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CLINICAL ARTICLE

Vital Root Resection in Maxillary Molar Teeth: A Longitudinal Study

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Root resections were performed on 86 maxillary molars as part of periodontal therapy. The amputation sites were sealed with Dycal and amalgam. The teeth were evaluated for vitality using electric pulp testing and cold (ice) up to 9 yr postoperatively. The greatest loss of vitality occurred within 12 months. The percentage of vital teeth at 6 months was 59% and at 12 months 38%. The number of vital teeth continued to decline until only 13% tested vital at 5 yr. The long-term prognosis for a vital root resection is poor; therefore, endodontic therapy prior to resection is preferable.

Root resection is the clinical procedure intended to remove one or two roots of an involved molar tooth while retaining the crown portion intact. It is synonymous with root amputation. This is in contrast to hemisection which removes the root of the involved tooth and the contiguous crown portion.

ETIOLOGY AND INDICATIONS

Advanced periodontitis with resultant interradicular bone loss is the most common area of furcation involvement (1). The furcation area is one of the most susceptible areas to advancing periodontal disease because it is almost inaccessible to plaque removal efforts. The furca of maxillary molars may be invaded on the buccal, mesial, or distal aspects. Less common causes of furcation involvement would include tooth fractures, juvenile periodontitis, enamel projections, faulty restorations, and perforations during endodontic therapy or post preparation. Some indications for root resections are: isolated areas of severe bone loss involving an individual root (2), fractured roots, failure of endodontic therapy (2, 3), bone resorption involving the furcation area of multirooted teeth (4), close interdental root proximity making plaque removal impossible, extensive root exposure and dehiscence contraindicating new attachment procedures (5), and root or furcation perforation.

CONTRAINDICATIONS

A thorough diagnosis can often unvail potential complications and risks that might occur during or after the surgical procedure. The surgical exposure can also reveal complications that may preclude root sectioning and even suggest extraction. Sectioning procedures should not be undertaken when the following conditions exist: individual roots are fused or are in close proximity to one another, poor root form or length of the retained roots, apical location of the furcation area, advanced bone loss and secondary occlusal trauma, or evidence of poor oral hygiene, suggesting a poor prognosis.

DIAGNOSIS

Radiographic and clinical examination are the basis for formulating a diagnosis and treatment plan. Several factors need to be considered: topography and dimension of the supporting alveolar bone, anatomy and configuratiion of the supporting roots, and position of the tooth in the arch (6). The extent of lateral periodontal destruction has been the basis for classifying furcation involvements by several authors (6–9). The three basic classes of furcation involvements are: *class 1*—pocket formation into the flute of the furcation with only incipient osseous destruction and intact interradicular bone; *class 2*—pocket formation into the furca to varying depths with significant interradicular bone loss but no through-and-through communication to the opposite side; and *class 3*—pocket formation with complete loss of interradicular bone that results in a through-and-through communication from one side of the furca to the other. Hamp et al. (9) refined the classification system by adding horizontal probing measurements. Class 1 represents horizontal attachment loss of less than 3 mm while class 2 is greater than class 1 but not equal to the total width of the furca. Class 3 involvement was through-and-through.

Radiography is a helpful adjunct to diagnosis but it has definite limitations. Van Swol and Whitsett (10) presented a radiograph depicting a hopeless prognosis due to lack of osseous support. The actual osseous

morphology in the interradicular area was more accurately determined by using Nabors furcation probes and bone sounding (11). Their clinical findings were not in agreement with the hopeless osseous picture depicted by the radiograph. Ross and Thompson (12), using radiographs, a periodontal probe, and a #17 explorer, examined furcation involvements and reported that only 22% of maxillary furcal involvements could be diagnosed by radiograph only. Their study often showed a lack of agreement between the results of radiographic and the clinical examinations. Since only 3% of the furcation involvements were diagnosed clinically, radiographic examination was the most frequent method of detecting furcation involvements in maxillary molars.

Glickman (13) found clinically significant tissue changes in furcation areas that were not detected radiographically. All of these studies seem to indicate that both radiographic and clinical examination are essential in order to formulate a diagnosis and treatment plan that might include root resection.

