential predisposing factors</th>
<th>No. of patients (%)</th>
<th>No. of teeth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgery as a sole factor</td>
<td>13 (5.9%)</td>
<td>13 (5.1%)</td>
</tr>
<tr>
<td>Surgery and orthodontics</td>
<td>1 (0.5%)</td>
<td>1 (0.4%)</td>
</tr>
<tr>
<td>Surgery and periodontal therapy</td>
<td>1 (0.5%)</td>
<td>1 (0.4%)</td>
</tr>
<tr>
<td>Total</td>
<td>15 (6.8%)</td>
<td>15 (5.8%)</td>
</tr>
</tbody>
</table>

occurred in eight patients (eight teeth). Transplantation of canine teeth had been carried out in three patients (three teeth) and the surgical exposure of an unerupted canine was performed in one patient (one tooth). Periodontal surgery involving root amputation had been performed in one patient (one tooth).

Illustrative case report. A 28-year-old woman presented with localized swelling of the gingival tissues associated with her maxillary left canine, which displayed a resorptive defect near the distogingival margin (Figs 7a and 7b). Her dental history indicated that the previously unerupted canine had been surgically exposed when she was 14 years old, prior to orthodontic treatment. Records indicated that orthodontic movement of this tooth was difficult and protracted. The radiograph (Fig 7c) indicated a class 3 resorption defect, with extensions both coronally and apically for at least a third of its depth.
Orthodontics

The distribution of patients and teeth showing orthodontics and related factors is shown in Table 5. The teeth most frequently affected by orthodontics were (1) maxillary canines (6.2%), (2) maxillary central incisors (4.3%), (3) mandibular molars (2.3%), and (4) maxillary and mandibular incisors (1.9%). In those patients with a history of orthodontics alone, multiple resorptions were recorded in six patients (2.7%). Of these patients, one had seven teeth involved, two patients had four teeth involved, and three patients had two teeth involved.

Illustrative case report. A 28-year-old woman presented with a pink discoloration of the crown of her asymptomatic maxillary right central incisor (Figs 8a and 8b). The patient had received fixed appliance orthodontic therapy 14 years earlier, apparently uneventful both during and after the 2-year treatment period. The radiograph revealed an irregular radiolucency extending from the cervical area into the crown (Fig 8c). This lesion was classified as class 2 invasive cervical resorption.
Periodontal therapy

The distribution of patients and teeth showing periodontal therapy and related factors is shown in Table 6.

Bruxism

Six patients (2.8%) with six teeth (2.4%) showed a history of bruxism.

Delayed eruption

Delayed eruption resulting from tooth impaction was found in three patients (1.4%) with four teeth (1.6%). One other patient had an additional history of trauma, which resulted in a total of four patients (1.8%) with five teeth (1.9%) where delayed eruption was involved.

Illustrative case report. The mandibular right canine of a 35-year-old man had been submerged until the patient was in his early 20s, at which stage its full eruption was still impeded by crowding in the mandibular arch (Fig 9a). Radiographic evidence of invasive cervical resorption could be observed in both the mandibular right canine (Fig 9b) and the first premolar (Fig 9c). The lesions were classified as class 3.

Developmental defects

Developmental defects were recorded in two lateral incisors (0.8%) of one patient (0.5%).

Other factors

Interproximal stripping was the only other potential predisposing factor identified.

Illustrative case report. A 22-year-old woman's maxillary anterior teeth had been treated 3 years earlier by a general dental practitioner who performed interproximal stripping in an attempt to reduce anterior crowding. Advanced invasive cervical resorption was present in the maxillary right canine tooth, as was evident clinically (Fig 10a). Radiographic examination revealed evidence of a deeply infiltrating resorptive process surrounding an apparently intact root canal (Fig 10b). The lesion was classified as class 3.

Intracoronal restorations

The presence of an intracoronal restoration was the only identifiable factor in 34 patients (15.3%) with 37 teeth (14.4%).

