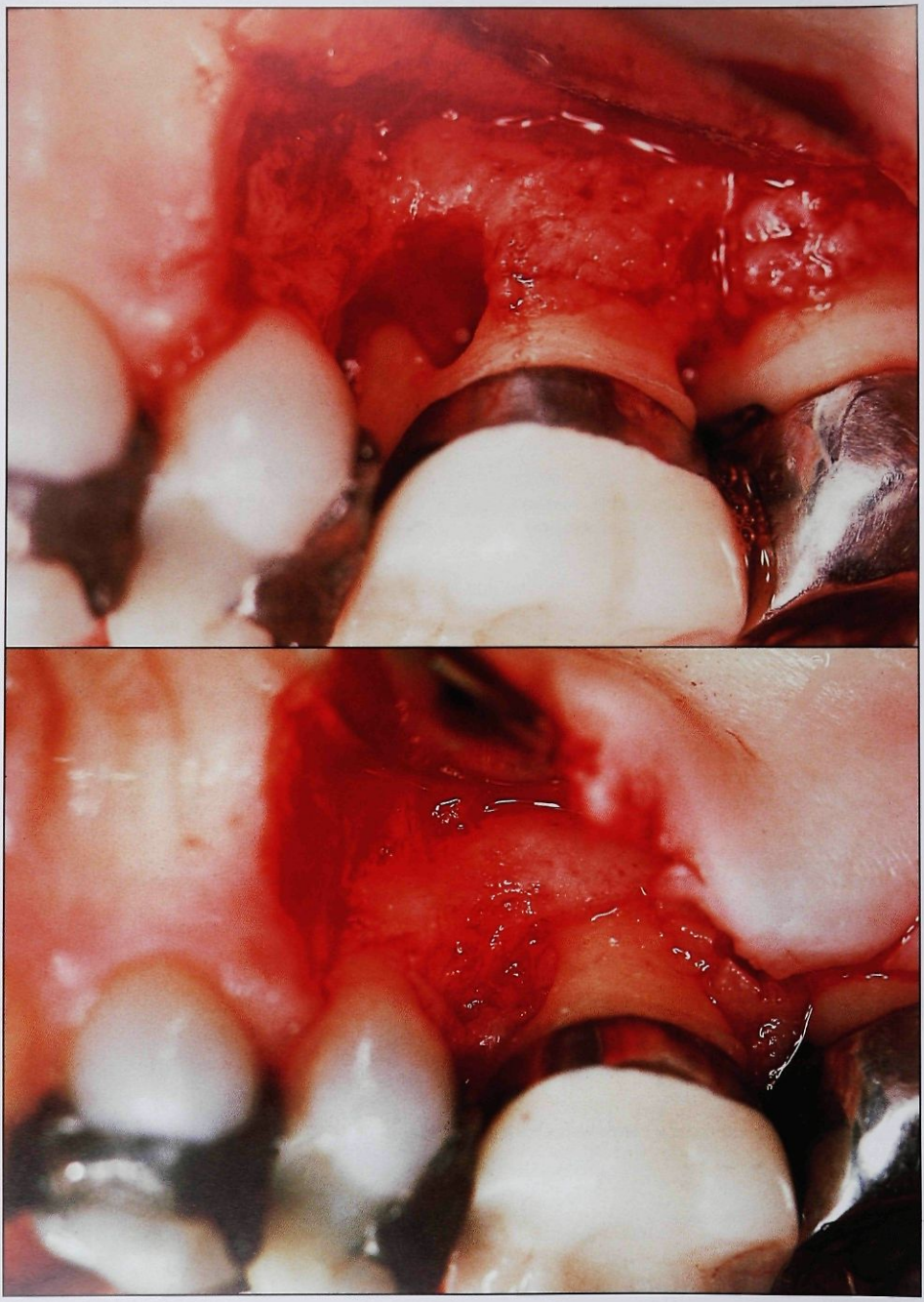

Regenerative Therapy in the Treatment of Maxillary Molar Class II Furcations: Case Reports

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This report demonstrates the use of regenerative therapy in the treatment of maxillary molar Class II furcations. The predominant therapy provided was open debridement in combination with DFDBA, e-PTFE membranes, and citric acid root conditioning. Case reports of consecutively treated patients that include radiographs and reentry photographs demonstrate that maxillary molar furcations can be successfully treated with predictability. (Int J Periodont Rest Dent 1997;17:517–527.)