MANAGEMENT OF THE FURCATION AREA

Elimination of a periodontal pocket localized around an individual tooth root was described as early as 1884 by Farrar (14) and by Black and Litch in 1886 (15). Messinger and Orban (16) described four successful cases in which deep pockets were eliminated by root resection which was preceded by endodontic therapy. Arvins (17) described a root resection technique involving a hopeless abutment tooth in a fixed bridge. Endodontic therapy was completed prior to periodontal surgery and concurrent resection. The clinical postoperative follow-up showed osseous fill in the root extraction site and a healthy dentogingival attachment.

Bergenholz (18) described a method called radectomy, which involved the resection of one or more roots. Forty-five radectomies were performed with follow-up periods up to 11 yr. His findings showed a good prognosis for the resected teeth but bone loss with accompanying pocket depth increased in the area of root resection during the first 5 yr. This was attributed to progressive marginal periodontal disease. His conclusion was that radectomy was a viable therapeutic mode for retaining natural teeth. Failures were related to lack of success in controlling the progression of periodontal disease, not due to complications of the surgical procedure itself.

A primary objective in root resection is the modification of tooth anatomy in order to enhance plaque removal. Root resection has been classically indicated for class 3 furcas (4, 9), but it is often the procedure of choice in class 2 involvements where osteoplasty would continue to make the furcation inaccessible for plaque removal or would sacrifice too much supporting bone from adjacent teeth. However, a different perspective in regard to root resection was expressed by Ross and Thompson (12), who studied molars with furcation involvements and found them to be functioning well for 5 to 24 yr without root resections. They suggested that root resection may not be necessary to improve the functional environment of the involved teeth. Their study showed no correlation between survival time and severity of the defect. Teeth with root resection were not included in the study and some of the extracted teeth might have been retained longer had resection techniques been implemented.

The root resection procedure must include clinical management of the periodontal disease affecting the entire tooth. This means pocket curettage, root planing, and any necessary osteoplasty needed to establish a healthy dentogingival unit. Odontoplasty must be performed in order to minimize occlusal forces and eliminate damaging occlusal interferences in centric and eccentric jaw movements. Coronal reshaping also helps to distribute occlusal forces and minimize chances for crown fracture (19) while facilitating plaque removal for the patient.

VITAL ROOT RESECTIONS

In a number of instances, definitive decisions regarding root resections cannot be made until the area is exposed surgically. At this time the actual amount of furcation destruction, root exposure, root proximity, root anatomy, furcation anatomy, and extent of osseous destruction can be accurately assessed. Weine (5) and Goldman and Cohen (8) believe that endodontic therapy should always precede root resection. However, the patient would have been subjected to an additional and unnecessary procedure and expense if the root resection proved unnecessary.

One of the first investigators to describe long-term success with vital root resection was Haskell in 1966 (20). Four successful cases were evaluated with observation periods ranging from 1 to 5 yr. In 1969 he reported 10 maxillary molars with vital root resections covering a period from 6 months to 6 yr (21). None of the molars retained vital pulps and only one failure occurred after 7 wk. He felt that endodontic procedures could be performed if pulpal disease occurred after a vital root resection.

Haskell and Stanley (22) reported a histological study of vital root resection 9 yr after calcium hydroxide was placed over the exposed pulp. The sections showed a dentinal bridge protecting a pulp which was generally free of inflammation and contained many pulp stones. Haskell et al. (23) performed root resections on 12 maxillary teeth and evaluated them over a 3-yr period. Three of these 12 teeth lost pulpal vitality within 1 to 5 months and required endodontic therapy.

Smukler and Tagger (24) and Tagger and Smukler (25) reported the effects of vital root resection on the remaining pulps of 26 teeth. The pulps responded

normally to vitality testing prior to root resection and 2 wk after resection. The exposed pulps were unprotected during this interval after root resection. Immediately before endodontic therapy, the pulpal tissues were removed with barbed broaches and processed for histological evaluation. The resected roots were decalcified, processed, and used as controls for comparison to the coronal pulps. They found the healthy vital pulps to be resistant to infection through the exposure site during this limited period of time, as evidenced by the absence of bacteria after gram staining. Histological examination of the extirpated pulps showed exudative and proliferative changes with inflammatory cells usually associated with granulomatous pulps at the exposure sites. The apical portions of the pulp showed no inflammatory changes.

