The conservative approach in the treatment of furcation lesions

Marcello Cattabriga, Vinicio Pedrazzoli & Thomas G. Wilson Jr.

Molars are the tooth type demonstrating the highest rate of periodontal destruction in untreated disease (50) and suffer the highest frequency of loss for periodontal reasons (3, 72). For the purposes of this chapter, furcation involvement is defined as bone resorption and attachment loss in the interradicular space that results from plaque-associated periodontal disease. Such a condition is reported to considerably increase the risk for tooth loss (24, 32, 57–59, 80, 99, 102). Therefore, furcation defects represent a formidable problem in the treatment of periodontal disease, principally related to the complex and irregular anatomy of furcations. Moreover, the responsiveness to therapy may be complicated by the presence of a greater radicular surface potentially offered to bacterial toxins and calculus build-up, as compared to defects surrounding single-rooted teeth. Once the lesion has established, the discrepancy in extent between the root surfaces and the periodontal soft tissues facing the bacterial insult may be responsible for a reduced healing response. Finally, the distal location in the arch and the difficult access may conceivably impair both self-performed and professional plaque control procedures in the furcation area, limiting their effectiveness.

The principles of therapy of furcation involvement may be discussed under three major headings: conservative, resective and regenerative. It must be borne in mind, however, that the borderline between conservative and resective terms sometimes does not lend itself to a sharp definition, as it is rather difficult in a clinical setting to completely separate conservative and resective treatments. This is especially true for furcation involvements. Resective procedures must sometimes be performed in order to attain a result which can eventually be considered more conservative. For instance, tunnel preparation is an example of conservative therapy carried out to avoid more radical and resective forms of treatment for class II and III furcation involvements. However, tunnel preparation is often accomplished at the expenses of bone and tooth substance within the furcation area to gain enough space for interdental cleaning devices. Root amputation represents another form of resective procedure used often for conservative purposes.

The conservative approach defined here comprises surgical and nonsurgical treatment employed to debride the furcation area excluding regeneration and root separation procedures. These treatments are sometimes accompanied by procedures that may change the tooth anatomy and the surrounding periodontal structures to improve access for plaque control, although they do not imply crown restorations.

An array of therapeutic procedures have been suggested by clinicians with the aim of improving the prognosis of furcated teeth. The scope of this review is to discuss the literature on the conservative approaches in the treatment of furcation involvements.

Epidemiology

The prevalence of severe periodontitis has been reported to vary from 5% to 20% of the different populations investigated according to the criteria employed to measure extent and amount of periodontal destruction (70, 71).

Longitudinal studies conducted to describe the progression of untreated periodontitis have shown that the majority of sites losing attachment belong to a small subset of the population (13, 14, 25, 50, 52). Molars appear to be the most affected teeth (50) and the tooth type most frequently lost (3, 55, 72).

Despite the well-documented evidence that periodontal therapy is effective in halting disease progression (42, 49, 80), tooth loss appears to be an unavoidable event even in some otherwise successfully treated patients, although at a considerably lower annual rate (0.05–0.1%) (4, 24, 32, 57, 102) compared with that of untreated populations (0.14–0.38%) (3, 11, 52, 72). Molars again represent the tooth type re-
sponding least favorably to therapy (36, 54, 67) and are at greater risk for extraction compared with other tooth types (24, 32, 57, 80, 99, 102).

The greater rate of mortality observed with maxillary and mandibular molars may partly be explained by the presence of furcations. When the latter are initially affected by the destruction of periodontal support, the peculiar anatomical configuration, together with the distal location, are likely to accelerate the rate of disease progression, whereas the control of infection by the patient becomes more troublesome. Indeed, an association between clinical or radiographic detection of furcation involvement, and increased risk of tooth loss has been repeatedly demonstrated (24, 32, 57–59, 80, 102).

Prevalence of furcation involvement

Sparse information is available regarding the prevalence of naturally occurring involvement of the molar furcation area in the general population in epidemiological surveys. Most of the available data are derived from studies based on observations performed in dry skulls (45, 46, 85, 90–92, 96). These results must be interpreted cautiously: the number of observations is relatively small and the anatomical specimens belong to populations that are ethnically and socially quite characterized. Thus, the results from these studies may not apply to other ethnic and social cohorts.

In the study by Volkansky & Cleaton-Jones (96) on 43 dry mandibles of South African Bantu people 30.9% of molar teeth present had furcation involvement. Tal (92) examined 100 dry mandibles from South African skulls and found that 85.4% of mandibular molars presented with osseous resorption in the furcation area. He reported also that the degree of furcation involvement, as expressed in terms of horizontal depth of the osseous defect, increased with increasing age. In a subsequent study on mandibular molars, Tal & Lemmer (91) confirmed the finding that moderate and severe involvements are predominant in older adults, first molars being more affected than second molars.

Björn & Hjort (6) assessed longitudinally the radiographic prevalence, degree and development of bone destruction in mandibular molar furcations in a sample of 221 factory workers observed over a period of 13 years. The prevalence of furcation involvement steadily increased from an initial value of 18% to 32% at the end of the observation period. Third and second molars had higher frequencies of advanced destruction than first molars.

Additional data are provided by investigations enrolling periodontally diseased subjects who either were referred for or spontaneously sought periodontal care (24, 32, 57, 88, 102). Therefore, the findings from these surveys may not be used to derive conclusions about the general population. Maxillary molars are more frequently affected than mandibular molars, although the prevalence values may greatly differ. The prevalence of involvement in the furcation area in maxillary and in mandibular molars range from 25% to 52% and from 16% to 35%, respectively (Table 1). Svärdström & Wennström (88) studied in detail the prevalence of furcation involvement in a group of 222 patients referred for periodontal treatment. They reported that, from the age of 30 years onward, about 50% of molars in the maxilla show at least 1 furcation site with deep involvement, while in the mandible a similar prevalence was first observed after the age of 40. Periodontal destruction was most frequently observed at the distal aspect of the first and second maxillary molars (53% and 35%, respectively). In the mandible the buccal and lingual entrances of furcations were affected with similar frequencies.