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The long-term maintenance of maxillary molars with furcation involvement remains one of the greatest challenges in periodontics. Long-term retrospective studies have shown that maxillary molars are the teeth most often lost.[1-4] Factors such as the inability to adequately clean furcation defects,[5] anatomic anomalies,[6,7] and position in the arch have made these teeth difficult to treat and to maintain in health and comfortable function.

Options for treating maxillary molars with furcation involvement include: tunnelization,[8,9] root resection,[10] and soft tissue surgery.[11] Tunneling procedures carry the risk of exposing the furcation to caries,[8] significant sensitivity, and recurrent disease as a result of the difficulty of cleaning this exposed area. Root resection has met with mixed results. While some studies have demonstrated excellent success,[12,13] others[14,15] have shown less favorable results related to endodontic

failures, root fractures, and continued bone loss. The cost of root resection and subsequent prosthetics is also a concern. Ross and Thompson[11] reported on 387 furcation defects in maxillary molars treated by soft tissue surgery. They followed these sites 5 to 24 years and reported a functional survival rate of 88%. Neither the degree of furcation invasion nor the level of health maintained was discussed in this article.

Recent efforts have aimed at treating maxillary furcation defects by regenerative therapy such as guided tissue regeneration with expanded polytetrafluoroethylene (e-PTFE) membranes[16-22] or combination therapy.[17,19] While success has been demonstrated for mandibular furcations,[17,19,23-39] the same has not been true in the maxilla.[18,20,21] Most controlled studies[18,20,21] in which e-PTFE has been used alone to treat maxillary furcation defects demonstrate more failures than successes. This has left clinicians believing that regenerative treatment of maxillary molars is unpredictable.

Contrary to this opinion is the landmark paper of McClain and Schallhorn.[19] Their study illustrated that maxillary molar Class II furcations could be closed by a combination of composite grafting, root conditioning, and guided tissue regeneration, and that furcation closure was stable over a 5-year period.

The purpose of this article is to report the results of a series of maxillary Class II furcation involvements that were treated by various regenerative techniques.

Method and materials

Twelve patients (three women and nine men), ranging from 31 to 63 years of age, are included in this report. All patients were diagnosed with adult periodontitis and were referred for comprehensive treatment. As a part of their initial therapy, patients were required to perform plaque control until visible plaque was absent or light. This consisted of a minimum of two visits outside the dental operatory environment where plaque disclosure, technique demonstration, and performance were reinforced. Patients also received supragingival and subgingival scaling and root planing. Occlusal therapy, where indicated, consisted of bite adjustment or splinting of teeth to reduce/eliminate excessive mobility or fremitus patterns. Examinations included assessment of probing depth (PD), clinical attachment level (CAL) and degree of furcation involvement as determined by a Nabers probe (Hu-Friedy). Zero horizontal depth was determined as having furcation closure (FC) while 1- to 2-mm horizontal depth was classified as a

Class I furcation invasion, and a depth of 3 mm or greater was classified as a Class II defect. Patients rinsed for 30 seconds immediately prior to the surgery with Peridex (Proctor & Gamble).[40] Full-thickness flaps using sulcular incisions were used to gain access. Defects were thoroughly debrided and the roots were scaled and planed with hand, ultrasonic, and rotary high-speed finishing burs (Brasseler). Citric acid (pH 1) root conditioning was performed for 3 minutes. Intramarrow penetration was performed to enhance rapid revascularization. Bony ledges or exostoses were removed or reduced to enhance primary closure and to permit coronal positioning of the buccal flap. Nine furcations were treated with demineralized freeze-dried bone allograft (DFDBA, LifeNet) mixed with tetracycline in a ratio of 4:1 and covered by an e-PTFE membrane (WL Gore), two were treated with DFDBA/tetracycline veneered by a demineralized freeze-dried laminar bone strip (100 to 300 μm thick), two were treated with DFDBA alone, one was treated with DFDBA combined as a composite graft with calcium sulfate and tetracycline covered by an e-PTFE membrane, and one was treated with DFDBA mixed with tetracycline. Demineralized freeze-dried bone allograft was placed to overfill the defects with light incremental pressure. The e-PTFE membranes were secured by a sling suture with attention to covering the defect and surrounding 2 to 3 mm of bone margin with the membrane. Flaps were positioned to obtain primary closure and were sutured with interrupted e-PTFE sutures. Coepak (GC America) was placed over the surgical site as a periodontal dressing for approximately 7 to 10 days. Patients were prescribed penicillin, erythromycin, or doxycycline for the first 10 to 14 days, followed by doxycycline, 100 mg per day, for an additional 21 days.

