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CLINICAL ARTICLE

Recall Evaluation of Iatrogenic Root Perforations Repaired with Amalgam and Gutta-percha

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Fifty-seven endodontic cases involving iatrogenic perforations were obtained from the student clinic at the University of Oklahoma College of Dentistry. The perforations had been repaired with internally placed amalgam (24) or gutta-percha (33). Five cases that were determined to be failing upon recall evaluation were subsequently treated surgically. Recall periods ranged from 3 months to 6 yr. Gutta-percha repairs had a 57.6% failure rate and accounted for 73% of all failures, while 26% of amalgam repairs failed. Seventy percent of all failures involved extruded material and 83% of these were gutta-percha repairs.

Successes outnumbered failures with both materials, even when the repair was delayed up to 60 days. Amalgam was found to be superior to gutta-percha when used under the conditions of this study. Repairs involving extrusion of gutta-percha were most likely to fail. The rate of success of perforation repair was not adversely affected by a treatment delay ($p > 0.05$). Of the five failing cases that were surgically treated, all demonstrated evidence of healing during subsequent evaluations.

Root perforations pose one of the most challenging problems encountered in endodontic therapy today. Except for those that are caused by caries or resorption, perforations usually are a result of procedural accidents. An iatrogenic perforation seriously compromises the prognosis of the involved tooth and requires special attention in diagnosis and treatment. The likelihood of this misadventure has greatly increased in recent years as the benefits of endodontic treatment have become more widely recognized. More dentists with varying degrees of training and skill are now providing endodontic treatments. In fact, the second most common reason for failure associated with endodontic treatment is reported to be perforations (1).

As of this writing, no comprehensive review of literature dealing with root perforations exists, nor do adequate numbers of clinical studies or predictable repair methods for these occurrences. Therefore, the purposes of this article are to provide a review of the literature which addresses the management of perforations and to present the findings of a clinical study using internally placed amalgam or gutta-percha to repair iatrogenic perforations.

LITERATURE REVIEW

As early as 1893, Smale and Colyer (2) described causes of root perforations related to restorative and endodontic procedures. Among these were misdirection and misuse of dental burs and instruments used for removal of pulp contents from infected root canals. Later, Peeso (3) described similar situations and proposed that these defects should be filled.

The earliest histological studies (4–7) of root perforations were undertaken in Germany. In those studies, inflammation and breakdown of periodontal tissues were reported to occur adjacent to perforative defects. Lantz and Persson (8–10) examined the effects of root perforations on the periodontium and the subsequent repair process in dogs, using both histological and radiographic evaluation methods. These investigators repaired experimentally produced perforations with chloroform-gutta-percha, amalgam, or zinc phosphate cement. They reported that repair with chloroform-gutta-percha resulted in less inflammation than either zinc phosphate cement or amalgam. Control perforations were left unsealed and these were found to cause the least favorable response.

Bhaskar and Rappaport (11) confirmed that sealed perforations result in less inflammation than unsealed perforations. They found that to be true even when the perforations were not immediately sealed.

Seltzer et al. (12) studied root perforations in rhesus monkeys and concluded that repair depended on the

location of the perforation as well as the time elapsed before sealing. Sinai (13) found that sealability and accessibility of the main canal are additional factors which affect the outcome of perforation repair.

Between 1969 and 1981 a large number of investigations were conducted which dealt with factors affecting the prognosis of perforations and various methods of repair (14–22). A number of case histories (24–35) and a master's thesis (36) have attempted to evaluate the short-term prognosis relative to the size and location, the influence of elapsed time, and the method of repair.

Few reports have been published to date which deal with long-term follow-up of perforation repairs on an adequate population of patients. Nicholls (37) reported the classification and treatment of root perforations based on the results of 29 clinical cases that had been repaired with zinc oxide-eugenol paste or amalgam. Teeth were not differentiated by repair material, nor was an overall success rate presented.

Twenty-four perforation cases that had been repaired with gutta-percha and resin-chloroform were followed by Stromberg et al. (38) for a period ranging from 1 to 8 yr. The investigators determined that 18 of the cases could be considered to be successful. They concluded that perforations in the furcation or coronal third of roots were least likely to repair.

Harris (39) evaluated 154 root perforations that had been repaired with Cavit (Premier Dental Products Co., Philadelphia, PA) for an interval of 6 months to 10 yr. Those cases that had periodontal breakdown adjacent to the repairs were treated with surgical curettage. An 89.3% success rate was reported in this study and it was concluded that Cavit was an adequate material to use for perforation repair. Immediate repairs were not differentiated from delayed repairs in this study and the percentage of cases requiring surgery was not reported.