Furcation involvement is more frequently detected in smokers (72%) than in nonsmokers (36%); the calculated odds ratio for a smoker to have furcation involvement in one molar is 4.6 (64). It has also been demonstrated that molars with crowns or

<table>
<thead>
<tr>
<th>Authors</th>
<th>Numbers (%) of molars with furcation involvement</th>
<th>Diagnostic method</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Maxillary</td>
<td>Mandibular</td>
</tr>
<tr>
<td>Hirschfeld &amp; Wassermann (32)</td>
<td>858/2217 38.7%</td>
<td>597/2054 29.0%</td>
</tr>
<tr>
<td>McFall (57)</td>
<td>95/378 25.1%</td>
<td>60/377 15.9%</td>
</tr>
<tr>
<td>Goldman et al. (24)</td>
<td>454/870 52.2%</td>
<td>169/865 19.5%</td>
</tr>
<tr>
<td>Wood (102)</td>
<td>87/205 42.4%</td>
<td>77/220 35.0%</td>
</tr>
</tbody>
</table>
proximal restorations have significantly higher percentages of furcation involvement (52–63%) compared with molars without restorations (39%) (98) (Fig. 1).

Classification of furcation lesions

Different clinical methods for classifying the extent of furcation involvement have been proposed. Glickman (23) initially devised a four-degree classification based on the extent of destruction of periodontal tissues within the furcation. Ramfjord & Ash (79) have described an index for evaluating the depth of involvement using 2 mm increments of periodontal probing measurements. With degree 1 the probe penetrates horizontally between the roots up to 2 mm; with degree 2 more than 2 mm and with degree 3 the probe penetrates the furcation all the way through to the opposite entrance.

Hamp et al. (29) have proposed the same approach as Ramfjord & Ash with the exception of using 3 mm increments to describe the 3 classes of involvement (Fig. 2), while Tarnow & Fletcher (93) have proposed a subclassification which takes into account the vertical extent of the lesion in an attempt to better describe its severity.

Reproducibility and reliability of diagnosis and diagnostic measures

Probing

Vertical measurements along the roots adjacent to furcation lesions have been shown to be reproducible in facial sides of maxillary molars and in facial and lingual sides of mandibular molars (62). The inter-examiner reproducibility, however, decreases with increasing pocket depth and increasing root separation because, as the probe penetrates deeper,
it is more difficult to maintain contact with the root surface. Reproducibility of horizontal measurements does not seem to be as satisfactory as with vertical recordings (62).

The reliability of vertical measurements taken at the deepest interradicular pocket depth is very poor, however, as the probe invariably penetrates the furcation connective tissue to an average depth of 2.1 mm (63), as shown in histological sections. Other authors have looked for a reliable correlation between the clinical diagnosis of furcation involvement and the extent of destruction visualized after flap reflection. Zappa et al. (106) used both the Ramfjord and Hamp indices to compare horizontal clinical assessments indicated in grades of severity with those recorded after surgical exposure. Regardless of the use of a calibrated or noncalibrated Nabers probe (Fig. 3) the results showed frequent over- and underestimation. On the contrary, Eickholz & Staehle (19) and Eickholz (20) found satisfactory reliability in terms of degree of furcation involvement when comparing clinical presurgical and intrasurgical measurements, except for disto-palatal sites where only moderate agreement between the two types of recordings was noted. The difficulties in accurately determining the extent and severity of furcation involvement shown by some of the former studies is noteworthy, as it has been demonstrated that clinicians base treatment options and strategies on the clinical assessment of the degree of interradicular destruction (65). Errors in diagnosing the extent and severity of furcation involvement may lead to errors in the choice of treatment.

Radiographic diagnosis

Radiographic diagnosis of furcation involvement is usually easier to perform in mandibular molars, as the superimposition of the palatal root on the radiograph film may conceal the actual bony morphology in the interradicular area in maxillary molars. Hardekopf et al. (30) have claimed that the identification of a triangular radiographic shadow (furcation arrow) on roentgenograms of maxillary molars could be a useful indicator for presence of a class 2 or 3 furcation involvement. Although the association of the furcation arrow image with class 2 or 3 furcation involvement was significant mesially and bucally when compared with uninvolved furcations, the absence of the furcation arrow image did not necess-
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Fig. 3. Use of a curved probe (Naber’s probe) for clinical assessment of furcation involvement. The probe’s tip is initially applied on the root trunk just under the gingival margin in order to locate the furcation entrance (A). Subsequently the probe is moved into the interradicular space (B).

arilly mean absence of a bony furcation involvement. The presence of a radiolucent interradicular area may not always be the result of a true furcation involvement due to periodontal reasons, as trauma from occlusion and endodontic pathoses due to accessory patent canals (28) communicating with the interradicular space may be responsible for bone resorption resembling that occurring during periodontitis.

Ross & Thompson (84) detected furcation involvement more frequently in maxillary molars by radiographic examination than clinical inspection, whereas the opposite was true for mandibular molars. They also observed that a more accurate furcation involvement diagnosis was accomplished by combining radiographic and clinical examinations.

Nevertheless, these studies showed acceptable long-term functional survival rate for furcated molars, indicating that the presence of furcation involvement is not per se a reason for assigning a questionable to hopeless prognosis to these teeth.

Studies based on tooth mortality (Table 2)

Ross & Thompson (83) followed 387 maxillary molars with radiographic evidence of furcation involvement in 100 patients with chronic destructive periodontal disease for a period ranging between 5 and 24 years. The treatment consisted of a combination of procedures including scaling, curettage, occlusal correction by coronal reshaping, periodontal surgery of soft tissues and oral hygiene instructions. No osseous surgery was performed; 305 of the 387 (84%) molars had a questionable to poor prognosis at the beginning of the study: at least one root with a minimum bone loss of 50%. A total of 341 (88%) were still functioning efficiently without pain at the end of the study, whereas the remainder had been extracted at various time intervals. However, 15 (33%) of the 46 teeth extracted had been in place for 11–18 years and 10 (22%) for at least 6 years.