Patients were seen every 7 to 10 days for postoperative treatment until the time of membrane removal. At the first to third visits, loose sutures were removed. After membrane removal, patients were seen bimonthly for the second month and every 3 months thereafter. Postoperative visits included plaque debridement, both mechanically and with topical chlorhexidine, selective stain removal, and reinforcement of oral hygiene.

The e-PTFE membranes were retained for 4 to 7 weeks; however, at two sites the membranes were removed at 3 weeks because of excessive exposure and accompanying recession. Membranes remained in a tight collar position until their removal, which was carefully done under local

Table 1 Summary of furcation information

Patient no.	Sex	Age	Smoker (Y/N)	Site	Pretreatment CAL	Pretreatment PD	Months post-surgery	Barrier used	Tetracycline in graft?	Barrier removal (wks)	Posttreatment CAL	Posttreatment PD	FC?
1	M	59	N	14(26)D	9	9	18	L	Y	NA	5	4	Y
2	M	42	N	2(17)MP	9	9	14	E	Y	6.0	4	4	Y
		42	N	15(27)MP	9	9	18	L	Y	NA	3	3	Y
3	F	35	Y	14(26)MP	8	8	15	E	Y	3.0	4	3	Y
4	M	5	N	14(26)MP	7	7	6	E	Y	4.5	3	3	Y
5	M	63	Y	3(16)MP	7	7	18	E	Y	5.0	5	4	N
		63	Y	14(26)MP	5	5	15	E	Y	4.0	5	5	N
6	F	46	N	15(27)MP	10	10	45	N	N	NA	5	4	Y
7	M	45	N	3(16)D	7	7	12	E	Y	7.0	3	2	Y
8	M	48	N	3(16)MP	10	11	12	E	Y	5.5	4	3	Y
9	M	50	N	3(16)MP	7	7	7	E	Y	5.0	6	6	N
10	F	52	N	3(16)MP	7	7	41	E	Y	4.0	3	3	Y
11	M	31	Y	15(27)D	7	7	37	N	N	NA	5	5	N
12	M	58	N	1(18)D	6	6	21	N	Y	NA	3	3	Y
		58	N	15(27)D	6	5	20	E	Y	3.0	4	3	Y

Treatment sites are given in the Universal tooth numbering system; FDI notation is given in parentheses. CAL = Clinical attachment level; PD = probing depth; N = no; Y = yes; D = distal; MP = mesiopalatal; E = e-PTFE; L = demineralized freeze-dried laminar bone strip; N = no barrier; NA = not applicable; FC = furcation closure.

Table 2 Summary of results by treatment modality

Treatment	No. of sites	Furcation closure (*n*)	Percent successful
DFDBA + TTC + e-PTFE	9	6	67
DFDBA + TTC + DLBS	2	2	100
DFDBA	2	1	50
DFDBA + TTC	1	1	100
DFDBA + $CaSO_4$ + TTC + e-PTFE	1	1	100
Combination therapy (e-PTFE only)	10	7	70
Combination therapy (Total sites = e-PTFE + DLBS)	12	9	75
Graft alone total	3	2	67
All sites	15	11	73

DFDBA = Demineralized freeze-dried bone allograft; TTC = tetracycline; e-PTFE = polytetrafluoroethylene barrier; DLBS = demineralized freeze-dried laminar bone strip; $CaSO_4$ = calcium sulfate.

anesthesia and flap reflection. The flap was repositioned to cover the regenerated tissue and sutured for 1 week.