Jew et al. (40) as well as Lantz and Persson (8–10) found that lateral perforation repairs with Cavit resulted in periodontal defects adjacent to the perforation sites. These studies concluded that Cavit posesses a "mild to moderate inflammatory potential" and results in a fibrous encapsulation type of repair.

Furcation perforations were experimentally created in dogs and were repaired with calcium hydroxide, amalgam, or Cavit by ElDeeb et al. (41). The tissues adjacent to the perforation sites were subsequently studied clinically, radiographically, and histologically. These furcal perforations were found to have a poor prognosis regardless of the repair material used. Amalgam was found to be the most suitable material of the three that were evaluated. Recently, Himel et al. (42) found that repairing perforations of the pulp chamber floor in dogs' teeth with calcium hydroxide caused more tissue destruction than did Teflon or tricalcium phosphate.

Since the advent of preparation techniques which use flaring, the relative risk of perforation has increased. This has been addressed by Kessler et al. (43) who advocate anticurvature hand instrumentation (44) as the technique least likely to result in root perforation.

This investigation was conducted to give a clinical and radiographic evaluation of teeth with iatrogenic perforations that had been internally repaired with amalgam or gutta-percha. Factors such as the delay in time before repair, material selected for repair, and extrusion of these materials into supporting tissues will be considered in an attempt to determine what effect they may have on the degree of healing observed with each tooth.

MATERIALS AND METHODS

Records and radiographs of 57 molar teeth involving mechanical root perforations were obtained from the undergraduate student clinic at the University of Oklahoma College of Dentistry. They were repaired with either amalgam or gutta-percha. Cases were selected strictly on the basis of availability of documentation. No attempt was made to select cases by anatomical category or complexity. Age, race, sex, and medical status of the patient were not considered. Evaluation periods ranged from 3 months to 6 yr.

Cases that were evaluated included 52 teeth with furcation perforations in the middle or coronal third of the root, four teeth with perforations of the chamber floor, and one mandibular tooth with a perforation in the apical third of the mesial root.

Repairs were placed by supervising faculty members of the Department of Endodontics. Selection of the repair material and the time when the repair was completed were left to the discretion of the faculty member who managed the case. Repairs that were not completed at the time of perforation were accomplished with amalgam. All repairs were done under "aseptic" conditions.

Teeth repaired with amalgam had their canals obturated by vertical condensation of warm gutta-percha (Premier Dental Products) and Pulp Canal Sealer (Kerr Dental Products, Romulus, MI) terminated at a point 2 to 3 mm apical to the perforation site. Amalgam (Dispersalloy; Johnson & Johnson, E. Windsor, NY) was then vertically condensed from that point to the orifice of the involved canal. A wet mix of Durelon (Premier) was placed over the amalgam repair as a secondary seal.

In teeth repaired with gutta-percha, canals were completely obturated, including the perforation site, using the same vertical condensation technique. Durelon was also placed over these repairs.

All patients were recalled at 3- and 6-month intervals for radiographic evaluation. A clinical examination was also completed to determine probing depths adjacent

to the perforation site, percussion or palpation tenderness, spontaneous symptoms, or the presence of sinus tracts.

Five mandibular molars with repaired furcation perforations were found to be failing at the initial recall and received surgical repair. This consisted of reflecting a full-thickness flap from a sulcular incision and complete curettage of the affected area using a slowly revolving round bur. The coronal collar of bone, if still intact, was left undisturbed by tunneling to the furcation using an apical to coronal orientation.

Documentation for each case was taken from entries in the patient's treatment record as well as completed standardized recall evaluation forms. Cases were also documented with preoperative, working length, obturation, and final periapical radiographs in addition to one or more recall radiographs. In cases where repair treatment was delayed, radiographs were taken at the time the repair occurred. A long cone parallel technique was used in all cases. Radiographic interpretation was done by the first author.

Perforation repairs were not considered to be successful unless the involved teeth met the following criteria described by Stromberg et al. (38): (a) free of symptoms, i.e. percussion or palpation, tenderness, and spontaneous pain; (b) free of excessive mobility; (c) free of oral communication with the perforation site; (d) free of sinus tracts; (e) they were functioning; (f) free from radiographic evidence of osseous demineralization adjacent to the repair site; and (g) the periodontal ligament adjacent to the repair site was intact and no more than twice as thick as the remainder of the periodontal ligament.