COMPLICATIONS WITH VITAL ROOT RESECTIONS

Smukler and Tagger (24) reported difficulty in obtaining profound anesthesia due to chronic inflammation of the pulps following root resection. Endodontic therapy, however, was not significantly modified by the change in tooth shape. On the other hand, Abrams and Trachtenberg (3) believed that altered tooth anatomy following vital root resection may adversely affect the performance of root canal therapy and the prognosis following therapy. In their opinion, maintaining the integrity of the anatomical crown and pulp chamber was necessary for an effective seal of endodontic medicaments. If root resection preceded endodontic therapy, a proper pulpal dressing and seal at the resection site was deemed necessary to maintain this integrity.

Pulpal calcification in the remaining canals may occur after vital root resection. Smukler and Tagger (24) found isolated areas of firosis and calcification in coronal pulps of vital teeth 2 wk after vital root resection. Haskell et al. (23) found dystrophic calcification, pulp stones, and scar tissue within the resected root areas after 1 to 3 yr. They felt that pulpal calcification would not affect the endodontic treatment or prognosis of a tooth with a vital root resection. Gerstein (26) expressed an opposing view and considered dystrophic calcifications from a chronically inflamed pulp to be a serious complication if vitally resected teeth were retained for any extended period. However, he did not feel this should be a deterrant to utilizing vital root resection techniques for a short period of time.

A chronic inflammatory response can produce internal resorption and several authors have reported internal resorption after vital root resection (23, 27, 28).

PURPOSE

An extensive review of the literature shows that few longitudinal studies have been done in regard to success or failure of vital root resections. Most were limited in scope and did not involve a sufficient number of cases or sufficient observation times. The purpose of this study was to determine the period of vitality to be expected after vital root resections in maxillary molar teeth and to evaluate the success and failure over a 9-yr period.

MATERIALS AND METHODS

A total of 86 maxillary molars were studied. The ratio of maxillary first molars to second molars was 3:1 (65 to 21). The teeth were periodontally involved and a mesiobuccal or distobuccal root resection was indicated as part of the overall periodontal therapy. Vitality testing was performed using an electric pulp tester and cold (ice).

At the time of surgery a wedge-shaped section of root was removed at the junction of the root and crown. The crown portion of the tooth was contoured for accessibility to allow adequate oral hygiene maintenance. A small retentive preparation was made at the amputation site and the pulp stump was dried by blotting with dry cotton. Dycal was then applied and allowed to set. When the area was free of any bleeding or wetness, amalgam was gently condensed into the preparation. Care was taken not to dislodge the Dycal base. After the amalgam had been placed and allowed to set, the remaining root tip was removed and all bony contouring performed.

The patients were instructed to report any problems they encountered with the root-resected tooth. The teeth were reevaluated at postoperative and periodontal maintenance recall visits over a 9-yr period. When a tooth produced acute symptoms or did not respond to vitality testing, it was classified as having irreversible pulpal disease and root canal therapy was recommended.

RESULTS

Because there were no apparent differences in the pulpal responses of the first and second molars, the data for these teeth were pooled. Table 1 summarizes the data in regard to the number of teeth that retained their vitality during specific time periods. Within the first 6 months 41% became nonvital. The greatest loss of

TABLE 1. Number and percentage of vital teeth at specified time intervals

Time (months)	No. of teeth	% of Total
6	51	59
12	33	38
18	27	31
24	22	26
36	18	21
48	13	15
60	11	13

vitality occurred within the first 12 months postoperatively, with only 38% of the teeth remaining vital. There was a steady decline in the number of vital teeth and only 11 (13%) remained vital at 60 months. Thus, the overall success in this study was 13% after 5 yr and the rate of failure was 87%.

DISCUSSION

A higher failure rate (87%) for vital root resections was experienced over a 9-yr period in this study than in the majority of previous studies. This possibly could be explained by the fact that the other studies, with one exception (Langer et al. (29)), were not longitudinal and the cases were not observed for a sufficient period of time to determine the actual rate of success and failure. A number of differences were readily apparent in the results of this study and that of Langer et al. (29), even though the time for both studies were comparable. Their overall failure rate (38%) was much lower than ours (87%) and during the first 5 yr they found only 6% failures whereas we observed 87%. Thus, the majority of their failures occurred after 5 yr and ours within the first 5 yr.