The retrospective studies by Hirschfeld & Wasserman (32), McFall (57), Goldman et al. (24) and Wood et al. (102) are centered on long-term observations of multiple forms of periodontal therapy. The quality of response to treatments by an individual patient was evaluated considering the number of teeth lost during the observation period. This allowed for the classification of patients into three categories: well-maintained group (lost 0–3 teeth), downhill group (lost 4–9 teeth) and extremely downhill group (lost

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Longitudinal long-term clinical surveys have shown that periodontal therapy is effective in halting the disease process in nearly every patient and site (18, 27, 40, 97). These results have been achieved independent of the type of surgical and nonsurgical therapy performed, provided that supportive periodontal therapy was administered on a regular basis (100). However, longitudinal prospective (36, 54, 67) and retrospective (24, 32, 57, 83, 84, 99, 102) studies showed that, in molars with furcation involvement, the results are not as satisfactory as those obtained for single-rooted teeth or nonfurcated molars.
Table 2. Molars’ mortality in long-term surveys on surgical and nonsurgical periodontal treatment

<table>
<thead>
<tr>
<th>Study</th>
<th>Number of subjects</th>
<th>Follow-up</th>
<th>Treatment</th>
<th>Intervals supportive periodontal therapy/supportive periodontal care</th>
<th>Tooth mortality in molars</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Mean years</td>
<td>(Range)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ross &amp; Thompson (83)</td>
<td>100</td>
<td>Not available</td>
<td>5–24</td>
<td>Supragingival scaling, curettage, occlusal adjustments, oral hygiene instruction, gingivoplasty, gingivectomy, apically positioned flap, no osseous surgery</td>
<td>3 months 46/387* 12%  Not available</td>
</tr>
<tr>
<td>Hirschfeld &amp; Wasserman (32)</td>
<td>600</td>
<td>22</td>
<td>15–53</td>
<td>Subgingival scaling, gingivectomy, flap surgery, root amputation, hemisection, occlusal adjustments</td>
<td>Not specified 460/1455 32% 191/3016 6%</td>
</tr>
<tr>
<td>McFall (57)</td>
<td>100</td>
<td>19</td>
<td>15–29</td>
<td>Supragingival scaling, subgingival scaling, occlusal adjustments, oral hygiene instruction, gingivectomy, gingivoplasty, osectomy, osteoplasty</td>
<td>The majority 3–6 months 88/155 57% 46/600 8%</td>
</tr>
<tr>
<td>Goldman et al. (24)</td>
<td>211</td>
<td>22.2</td>
<td>15–34</td>
<td>Supragingival scaling, subgingival scaling, gingivectomy, gingivoplasty, apically positioned flap, scaling, curettage, occlusal adjustments</td>
<td>3–6 months 270/630 43% 190/1112 17%</td>
</tr>
<tr>
<td>Wood et al. (102)</td>
<td>63</td>
<td>13.6</td>
<td>10–34</td>
<td>Supragingival scaling, subgingival scaling, scaling and root planing, curettage, occlusal adjustments, gingivectomy, flap surgery, flap curettage, osseous grafting, root amputation</td>
<td>Not specified 38/164 23% 36/261 14%</td>
</tr>
<tr>
<td>Wang et al. (99)</td>
<td>24</td>
<td>8</td>
<td>8</td>
<td>Scaling and root planing, pocket elimination surgery, modified Widman flap, curettage</td>
<td>Not specified 20/87 23% 10/78 13%</td>
</tr>
</tbody>
</table>

Surgical procedures in italics. * Only maxillary molars.
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10–23 teeth). Such subdivision has been maintained in this review to construct a table reporting tooth mortality rate for furcated molars (Table 3).

Hirschfeld & Wasserman (32) examined retrospectively the periodontal conditions of 600 patients who had been previously treated in a private practice for 15 to 53 years (mean 22 years). A total of 76.5% of the patients had been initially classified as having advanced periodontal disease, whereas 16.5% had disease of intermediate severity and only 7% exhibited early signs of periodontitis. The periodontal treatment rendered throughout the years consisted of subgingival scaling, gingivectomy and flap surgery. Root amputation (17 teeth) or hemisections were performed as well. Patients were subjected to periodic maintenance, and subgingival scaling was carried out when deemed necessary. Evaluation of response to therapy was based on the number of teeth lost during the observation period. The well-maintained group accounted for 499 (83.2%), the downhill group 76 (12.6%) and the extremely downhill group 25 (4.2%) of the sample investigated. Although the majority of patients had been initially classified as having advanced disease, most of them responded favorably to therapy, leaving a small subgroup of patients whose periodontal condition continued deteriorating despite treatment. These data confirmed epidemiological findings reported from studies on the natural course of the disease, attesting that a small subfraction of the population accounts for the majority of periodontal destruction recorded (13, 14, 50, 52). During the maintenance phase, 7.1% of all teeth were lost for periodontal causes; 460 of 1455 (31.6%) molars presenting with furcation involvement were lost, the majority belonging to the downhill and extremely downhill groups, whereas only 19.3% belonged to the well-maintained group. Overall, the proportion of lost molars with furcation involvement was about 5-fold that of molars without furcation involvement.

McFall (57) analyzed a sample of 100 patients who had been treated and maintained for 15 years or longer (average duration 19 years, range 15 to 29 years). Severity of periodontal disease was classified according to the criteria of Hirschfeld & Wasserman (32): 36 of 100 were diagnosed as having advanced disease, 53 presented with intermediate degree of severity and 11 had early signs of disease. Therefore, this study population contained fewer advanced cases than those monitored by Hirschfeld & Wasserman (32). All patients were treated similarly during the period of initial preparation with supragingival and subgingival scaling, occlusal adjustment and oral hy-
gingivectomy and gingivoplasty. Infrabony defects were treated with ostectomy and osteoplasty where pocket elimination was deemed feasible. Root amputation was performed on only 5 teeth. Other molars with furcation involvement were treated surgically or maintained with open or closed curettage. The majority of the patients had been under a maintenance regime at 3-, 4- or 6-month intervals. During this period, when indicated, patients were rescheduled for surgical procedures. The study population, divided on the basis of tooth loss, was distributed in the following manner: well-maintained group 77, downhill group 15 and extremely downhill group 8. Periodontal disease was the cause of 259 teeth (9.8%) lost; 56.7% of teeth with furcation involvement were lost during the observation period, and the well-maintained group had only 27% of the furcation involvement teeth extracted. Of 600 molars without furcation involvement, only 46 (7.6%) were lost. Remarkably, molars with furcation involvement had functioned before extraction for an average of 14 years, 10.5 years and 9 years in the well-maintained, downhill and extremely downhill groups, respectively.

Goldman et al. (24) examined the clinical records of 211 patients treated and maintained for 15 to 34 years (average time 22.2 years). Treatment rendered consisted of supragingival and subgingival scaling, oral hygiene instruction and occlusal adjustment when needed. Surgery consisted mainly of gingivectomy or gingivoplasty, and in few cases a flap or open curettage was performed. According to their response to treatment, patients were classified as follows: well-maintained group 131 (62%), downhill group 59 (28%), and extremely downhill group 21 (10%). At no time was osseous tissue removed. Furcations were treated by gingivectomy or gingivoplasty or an apically positioned flap and maintained by scaling and curettage. In only five cases was root amputation performed. Of the teeth initially present, 13.4% were lost. Of 630 teeth with initially diagnosed furcation involvement, 270 were extracted (43.5%), whereas in the well-maintained group the number of lost teeth having furcation involvement was 56 of 335 (16.7%). Among nonfurcated molars, 190 of 1112 (17.0%) were lost during the study.