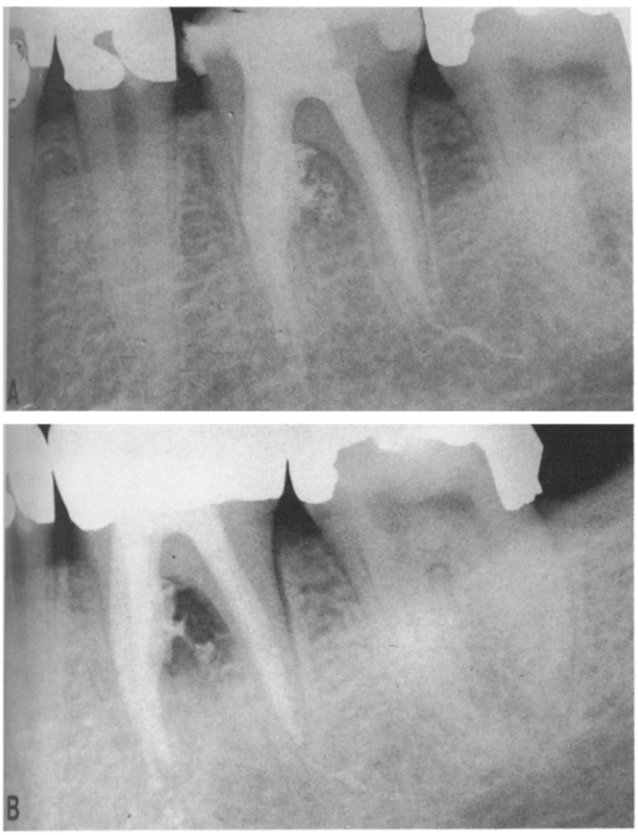

FIG 1. *A*, A mandibular molar with a mesial root perforation obturated and repaired with gutta-percha after a 14-day delay. Note extrusion of gutta-percha and sealer into the furcation. *B*, A 1-yr recall shows considerable breakdown of bone adjacent to the perforation. The final crown restoration should have been deferred.

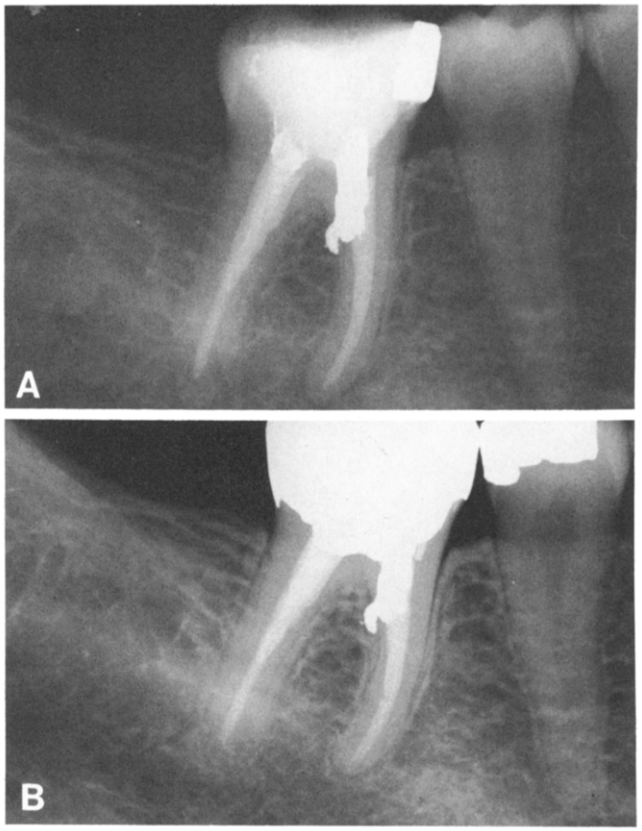

FIG 2. *A*, A mandibular molar repaired with internal amalgam 1 day after perforation of the mesial root. Note extruded amalgam. *B*, Eighteen-month recall shows normal osseous appearance adjacent to extruded repair.

RESULTS

Of the 57 molars studied during the evaluation period, 31 were judged to be successful. The overall success rate for perforation repairs of all types was therefore 54.4%.

When mandibular molar teeth were considered alone ($n = 47$), 25 were classified as successful (53.2%). Of the repaired maxillary molars ($n = 10$), six were found to be successful (60%).