Results

Fifteen maxillary molars were consecutively treated in 12 patients. A majority of the Class II furcations would not be described as "keyhole lesions" when using Tarnow and Fletcher's[41] classification, since 10 of the teeth had Class IIB

Fig 1a *Mirror view shows Class II furcation invasion at the distal of the maxillary right first molar of patient 7.*

Fig 1b *Broad three-walled intrabony defect associated with the distal of the first molar.*

Fig 1c *Demineralized freeze-dried bone allograft mixed with tetracycline is placed after citric acid conditioning of the roots.*

Fig 1d *Expanded polytetrafluoroethylene membrane is secured by a sling suture.*

Fig 1e *Reentry at 1 year shows complete resolution of the intrabony defect.*

Fig 1f *The distal furcation is completely closed with bone. There has been a 4-mm gain in clinical attachment level, while probing depth has been reduced by 5 mm.*

furcation involvement, while five had Class IIA involvement. There was an intrabony component associated with six of the 15 furcations, and the crestal height of the intrabony defect was always below that of the furcation fornix.

Results of treatment are summarized in Table 1. Of the 15 molars treated, 11 were clinically closed for an overall success rate of 73%. Seven of the 11 closed furcations were located on the mesiopalatal aspect, while four were located on the distal. None of the furcations treated were on the buccal aspect. The four furcations that did not respond remained as Class II defects.

Four of the furcation defects treated were in three patients who were smokers, all of whom smoked one half of a pack of cigarettes per day or less. Only one of their furcations treated was closed compared to 10 of the 11 furcations in nonsmokers, representing a 25% success rate for smokers versus a 91% success rate for nonsmokers.

Table 2 summarizes the success rate of the different modalities of treatment. Combination therapy with either e-PTFE or a laminar bone strip covering the DFDBA had a success rate of 75%. Demineralized freeze-dried bone allograft alone or mixed with tetracycline was successful in closing 67% of the furcations treated.

Surgical reentry was performed at 12 to 37 months on eight closed furcations, and representative photographs are shown in Figs 1 to 3.

Fig 2a *Pretreatment radiographs of the maxillary right first molar in patient 8. An advanced intrabony lesion with Class II furcation invasion is suggested at the mesial of the first molar.*

Fig 2b *Surgical view of the mesiopalatal furcation prior to the completion of scaling, root planing, and citric acid treatment. The angular lesion is a combination of one, two, and three walls associated with a Class II furcation.*

Fig 2c *Demineralized freeze-dried bone allograft mixed with calcium sulfate and tetracycline is placed to fill the furcation and osseous defect.*

Fig 2d *Expanded polytetrafluoroethylene membrane (GTA2) is trimmed and secured to cover the DFDBA.*

Fig 2e *Radiograph taken at 1 year posttreatment suggests complete fill of the intrabony lesion and the furcation.*

Fig 2f *Reentry at 12 months confirms the complete furcation fill. There has been a gain of 6 mm in the clinical attachment level and a reduction of 8 mm in the probing depth.*

Discussion

These case reports demonstrate that maxillary molars with Class II furcation defects can be closed by various types of regenerative therapy. The technique most commonly used was DFDBA and e-PTFE plus citric acid root conditioning. These results are consistent with those of McClain and Schallhorn,[19] who treated 11 maxillary furcations with composite grafting, e-PTFE, and root conditioning, and had complete furcation fill in eight cases for a success rate of 73%. The case reports presented in this study compare favorably to studies where flap debridement with e-PTFE membranes was used to treat maxillary molar Class II furcations. Metzler et al[18] and Mellonig et al[20] reported that none of their maxillary molars reentered at 6 months had complete furcation fill. Pontoriero and Lindhe[21] had three test sites, flap debridement with e-PTFE membranes, and one control site, flap debridement alone, of the 56 molars treated fill completely with bone. Flores-de-Jacoby et al[22] reported furcation closure in 50.7% of their 73 maxillary molars treated and maintained over a 4- to-6-year period.

Fig 3a *Pretreatment radiograph of the maxillary right first molar in patient 10. Bone loss is suggested in the furcation.*

Fig 3b *Surgical view of the mesiopalatal furcation after root planing with finishing burs on a high-speed handpiece and citric acid treatment. There is a combination one-wall/two-wall defect at the mesial of the molar.*

Fig 3c *Demineralized freeze-dried bone allograft mixed with tetracycline is placed in the furcation using light pressure.*

Fig 3d *Expanded polytetrafluoroethylene membrane (GTA2) is placed and secured with an e-PTFE sling suture.*

Fig 3e *Reentry at 14 months shows complete furcation fill with bone. The clinical attachment level and probing depth have improved by 4 mm.*

Fig 3f *Radiograph at 37 months suggests continued stability of the furcation. Probing depth and attachment level measurements have remained unchanged.*

There are many elements that affect the outcome of regenerative treatment, particularly in furcation defects. Machtei and Schallhorn[42] summarize factors that affect clinical outcomes of molar furcations in their recent article. While no particular factor can be considered most important, some factors appear to be more crucial to the closure of maxillary molar Class II furcations. These include furcation access, combination therapy (the use of an inductive graft material plus a barrier), plaque control and supportive periodontal treatment, and the smoking status of the patient.