Wood et al. (102) studied 63 patients who had received periodontal treatment for at least 10 years previously (average duration 13.6 years, range 10–34). Therapy consisted initially of supragingival and subgingival scaling accompanied by oral hygiene instructions. Subsequent surgical therapy included gingivectomy, flap surgery, flap curettage, osseous contouring, osseous grafting and root amputation. Maintenance intervals differed greatly among patients, from <6 to >9 months. According to response to therapy patients were divided as follows: well-maintained group 54 (85.7%), downhill group 7 (11.1%) and extremely downhill group 2 (3.2%). During the maintenance period, 5% of teeth initially present were lost due to progressing periodontal destruction. Thirty-eight (23.2%) of the initially furcated teeth were lost. In the well-maintained group, 21 of 126 (16.6%) teeth with furcation involvement were lost. Among the 261 molars without furcation involvement, 36 were extracted (13.8%).

In a study on 24 patients treated either with mechanical or surgical procedures, Wang et al. (99) demonstrated that molars with furcation involvement were 2.54 times more likely to be lost compared with teeth without furcation involvement during the 8-year maintenance period.

The above-mentioned longitudinal studies reveal that molars with furcation involvement are definitely more prone to loss than nonfurcated molars (Table 2). However, the number of molars having furcation involvement lost for periodontal reasons may be lower, as some teeth, mainly third molars, might have been extracted for other causes related to the accomplishment of comprehensive treatment plans, such as extrusion due to absence of the antagonist tooth or poor compatibility with prosthetic reconstruction. On the other hand, some furcated molars were extracted in these studies at the commencement of treatment and hence were not included in the computation of survival rates. Moreover, the presence of furcation involvement might have been overlooked due to diagnostic misjudgment. Therefore the figures reported in the surveys may not correspond to the actual mortality rates for molars with furcation involvement.

The percentages of initially furcated molars lost during the observation periods of the studies varied from 11.8% to 56.7% (24, 32, 57, 83, 99, 102). However, the well-maintained groups, representing the vast majority of the patients enrolled in the surveys (ranging from 62% to 85.7%), had considerably lower rates of molars with furcation involvement extracted (16.7% to 27.3%) compared with patients in the ill-responding groups (Table 3). This finding is in accordance with the assumptions that the majority of patients in these studies, probably because of lower susceptibility to disease or effective plaque control, responded well to periodontal treatment. Thus, molars with furcation involvement do not seem to be necessarily associated with a questionable prognosis,
The conservative approach in the treatment of furcation lesions because most of them remained in the well-maintained groups for many years. Moreover, many of the lost furcated molars had been claimed to function well for a considerable length of time before their extraction. However, despite the tenet that furcated teeth can be successfully treated and maintained in compliant and less susceptible individuals, the presence of furcation involvement must still be considered a true risk factor, as clearly shown by the calculation, for each response-to-treatment category, of the odds ratios for extraction between molars with and without furcation involvement in the long-term studies from which data for such computations are available (24, 32, 57). The meta-analysis (Table 4) clearly indicates that furcated teeth have significantly greater chances to be lost than nonfurcated molars, regardless of the response to treatment, with the sole exception of the extremely downhill group in the survey by Hirschfeld & Wasserman (32).

Unfortunately, no long-term investigation reported in Table 2 provides data about the frequency distributions of furcation involvement according to the extent and severity of destruction nor do they report as to the choice of treatment in relation to the degree of involvement. It is therefore impossible to draw any conclusion from these articles about the efficacy of the various periodontal treatments applied in accordance with the initially diagnosed severity of involvement. More recently, other studies have been carried out to investigate the effectiveness of specific periodontal treatments on furcations with different degrees of destruction. This issue is discussed in another section.

Studies based on clinical measurements, microbial parameters and efficacy of root instrumentation

The above-mentioned retrospective longitudinal studies have all based their conclusions on tooth mortality. Shorter prospective studies, owing to the limited duration of the period of investigation, have focused on the response to treatment based on measurements of clinical parameters such as attachment level and pocket depth rather than tooth mortality. A few studies have also investigated the effects of periodontal therapy on the subgingival microflora and the distribution of calculus deposits.

Two 2-year prospective studies (54, 67) investigated the effects of root debridement and plaque control in adult periodontitis patients. Molar furcation sites responded less favorably to treatment compared with molar flat surfaces and non-molar sites. This was revealed by higher mean bleeding on probing scores, higher mean loss of attachment and less reduction of probing depth. Among the deepest sites (initially ≥7 mm), 21–38% of molar furcations lost attachment as compared with 1.7–7% of the molar flat surfaces and 6–11% of the non-molar sites. Similar trends have been observed in other independent researches. Kaldahl et al. (36) found that furcations of molar teeth always responded less favorably than other site groupings to surgical periodontal therapy in terms of attachment level measurements, regardless of the initial probing depth. Finally, Wang et al. (99) reported that during 8 years of supportive periodontal therapy, molars with furcation involvement lost an average of 1.24 mm in attachment level, while molars without furcation involvement lost only 0.6 mm.

The comparatively poorer clinical response of molar furcated sites is also reflected in the microbiological outcome observed in a study conducted by Loos et al. (53). These authors monitored for 52 weeks the clinical and microbiological effects of plaque control and root debridement with ultrasonics at 24 non-molar sites and at 31 grade II molar furcation sites with probing depth ≥5 mm in 11 patients. Throughout the study, numbers and percentages of spiro-

<table>
<thead>
<tr>
<th>Study</th>
<th>Well maintained</th>
<th>Downhill</th>
<th>Extremely downhill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hirschfeld &amp; Wasserman (32)</td>
<td>13.56</td>
<td>5.24</td>
<td>1.55</td>
</tr>
<tr>
<td>Odds ratio</td>
<td>10.39–17.66</td>
<td>3.04–9.01</td>
<td>1.42–1.68</td>
</tr>
<tr>
<td>95% confidence interval</td>
<td>19.35*</td>
<td>5.98*</td>
<td>1.04</td>
</tr>
<tr>
<td>z</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>McFall (57)</td>
<td>7.73</td>
<td>7.64</td>
<td>10.33</td>
</tr>
<tr>
<td>Odds ratio</td>
<td>4.26–14.01</td>
<td>3.35–17.41</td>
<td>2.63–40.44</td>
</tr>
<tr>
<td>95% confidence interval</td>
<td>6.74*</td>
<td>4.84*</td>
<td>3.35*</td>
</tr>
<tr>
<td>z</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goldman et al. (24)</td>
<td>3.23</td>
<td>3.30</td>
<td>10.81</td>
</tr>
<tr>
<td>Odds ratio</td>
<td>2.16–4.83</td>
<td>2.26–4.80</td>
<td>4.46–26.15</td>
</tr>
<tr>
<td>95% confidence interval</td>
<td>5.73*</td>
<td>6.21*</td>
<td>5.28*</td>
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<td>z</td>
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</table>