While it is not possible to reconcile these differences without more specific data in regard to case selection and treatment methodology, it is of interest to consider the effect of factors such as pulpal status, presence of accessory canals, types and methods of applying the capping material, presence of bacteria, and induction of rapid bone loss, upon the success of vital root resections. It is possible that a chronic pulpitis could be present in a tooth before the resection procedure which is almost invariably performed on periodontally involved teeth which have accessory canals in the furcation and coronal one-third of the roots in maxillary molar teeth (30, 31). The presence of both patent accessory canals and periodontal disease could potentially affect the pulp in an adverse way (32–34). The additional trauma of the resection procedure to an already injured pulp could cause an acute exacerbation of a chronic situation. Tagger and Smukler (25) in their examiantion of 20 pulps from root-resected teeth noted that the majority of the inflammatory changes were in the coronal pulp and the changes extended down into the radicular pulp. The use of calcium hydroxide as a pulp capping material may also cause additional trauma to the pulp, especially if it is inadvertently forced into the coronal pulp tissue during amalgam placement. Studies showing inflammation and abscess formation have been reported following the use of calcium hydroxide as a pulp capping agent (35, 36).

Bacterial contamination of the root canal system during the resection procedure may adversely effect its ultimate success. Bacteria from plaque and periodontal disease can easily enter the pulp via the amputation site. The pulpal tissue may or may not be able to withstand the challenge, depending on the status of the pulp and the amount of insult incurred. To help prevent pulpal contamination as much as possible, it is recommended that a wedge of root be removed and the pulp stump be sealed before the remaining root tip is removed and bone contouring is done. Finally, the induction of rapid loss of supporting bone around the tooth, as was frequently seen in this study, must be taken into consideration. This is extremely critical when treating a patient with reduced bone support. Failure of the total periodontal therapy can occur unless root canal therapy is initiated immediately.

Since the long-term success rate in this study was very low, we can only conclude that the prognosis for vital root resections *without concurrent endodontic therapy* is poor. The remaining pulpal tissue may become symptomatic or nonvital many years after the resection procedure. The differences in longevity among treated teeth in this study and other studies may be explained, at least in part, by factors such as initial status of the pulp (inflamed or noninflamed), extent of the periodontal disease and associated accessory canals, caustic effect of medicaments, bacterial contamination of the pulp, and placement of the medicament and amalgam seal. We strongly recommend the root canal therapy be initiated before or shortly after the root resection procedure.

SUMMARY

Eighty-six maxillary root-resected molar teeth were studied. All teeth had vital root resections performed, followed by a Dycal and amalgam seal at the amputation site. The teeth were observed up to 9 yr postoperatively. Forty-one percent of the teeth lost vitality within the first 6 months. Thirty-eight percent remained vital at 1 yr but only 13% were vital after 5 yr. The prognosis for a vital root resection is poor and endodontic therapy should be done before or as soon after vital root resection as possible.

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RAYMOND L. HAYES

One of the most important missions of dentistry is the preservation and maintenance of the health and integrity of the dental apparatus.

There were many occasions when, as a student in dental school (1931–1935), I became disillusioned and frustrated because patients of mine presented with teeth which, I was told, had to be extracted. Often, it was my desire to save these teeth which had good remaining tooth structure and good periodontal support. However, very few teachers would permit the performance of root canal therapy in the clinic. At this time, treatment technics varied greatly among those dentists who did perform root canal therapy in their offices. Treatments were often very painful, causing great suffering by patients. Very few dentists or physicians had confidence in the treatment procedures or in the health of the treated pulpless tooth. There were no courses in Endodontics in dental schools.

Through the efforts of the American Association of Endodontists, Endodontics has become an important part of dental education and dental practice. Basic research studies in Endodontics have increased our knowledge of the dental pulp in health and disease and also improved treatment procedures.

Today, Endodontics, more than any other branch of dentistry, successfully fulfills this mission of dentistry. Dental students and dental practitioners are able now to save many pulp-involved teeth through relatively painless procedures. As a dental educator, I have been able to teach my students correct technics for treatment and restoration of pulpless teeth. Also, it is now possible for me to give assurance to students, dentists and patients that a high degree of success can be expected through endodontic treatment procedures.

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