Successful wound debridement and root preparation are dependent on access to the area. Both Metzler et al[18] and Pontoriero and Lindhe[21] demonstrated better results in buccal furcation defects than in defects at the mesiopalatal or distal aspects of maxillary molars. In attempting regeneration in a furcation, access is important.[18,21,43-45] The use of narrow, flame-shaped finishing burs on a high-speed handpiece will give the operator better access for odontoplasty and cleaning of the furcation than traditional hand instrumentation.

The inductive potential of DFDBA[46,47] and its ability to enhance periodontal regeneration is well established in the literature.[48,49] The DFDBA not only induces bone formation, but one of its morphogenetic proteins, BMP-2, has also been shown by Sigurdsson et al[50] to induce new cementum formation. McClain and Schallhorn[19] reported excellent results in maxillary Class II furcations after combining DFDBA with an e-PTFE membrane.

The combined use of DFDBA and tetracycline in a ratio of 4:1 was influenced by the impressive results of Yukna and Sepe[51] and Mabry et al.[52] Retrospective evaluation of tetracycline incorporated with DFDBA has indicated trends toward improved attachment levels versus DFDBA alone in intrabony sites followed for 2 to 5 years.[53] The incorporation of tetracycline with DFDBA may be beneficial for both its bacteriostatic properties and stabilization of collagen.[54] The clinician must not be overzealous when using tetracycline, because high concentrations may denature some of the essential morphogenetic proteins or interfere with fibroblastic proliferation.[55]

Successful regenerative treatment relies on excellent postoperative plaque control. Cortellini et al[56] found that the full-mouth bleeding scores of their patients directly correlated to the gains seen in clinical attachment levels. The concern with the use of e-PTFE membranes is contamination by putative periodontal pathogens. Machtei et al[29,43] reported that mandibular Class II furcation sites infected by *Actinobacillus actinomycetemcomitans* had significantly less bone fill. Selvig et al[57] and Nowzari and Slots[58] reported that bacterial colonization of the e-PTFE membranes can be detrimental to the regenerative site. Studies[59,60] in which antibiotics were used in conjunction with e-PTFE membranes have shown better gains in probing attachment levels.

Effective plaque control was obtained in this study in several ways. Patients rinsed with Peridex immediately prior to the surgical procedure to reduce salivary bacteria.[40] Systemic antibiotics were used throughout the critical healing period until membrane removal. Patients were deplaqued on a weekly basis until membrane removal.

It is essential to have such stringent plaque control while the membranes are in place, because exposure of the membrane collar may be unavoidable as a result of the anatomic concavity of the maxillary molar root trunk.[61] This could lead to the membrane acting as a nidus for bacterial colonization and subsequent infection of the site.

Recent evidence has demonstrated the negative effects of smoking on regenerative therapy in humans.[62-64] Rosenberg and Cutler[63] found that smokers treated with guided tissue regeneration for Class II molar furcation involvement contributed to 80% of failures. The effect that smoking exhibits may be related to the vasoconstrictive properties of its by-products that penetrate the saliva and crevicular fluid,[65] its alteration of fibroblast adherence,[66] and its diminution of phagocytosis by polymorphonuclear leukocytes.[67] The expectation for success has to be tempered for patients who use tobacco products. The authors tried to limit therapy to patients who smoked less than 10 cigarettes per day. This was based on a study by Ah et al,[68] who showed that patients that smoked greater than 10 cigarettes per day responded less favorably to both surgical and nonsurgical periodontal therapy than nonsmokers.

Conclusion

The case reports presented support the use of regenerative treatment for closure of maxillary furcation defects. The technique most frequently used was flap debridement in combination with DFDBA, e-PTFE membranes, and citric acid root conditioning. Radiographs and reentry documentation of bone fill strongly suggest that maxillary furcations can be successfully treated with predictability. Access to the furcation, plaque control, supportive periodontal treatment, and smoking appear to be critical factors in the successful closure of maxillary furcations.

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