* P<0.05.
chertes, total anaerobic colony-forming units and numbers of Porphyromonas gingivalis were always higher in furcations than in non-molar sites. This finding may be accounted for by the difficulty in achieving complete debridement in furcation sites. Indeed, it has been demonstrated that more residual calculus is left after debridement in furcation areas than on other root surfaces (22, 73, 74, 101). Parashis et al. (74) studying 30 mandibular molars scheduled for extractions with class II and III furcation involvement and Calculus Index ≥2 (78) showed that the mean values of residual calculus were statistically lower for the external surfaces than for furcation areas when using a closed approach.

The influence of furcation anatomy

The reduced rate of success experienced with the conservative approach in the treatment of furcation involvement seems to result from the incomplete removal of hard and soft debris present in the interradicular area owing to the peculiar anatomy of the furcation space (cervical enamel projections, bifurcation ridges, convexities, concavities and furcation entrance dimension) (8, 9, 17, 33–35, 87).

Svärdström & Wennström (87) have described in detail the topography of the furcation area in the maxillary and mandibular first molars. By implementing a photogrammetric method, these authors plotted the interradicular area to obtain three-dimensional contour maps. The complexity of the internal surfaces of the furcation areas was outlined showing an array of small peaks, ridges and pits.

Bower (9) found that, in maxillary first molars, the furcal aspect of the root was concave in 94% of mesiobuccal roots, 31% of distobuccal roots and 17% of palatal roots. Moreover, he observed that the concavity of the furcal aspect was present in 100% and 99% of mandibular mesial and distal roots, respectively. Once the plaque front has reached the furcation area, these configurations render the cleansing procedures quite awkward.

Furcation entrance dimension is of paramount importance for successful therapy, as it influences the feasibility of gaining access to the interradicular area with mechanical instruments, as shown by Matia et al. (56) and Parashis et al. (74), who found that the amount of residual calculus was related to the width of the furcation entrance when open root planing was performed.

Furcation entrances that are not amenable to access by mechanical instruments are a quite common finding. In a study conducted by Bower (8), the furcation entrance diameter in a sample of 114 maxillary and 103 mandibular first molars was found to be narrower than the width of commonly used periodontal curettes in 58% of the furcations examined. A later study by Chiu et al. (17) found in 185 Chinese first maxillary molars that furcation entrance dimension ≤0.75 mm were present in 79% of buccal, 39% of mesial and 43% of distal entrances. In 178 mandibular molars, furcation entrances ≤0.75 mm were detected in 36% and 47% of buccal and lingual aspects, respectively. Half of all furcation entrance dimensions of these first molars were less than the blade width of a new Gracey curette. Hou et al. (35) examined the furcation entrance dimension of 89 Chinese maxillary molars (49 first and 40 second molars) and 93 mandibular molars (50 first and 43 second). The majority of furcation entrances in second molars had smaller dimensions than the width of a Gracey curette (0.76 mm), although they were larger than the average dimension of a new standard ultrasonic tip. Ultrasonic inserts may then have easier access to furcation areas than curette blades, especially in deep furcation involvements. Such assumption is in accordance with the clinical and microbiological results reported by Leon & Vogel (48), who compared hand versus ultrasonic debridement in class I, II and III furcation involvements by assessing gingival crevicular fluid flow and the composition of the subgingival microflora using dark-field microscopy. While in class I both treatments were equally effective, ultrasonic instruments proved more effective than hand scaling in reducing gingival fluid flow and bacterial proportions of spirochetes and other motile organisms in class II and III. This finding substantiates the results reported by Matia et al. (56), who found significantly more residual calculus in furcations ≤2.3 mm wide after debridement with curettes than with ultrasonic scalers.

Therefore, efforts have been made to construct specially designed ultrasonic tips to improve accessibility to the innermost areas of the interradicular space. In vitro studies have tested different sonic and ultrasonic tips devised to gain access in the furcation area, reporting satisfactory results in terms of artificial calculus removal (43, 69, 75, 89). Longitudinal controlled clinical trials based on the use of these new instruments are needed to show their ultimate effectiveness in vivo. However, improvement in calculus elimination in furcations with entrance dimension of <2.4 mm has been also attained by utilizing...
a rotary diamond bur, thus circumventing the complications related to the presence of narrow furcation entrances (73, 74).

Methods and techniques of conservative therapy

The long-term retrospective clinical studies reviewed above (Table 2) employed a vast array of surgical and nonsurgical procedures. Unfortunately, as noted before, no information is available on the application and outcome of the various techniques according to the clinically diagnosed degree of involvement, precluding the possibility of drawing conclusions about the proficiency of each procedure in the different types of destruction in furcations. The following sections will discuss the effect of surgical and nonsurgical procedures, chemotherapy and the more invasive tunnel preparation and root amputation.

Surgical and nonsurgical procedures

Few short-term studies are available for comparisons of different forms of conservative techniques in the treatment of selected furcation lesions. The effectiveness of the various surgical and nonsurgical approaches employed has been studied in regard to the residual amount of subgingival calculus (22, 56, 73, 74, 103, 104), clinical parameters (38, 86, 99), and interradicular bone density changes (10, 76). Other studies have used mechanical debridement as a positive control to determine whether any possible adjunctive effect could be derived from the use of locally delivered antibiotic therapy beyond that of root planing alone (61, 66, 68, 94).

A preliminary report by Wylam et al. (103) demonstrated the inadequacy of root planing with or without surgical access in grade II and III furcation areas of condemned teeth: residual plaque and calculus were found in 89% and 95% of surgically and nonsurgically treated molars. A later article by the same authors (104) reported that residual calculus deposits covered on average 93.2% (range 79.2–100%) and 91.1% (range 77.4–100%) of furcal root surfaces after closed and open instrumentation, respectively.