In 35 patients (14.9%) with 36 teeth (16.4%), no predisposing factors could be identified.

<table>
<thead>
<tr>
<th>Potential predisposing factors</th>
<th>No. of patients (%)</th>
<th>No. of teeth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Periodontal therapy as a sole factor</td>
<td>4 (1.8%)</td>
<td>4 (1.6%)</td>
</tr>
<tr>
<td>Periodontal therapy and orthodontics</td>
<td>1 (0.5%)</td>
<td>1 (0.4%)</td>
</tr>
<tr>
<td>Periodontal therapy and surgery</td>
<td>1 (0.5%)</td>
<td>1 (0.4%)</td>
</tr>
<tr>
<td>Total</td>
<td>6 (2.8%)</td>
<td>6 (2.4%)</td>
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</tbody>
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DISCUSSION

To date, there do not appear to have been any previous epidemiologic studies that specifically indicate the proportion of a population group that may develop invasive cervical resorption. The present sample of patients referred to the author, a specialist endodontist with a special interest in the condition, represents approximately 0.02% of the population of Adelaide, a city of approximately 1.2 million people. Several statistical tests were considered for this study, including analysis of variance, but the nonrandomized nature of subjects indicated that the only valid statistical method applicable was that of frequency analysis.

There was little overall difference between males and females in the incidence of invasive cervical resorption, but there were some interesting age group variations. In the 35- to 39-year-old group, the majority were males, which contrasted with the 45- to 49-year-old group, where the sex distribution was reversed. While an analysis of potential predisposing factors for the two groups gave no indication for the predominance of females in the 45- to 49-year-old group, males in the 35-year-old group had a predictably greater history of dental trauma than females, no doubt resulting from a greater participation in contact sports. Surprisingly, males in this group also had a greater history of orthodontic treatment.

For invasive cervical resorption to be initiated, the normally protective cementum-cementoid layer must be deficient or damaged. This may have occurred developmentally or can be caused by physical or chemical trauma. Chemical trauma may be involved in the initiation of invasive cervical resorption associated with intracoronal bleaching with hydrogen peroxide. Intracoronal bleach-related cervical resorption has received the attention of the dental profession since the first case reports in 1979.
The results of the present study show that intracoronal bleaching was the sole potential predisposing factor in 4.5% of patients (3.9% of teeth). When combined with other potential predisposing factors, 14.9% of the patients surveyed, or 13.6% of the teeth, showed a history, at some stage, of intracoronal bleaching with hydrogen peroxide. The intracoronal bleaching method varied between a thermocatalytic technique with hydrogen peroxide and the walking bleaching method using hydrogen peroxide alone or mixed with sodium perborate. A combination of the two methods had also been used.

Two studies have assessed the incidence of intracoronal bleaching-related resorption. Friedman et al. found an incidence of 6.8% in a sample of 58 teeth treated by either a thermocatalytic or a walking bleaching technique. None of the teeth had a history of trauma. A more recent study of 202 patients treated with a combination of thermocatalytic and walking bleaching reported an incidence of 1.96%. All teeth with resorption in this study had a history of trauma.

This was also the case in each of the seven cases of invasive cervical resorption reported by Harrington.
and Natkin in 1979. These authors suggested that leakage of bleaching agent from the pulp chamber through patent dentinal tubules into the cervical periodontal tissues may be sufficient to initiate the resorptive process. Furthermore, a passage of hydrogen peroxide from the pulp chamber of root-filled teeth to the external surface during intracoronal bleaching with 30% hydrogen peroxide was demonstrated by Rotstein in 1991 and found to be facilitated by the presence of cemental defects at the cementoenamel junction.

Further information regarding the possible pathogenesis of intracoronal bleaching-related resorption has been provided by recent studies that demonstrated hydroxyl radical activity at the external root surface following the thermocatalytic intracoronal bleaching of root-filled teeth. The hydroxyl radical is one of a number of oxygen-derived free radicals that can destroy components of connective tissue, including the periodontal ligament. These hydroxyl radicals could be involved in the initiation of postbleaching invasive cervical resorption, particularly if a thermocatalytic method has been employed.