In contrast, Matia et al. (56) found significantly more residual calculus after closed than open root planing in furcated molars with deep lesions (class II and III). No difference was observed between the use of ultrasonic scalers and curettes in either group. However, when the data were stratified according to the dimension of the furcation entrance, open debridement with ultrasonics left significantly less calculus than curettes in entrances measuring ≤2.3 mm. Similarly, Fleischer et al. (22) assessed the post-extraction amounts of residual calculus after a single session of scaling and root planing with or without surgical access performed by operators with two different skill levels. Among more experienced operators, open root planing left more furcations free of calculus than closed debridement (68% versus 44%), but this difference did not reach statistical significance. When these procedures were performed by the less experienced dentists, furcations occurred significantly more frequently with flap access than following closed debridement (43% versus 8%). Thus, the level of experience seems to play an additional role in furcation debridement, as the more skilled periodontists achieved calculus-free furcation surfaces more often than the less experienced operators, regardless of the type of approach, although a significant difference was noted only for those lesions treated with closed root planing.

No information was provided by Fleischer et al. (22) concerning the type and distribution of the furcal defects to be treated. Parashis et al. (73, 74) evaluated in detail the efficacy of calculus removal in class II and III furcations achieved by scaling and root planing with or without surgical access. A third approach comprised the use of a rotary diamond bur to remove calculus deposits in the furcation area after surgical exposure. This combined treatment was best in removing calculus from furcations, especially in the flute area and when the furcation entrance measured <2.4 mm. The studies by Matia et al. (56), Wylam et al. (103, 104), Fleischer et al. (22) and Parashis et al. (73, 74) were conducted on molars proposed for extraction, characterized by the presence of severe bone destruction and heavy calculus deposits. Whether the results reported in these articles are applicable to molars with less dramatic furcation involvements and calculus accretions has not yet been established by other investigations.

It can be concluded that experienced operators remove more calculus than those with less skill. In addition, the open approach proves more efficacious at removing calculus deposits from the furcation area, especially when combined with the use of a diamond bur.

However, the seemingly more beneficial results achieved with the combination of root planing and access surgery in terms of calculus removal demonstrated by Matia et al. (56), Parashis et al. (73, 74) and Fleischer et al. (22) are not accompanied by a
corresponding superiority when dealing with clinical parameters, as demonstrated by Kalkwarf et al. (38), Schroer et al. (86) and Wang et al. (99).

Kalkwarf et al. (38) evaluated the clinical response of furcation regions to four types of periodontal therapy: supragingival scaling, root planing, modified Widman flap surgery or flap surgery with ostectomy. Flap surgery with concomitant bone resection was significantly better at reducing pocket depth than the other procedures, producing a mean decrease of 1.65 mm. Conversely, it was the only type of treatment to produce a mean vertical attachment level loss (0.36 mm) at the end of the 2-year observation period. Supragingival scaling, root planing and modified Widman flap surgery demonstrated gain in probing attachment of 0.32 mm, 0.44 mm and 0.4 mm, respectively. All procedures, except root planing, caused a loss of horizontal probing attachment in furcations. The loss associated with osseous surgery was significantly greater (0.51 mm) than those created by supragingival scaling (0.13 mm) and modified Widman flap (0.14 mm). The best results for attachment levels (vertical and horizontal) and pocket depths were recorded within the first year post-operatively. Despite the limited reduction of pocket depths compared with the surgical procedures, root planing proved more efficacious in preserving both vertical and horizontal attachment levels in furcations, and even produced gains in some sites. Interestingly, the implementation of osseous surgery brought about the extraction of a remarkable number \( (n=55) \) of furcated molars compared to other procedures. On the other hand, the remaining furcations, once treated with bone resective surgery, yielded a lower percentage of sites demonstrating clinically significant breakdown during the 2 years of maintenance. This may derive from the apical positioning of the gingival margin, whereby a facilitated cleanability of the furcation entrance was attained.

Schroer et al. (86) investigated attachment level and probing depth change of closed versus open debridement in facial class II molar furcations. At 16 months, both procedures had reduced pocket depth by 1.2–1.5 mm. A mean gain in attachment level from baseline was observed after closed subgingival scaling (0.6 mm), whereas treated furcations lost attachment (–0.46 mm). However, this difference did not reach statistical significance. Similarly, Wang et al. (99) reported no statistically significant difference in attachment levels changes following either pocket elimination surgery, curettage or modified Widman flap.

The more favorable clinical outcome in terms of clinical attachment level observed by some investigators with closed debridement has also been corroborated by studies aiming at assessing the quantitative densitometric changes of alveolar bone within furcation areas either subjected to scaling and root planing or exposed to flap surgery (10, 76).

Payot et al. (76) treated class I or II furcation involvement with either subgingival curettage or modified Widman flap or by furcation osteoplasty. All 3 procedures resulted in an initial loss of density in the superficial layer of interradicular bone during the first 2 months following treatment. The loss was then followed by a statistically significant recovery, which became a net gain in density 1 year post-operatively only for sites treated by curettage. Likewise, bone loss was initially found in the profound layer after the two surgical procedures. However, a significant net gain in density was detected at the end of the study, 1 year after therapy.

Equivalent results were reported by Brägger et al. (10). Loss of bone density occurred readily after surgical exposure, whereas a gain was recognized for furcation sites treated by closed root planing, denoting a statistically significant difference between the two treatments. However, bone density levels were shown to be of comparable magnitude in surgical and nonsurgical sites 1 year post-operatively.

In conclusion, although scaling and root planing combined with flap surgery is more effective at removing calculus, the clinical evaluations do not indicate a dramatic difference between surgical and nonsurgical treatments irrespective of the degree of furcation involvement. Rather, closed scaling and root planing proves more effective at preserving the existing attachment level, together with producing a more expeditious bone remineralization, although these phenomena are accompanied by a lesser reduction in pocket depth. The equivalence in clinical efficacy between closed and open procedures may be attributed to the procedure, operator variables, compliance with professional recommendations, the initial risk of the patient or, most likely, to a combination of these factors.

A few studies are also available to compare the effects of conservative treatment (open debridement) following surgical access used as a positive control, with those of some selected regenerative procedures (39, 77, 105). Allografts such as porous hydroxyapatite (39) or tricalcium phosphate in combination with doxycycline (77) and collagen membranes (105) produced greater pocket reduction and
defect fill than surgical debridement alone in class II and III furcation defects.

**Chemotherapy**

The difficulties of performing adequate debridement in furcations by mechanical means has prompted experimentation with chemotherapeutic agents in these areas. Needleman & Watts (66) tested the adjunctive effect of 1% metronidazole gel irrigation into furcation areas with class II and III involvements during periodontal maintenance with subgingival scaling. Clinically, no further improvement was seen for the furcations treated with metronidazole. Likewise, lack of adjunctive effect exerted by the metronidazole gel was reported for proportions of spirochetes, motile rods and cocci observed with dark-field microscopy.

Nylund & Egelberg (68) evaluated the therapeutic effects of subgingival irrigation with tetracycline as a supplement to mechanical debridement in furcations with class I, II and III involvements. The professional irrigation of 50 mg/ml tetracycline solution was performed every second week for 3 months. One-year evaluation of attachment levels and pocket depths showed similar clinically negligible (<1 mm) variation in both tetracycline- and saline-irrigated furcations. It may be therefore concluded from these studies that sporadic, uncontrolled local delivery of antibiotic substances is unlikely to exert any supplemental effect over that produced by subgingival mechanical treatment. Consequently, Minabe et al. (61) immobilized tetracycline in a cross-linked collagen film to obtain a slow, sustained release of the drug. The film has been subsequently used alone or in conjunction with root planing in furcation class II involvements in a controlled randomized clinical trial. A dramatic decrease in frequency of sites bleeding on probing was noted in the group treated with a combination of tetracycline and mechanical debridement. The magnitude of reduction was significantly greater than that produced by either root planing or tetracycline film alone throughout the study period (8 weeks). Probing attachment levels and pocket depths were similarly reduced by the three treatment regimens. Likewise, comparable decreases in the three groups were observed for total microbial counts and proportions of spirochetes, which dropped from pre-operative values of 10–17% to proportions of 2–3% at the end of active treatment (4 weeks). At 8 weeks, spirochetes in all three treatment groups were still far below the initial counts, although a slight return towards baseline values was noticeable. Very recent data by Tonetti et al. (94) show that tetracycline-containing fibers exert a significant adjunctive pocket depth and bleeding reduction over that produced by scaling and root planing alone, although this finding is confined only to the first 3 months following fiber insertion. No difference between treatments could be observed, however, at the 6-month follow-up visit, except for the significant greater number of sites presenting with a pocket depth reduction >2 mm in the group receiving both scaling and root planing and fiber therapy. In summary, aside from a significant short-term anti-inflammatory effect mirrored by the increased reduction in bleeding upon probing, tetracycline in slow-delivery devices does not seem to greatly enhance or prolong the effectiveness of commonly used subgingival debridement in class II furcations.

**Tunnel procedure**

The tunnel preparation of multi-rooted teeth is a very conservative approach in the treatment of class II and III furcation involvement (Fig. 4). The objective of this treatment is to obtain the possibility of cleaning the furcal area by the patient using an interdental toothbrush (29). The main advantage of this technique is the avoidance of prosthetic reconstruction and, for mandibular molars, endodontic therapy. Unfortunately, tunnel preparation can be utilized only when the furcation entrance dimension is wide enough and coronally located to allow for an easy utilization of cleaning devices. These anatomical restrictions limit use of this technique mainly to mandibular first molars, even if it can be implemented sometimes in maxillary molars (31). In this situation, however, one of the three roots may have to be resected to improve accessibility to the furcation area.

Very few studies have investigated the possibilities of tunnel preparations. In a 5-year longitudinal study, Hamp et al. (29) found that four of seven teeth treated with this technique developed root caries, and three of them had been extracted during the observation time.

Helldén et al. (31) evaluated in a retrospective study the clinical outcome of tunnel preparations in 102 patients (149 teeth) for a mean observation time
of 37.5 months (range 10 to 107 months). Sixty-three maxillary and 35 mandibular first molars were the most treated teeth. Fluoride prophylaxis was performed after tunneling in the furcation areas. Ten teeth (7%) were extracted and 7 teeth (5%) were retreated by hemisection. In 12 of these 17 teeth, the extractions and hemisections had been performed because of root caries. Among the remaining 132 teeth, 23 (15%) showed initial or established caries. As approximately 75% of the treated teeth were still caries-free and in function at the end of the observation period, the authors opined that tunnel preparations had a considerably better prognosis than previously reported by Hamp et al. (29) and could therefore be considered a valid treatment alternative. However, this is not an evidence-based conclusion but rather only a proof of principle. To what extent the procedure is better or worse than other forms of conservative treatment cannot be said until a randomized controlled clinical trial is performed.

It could be argued that the shorter mean observation time could account for the relatively lower percentage of new root carious lesions reported by Helldén et al. (31) when comparing their results to those of Hamp et al. (29). However, the former authors observed an increase root carious lesions
development mostly during the initial 19 months of the follow-up period. This is in agreement with data reported by Ravald & Hamp (81) and Ravald et al. (82), who demonstrated that following periodontal surgery the development of root caries mostly occurs within 2 years after treatment. The results obtained by Helldén et al. (31) in relation to root caries development could be due to the fluoride prophylaxis performed by the patients in the furcations. In a recent study (51), the possibility of a tunnel preparation procedure has been evaluated in 18 subjects, each having a molar with Glickman class II or III furcation involvement, who were followed for a mean observation time of 5.8 years. The treated teeth were five maxillary and 13 mandibular molars. At the end of the observation period, root caries was detected in only three teeth (16.7%) confirming the results obtained by Helldén et al. (31). In addition, no difference was found in attachment level and in radiographic bone evaluation in surgically tunneled mandibular molars compared with adjacent sites treated by osseous surgery.

**Root amputation**

Root amputation is a technique used in maxillary molars by removing one of the three roots in order to eliminate the furcation problem and to achieve good access for proper plaque control. As this technique can be applied without gross changes in tooth anatomy and without prosthetic reconstruction, it can be considered a conservative approach to treat the furcation involvement. This technique was introduced by Farrar in 1884 (21) and reintroduced by Messinger & Orban in 1954 (60). It has been advocated for use in combined periodontal-endodontic lesions (95) as well as bone loss related only to periodontitis (1). Only a few studies have followed the clinical course following root removal. Green followed 122 cases of molar hemisection or root amputation for up to 25 years. In this group, 41 of 101 maxillary molars that received root amputation were removed, most before 8 years (26). The cause of loss in almost every case was continuing breakdown of periodontal bone in spite of good oral hygiene and careful plaque control on the part of these patients. Patients in a second study fared better, with 33 of 34 maxillary molars surviving for 11 to 84 months after root amputation (41). Clinical experience has shown that this procedure is often an interim step and that a large percentage of these teeth fail within a few years of root removal.