Invasive cervical resorption has been identified as a long-term complication of luxation and exarticulation injuries, and the relatively high incidence of 25.2% of patients (or 25.7% of teeth) in this study confirms trauma as a potential predisposing factor. It suggests that the injury has left the cementum surface damaged, deficient, or altered in character, thereby allowing the possibility of ingrowth of potentially resorbing cells from the periodontal ligament. Maxillary central incisors were those predominant recorded in this study, and this observation is consistent with their strategic vulnerability to dental trauma. The present study also showed that more than one factor may be involved in the same patient, and this was particularly significant when there had been a history of trauma and bleaching.

Surgical procedures involving the sensitive cementoenamel junction were identified as potential predisposing factors in 6.8% of patients (5.8% of teeth). This represents a comparatively low incidence, considering the frequency of such treatment procedures. The removal of unerupted third molars has the potential for damage to the cementoenamel junction of the adjacent second molar, while the exposure of unerupted canines for orthodontic purposes may cause similar damage, especially if a cervical wire ligation is used rather than a bonded bracket. Similar damage to the cementoenamel junction also occurred in one patient who had a history of interproximal stripping.

There were three patients with a history of orthognathic surgery who displayed root resorption with similarities to invasive cervical resorption. However, these patients were excluded from this study, because the predominating type of resorption was replacement resorption resulting from loss of the periodontal ligament and progressive root replacement by bone.
The highest incidence of invasive cervical resorption was found in patients with a history of orthodontic treatment; the resorption was detected as early as 18 months after the removal of appliances or as late as 35 years. There was no correlation between the orthodontic technique employed and the development of this type of resorption. Some degree of surface resorption can occur during orthodontic treatment. However, this resorption is usually transitory and will undergo repair after the removal of orthodontic forces. However, if surface resorption of cementum exposes the underlying dentin, then a potential will exist for resorption to be initiated by mononuclear precursor cells from the periodontal ligament, should they be stimulated by other factors. For example, pressure caused by excessive orthodontic forces may result in localized tissue necrosis adjacent to denuded cementum. The resulting tissue metabolites may stimulate mononuclear precursor cells to differentiate into specific clastic cells, which could cause active resorption.

It is of interest to note that, of the teeth with a history of orthodontics, maxillary canines were the most commonly recorded in this study, occurring as multiples in two patients. Because of their position, tooth length, and bone support, canines often are more resistant to orthodontic movement than other teeth in the dental arch. Furthermore, if class 2 elastics are used in treatment, they are attached to the maxillary canines and the mandibular first molars. This may translate into greater forces on one root surface, which could predispose the area to invasive cervical resorption.

Maxillary central incisors were the next most frequently affected teeth. This high incidence may be due to the position of the maxillary central incisors at the apex of the dental arch, where they could be subjected to greater tooth movement than other teeth in the dentition. Mandibular molars were the third most frequently affected teeth. These teeth are often used as anchor teeth, and the orthodontic treatment may subject some root surfaces to localized and perhaps excessive pressure during treatment.

Multiple resorptions were present in six patients with a history of orthodontics, the number varying from two to seven teeth per patient. This suggests a need for a complete-mouth radiographic examination for any patient with a history of orthodontic treatment who develops invasive cervical resorption.

The apparent association between invasive cervical resorption and orthodontic treatment must be viewed within the context of the frequency of orthodontic treatment within the community. There has been a significant increase in the use of orthodontic services within South Australia since 1973, when a study indicated that only 7% of patients to the age of 14 years were using specialist orthodontic services. However, that study did not assess the extent of orthodontic treatment provided by the State School Dental Service and general dental practitioners at that time. A more recent study of the use of orthodontic services by a cohort of adolescents enrolled in the South Australian School Dental Service program showed that, by age 15 years, 27.5% of young patients had received fixed orthodontic treatment, and 15.5% had also been treated by removable appliances.