**Concluding remarks**

- The studies reviewed here have shed new light on the topic, transforming our therapeutic concepts and prognostic paradigms regarding the management of furcation lesions.
- No data are to date available to infer that any of the various approaches advocated for treatment of furcation lesions is to be preferred because it produces better long-term results in terms of functional survival. Likewise, studies comparing the effects of different approaches within the same subject are lacking.
- Retrospective long-term studies based on tooth mortality demonstrated that teeth with initial furcation involvement can have a remarkable survival rate following conservative treatments in patients responding well to treatment.
- However, furcated teeth are lost in higher proportions as compared with single-rooted teeth or with nonfurcated molars. The same trend has been shown in studies based on clinical parameters, comparing the outcome of treatment between teeth with furcation involvement with molar flat surfaces and single-rooted teeth (36, 54, 67, 99).
- These results could have been caused by the difficulties in obtaining adequate debridement in teeth with furcation involvement. The peculiar anatomy of the area and the dimensions of the entrance diameter seems to be the reason for the possible presence in furcations of residual amounts of subgingival plaque (53) and calculus (56, 73, 74). In this regard, more effective debridement was achieved in class II and III furcation involvement when surgical access was provided and ultrasonic scalers or rotary diamond burs were implemented (48, 56, 73, 74).
- However, the clinical outcome of surgical and nonsurgical approaches is comparable in long-term as well as in short-term longitudinal studies. In some instances closed root planing has been shown to better preserve clinical attachment levels (38, 86) and exert faster remineralization of the interradicular alveolar bone (10, 76).
- The above-mentioned studies show that the incomplete removal of subgingival debris in furcations using conservative treatments may not affect the clinical and biological response on an individual site and patient basis. On the site level, the procedure utilized during the conservative approach may have enhanced both self-performed and professionally performed plaque control. On
the patient level, the favorable response to treatment of most subjects observed in the long-term retrospective studies (well-maintained groups) together with the long functional survival rate of most furcated molars may be related to adequate plaque control and low susceptibility to disease in the majority of periodontal patients, thus explaining the long-standing acceptable results of treatment. On the other hand, the specific procedures employed and the severity of furcation involvements were not taken into account in these surveys. This made it impossible to relate the type of treatment applied to the degree of involvement in the evaluation of the outcome of therapy.

- A very limited number of studies have been performed on tunnel preparation, with differing results. However, the study by Hellénd et al. (31), who enrolled a considerable number of patients, demonstrated promising results, although the mean observation time was limited. Moreover, long-term prospective and controlled studies on this technique are needed to corroborate these findings.

- Very little information is available on root amputations and odontoplasty. However, root amputation has not been extensively used in clinical long-term studies. Therefore, caution must be exercised when interpreting the limited published data.

- The use of drugs does not seem to add long-term advantages to the benefits obtainable by root planing alone. However, the encouraging short-term reduction in bleeding on probing and pocket depth observed by Tonetti et al. (94) indicates that high concentrations of an antimicrobial drug combined with conventional treatment have the potential of improving the clinical response at furcation sites, during supportive periodontal care.

- Even if the management of furcation involvement teeth with a conservative approach does not yield the same satisfactory results as with single-rooted teeth or molar flat surfaces, the alternative treatments based on resection or regeneration are not much more promising. Studies on regeneration have shown the unpredictability of complete closure of furcation involvement (16). Some reports on root resection or root separation have shown remarkably low failure rates (4–8%) (2, 5, 15), although other long-term studies demonstrated definitely less favorable results with such therapy, tooth mortality ranging after 10 years between 32–38% (12, 26, 47), while Langer et al. (47) reported a total failure rate of 51% after 20 years of follow-up. However, the well-maintained groups, representing the vast majority of the patients in long-term retrospective studies based on a conservative approach, have shown, in a much longer observation period, a tooth mortality of furcation involvement molars ranging from 16.7% to 27.7% (Table 3). These rates are much lower than those reported by the majority of the studies based on root separation or resection for a considerably shorter time. These findings lead to the conclusion that the conservative approach for furcation involvement teeth can be performed in the majority of patients with the expectation of a high long-term survival rate for the patients demonstrating an overall satisfactory response to conventional periodontal treatment (Fig. 5).

### Establishing prognosis

The prognosis of furcated teeth treated by conservative approach lends itself to a moderate degree of optimism, bearing in mind, however, that the presence of interradicular alveolar bone destruction may still be considered a local risk factor for tooth loss (58, 59) (Table 4).

Other local factors may accelerate the rate of disease progression, thus increasing the risk for exfoliation of furcated teeth: restorations (98) and smoking habits (64) have been shown to be positively correlated with the presence of furcation involvement, while mobile furcated molars are at greater risk for loss of attachment in the furcation area (99).

A few risk factors have been identified in the literature to play a role in the fate of treated furcated teeth. Advanced periodontal disease (7) and smoking have generally been shown to influence the outcome of therapy in conservative and resective treatments (7, 37). Such factors must be kept in mind by the clinician in that their suppression or reduction may greatly improve the prognosis of furcated teeth. Moreover, genetic testing for inflammatory modifiers (44) may be helpful to guide treatment planning and prognosis for the different approaches according to the individual response to treatment.

Once the identified risk factors are ameliorated or eliminated, the clinician may consider the conservative approach as a first option. Frequent monitoring during supportive periodontal treatment is important to ensure the stability of the periodontal structures within furcations. If recurrence appears, additional care, including new instrumentation, local
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Fig. 5. A, B. Clinical pictures taken in 1980 from a patient with generalized periodontal destruction. The patient was treated by scaling and root planing under local anesthesia and refused surgical treatment. C, D. Clinical pictures of the same patient 17 years later. Note the good plaque control and the generalized recession of the gingival margin. The patient had been subjected to 3-month supportive periodontal care since initial scaling and root planing. E. Initial radiograph of maxillary right molars showing furcation involvement in the first molar (the tooth was vital). F. Radiograph of the same area as in Fig. 5e showing the remineralization of the interradicular osseous lesion 17 years later. The wisdom tooth was extracted. G. Clinical appearance of the area in 1997.
Fig. 6. A. A radiography of the mandibular right posterior sextant taken in 1981. B. The patient (seen here in 1987) continued to lose bone in spite of the fact that he improved his compliance with home care and professional cleanings and had several rounds of closed and open scaling and root planing. C. The teeth were removed in 1997 and dental implants placed. The patient was found to be genotype-positive for the IL-1 gene.

drug therapy and root separation, may be appropriate.

References


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