An association between invasive cervical resorption and orthodontics has been reported previously. The endodontic implications of orthodontic treatment have been studied in 87 patients, aged 20 to 25 years, who had received orthodontic treatment earlier in their lives. The authors recorded only one case of cervical resorption in an incisor, representing 1.5% of the group. A control group of a similar age range showed no evidence of cervical resorption. It should be noted that only anterior teeth were examined in that study. In addition, the lag time between orthodontic treatment to the diagnosis of invasive cervical resorption can vary, and this should be taken into consideration in any comparative study. In the present study, the average age of detection of invasive cervical resorption in patients with a history of orthodontic treatment was 31.5 years.

Despite the opinion that cemental defects appear to predispose teeth to this type of resorption, periodontal therapy with deep scaling or root planing was not identified in this study as a major potential predisposing factor, being recorded as a sole factor in only four patients (1.8%) with four teeth (1.6%). When combined with other factors, namely, surgery or orthodontics, the incidence was still low (2.8% of patients; 2.4% of teeth). This may be due to the fact that in chronic periodontal disease there may be inhibition or destruction of the precursor resorbing cells in the periodontal ligament in the area of denuded cementum, or rapid epithelial downgrowth may effectively prevent contact of connective tissue cells with that surface.

Of the six patients with invasive cervical resorption associated with bruxism, it was perhaps significant to the occupational stress of our profession that two were dentists and one a medical practitioner.

The presence of intracoronal restorations may have little significance in anterior teeth, but in posterior teeth they can be associated with the development of dentinal and cemental cracks, especially if the restorations are supplemented with pins. Such cracks often extend into the periodontal ligament and, accordingly, may allow invasion of resorbing tissue.

Delayed eruption resulting from tooth impaction, observed in four patients (1.8%) and five teeth (1.9%), tends to leave a tooth crown partially surrounded by attached gingival tissues. This may result in conditions similar to those obtained experimentally when gingival...
flaps are coronally repositioned. In these experiments, invasive cervical resorption was observed in association with a high proportion of root surfaces. While 14.9% of patients (16.4% of teeth) did not have a registrable potential predisposing factor, it is possible that some may have had undetectable developmental defects, such as hypoplasia or hypomineralization of cementum.

In 28.9% of patients, there was more than one potential predisposing factor (for example, 7.5% of patients had a history of trauma and intracoronal bleaching). These observations confirm a need for careful follow-up examinations for such patients.

The present analysis shows that the majority of cases referred for treatment were classified as class 3 severity (see Fig 3). In lesions with this classification, there has been invasion of resorptive tissue into the crown and at least one third the length of the root. Resorptions of this magnitude usually have a complicated structure. Not only is there invasion by fibrovascular tissue, but ectopic calcifications both occur within the fibrovascular tissue and are deposited on the resorbed dentin. A series of channels containing resorptive tissue are present, and they usually have connections further apically with the periodontal ligament. The pulp space is surrounded by the resorbing tissue, but generally this is walled off by a thin layer of intact dentin and predentin.

Detection of invasive cervical resorption at an early stage is important, because it provides a clinician with the possibility of treating such lesions with a satisfactory degree of success. While several methods of treatment can be employed, a technique involving the topical application of trichloracetic acid, curettage, nonsurgical root canal treatment, where necessary, and restoration with glass-ionomer cement will be outlined in a further report, along with the long-term results of such a treatment regimen for each of the four classes of invasive cervical resorption as defined in this study.

CONCLUSION

This study has attempted to identify potential predisposing factors in the development of invasive cervical resorption. There appear to be strong associations between the incidence of invasive cervical resorption and orthodontic treatment, intracoronal bleaching, and dental trauma, alone and in combination, but further investigations with randomized samples are warranted.

REFERENCES