Thirty-three teeth were repaired with gutta-percha, of which 14 (42.4%) succeeded and 19 (57.6%) failed (Fig. 1). Twenty-seven teeth were repaired with amalgam, including 20 (74.1%) that were considered to be successful (Fig. 2) and 7 (25.9%) that were failing. Of the 26 teeth that failed, 19 (73.1%) had been repaired

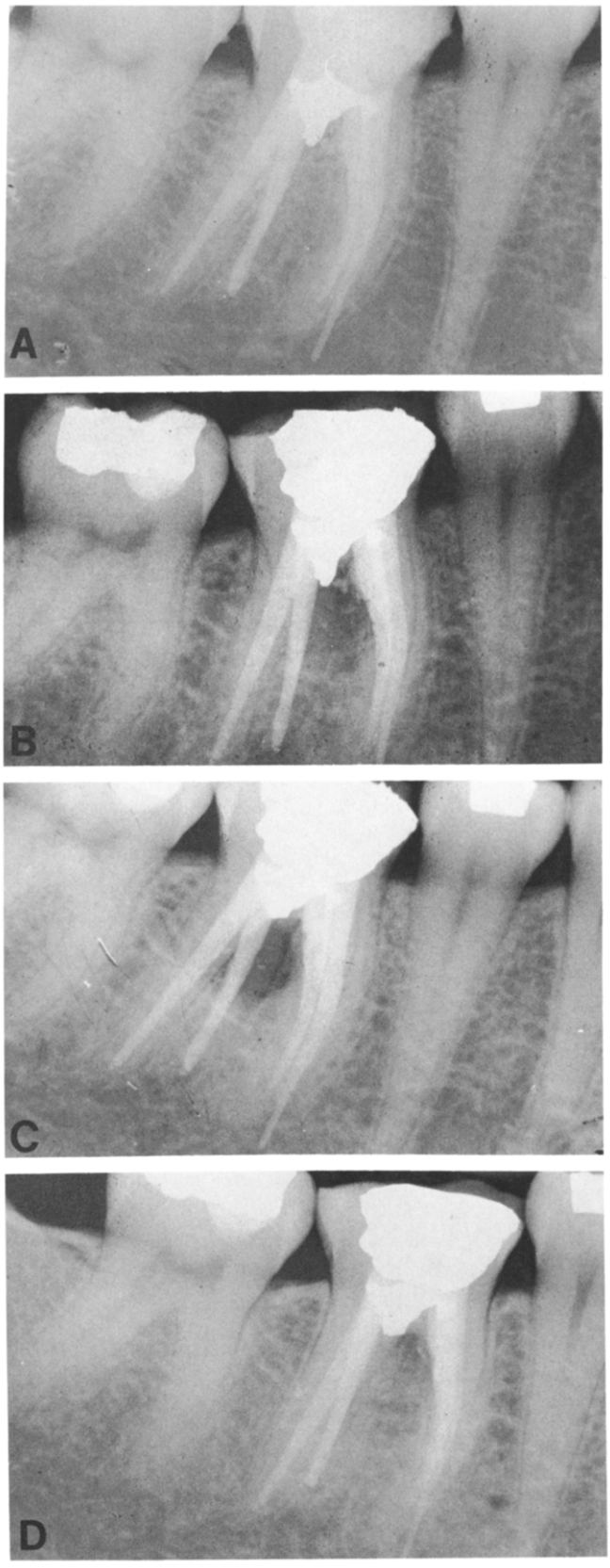

FIG 3. *A*, A mandibular molar with four roots. Perforation of the chamber floor was immediately repaired with amalgam. Note extrusion of material into the furca and the overextended gutta-percha on one mesial root. *B*, 7-month recall shows failing repair with osseous breakdown in the furcation. *C*, Surgical curettage removed the excess amalgam in the furcation. *D*, A 13-month postsurgery recall shows considerable repair in the furcation and no lesion at the mesial root apex.

TABLE 1. Results related to delay in repair*

Time Lapse (days)	Successes	Failures
0	17	18
1–7	3	2
8–15	7	5
16–30	0	1
31–60	4	0

* t test value = 0.2431 ($p < 0.05$).

with gutta-percha and 7 (26.9%) had been repaired with amalgam.

Five of the failing repaired teeth subsequently treated by surgical curettage for removal of extruded repair materials were involved in evaluations recall from 6 to 18 months. All of these surgically treated teeth were judged to be healing successfully at recall evaluations (Fig. 3).

All teeth that were failing were identified by the 24th month of the recall evaluation periods encompassed by the study. Of the teeth repaired with amalgam, all of the failing ones were identified by the 18th month and all but one was identified by the 20th month. Regardless of the recall period involved, teeth with gutta-percha repairs failed numerically more often than teeth with amalgam repairs.

The majority of perforations considered in this study were repaired on the same day they were discovered (Table 1). However, delays of 1 to 60 days did occur in 38.6% of the cases ($n = 22$). Student's t test was performed on the success/failure data of the delayed and nondelayed repaired teeth. It revealed no significant difference ($p < 0.05$) in failure rates as a function of repair delay (Table 1).

Extrusion of repair material into the adjacent tissues occurred in 18 of the 26 failed cases (69.2%). This operative event correlated more closely with failure than any of the other factors evaluated. Extruded gutta-percha was found in 79% of all gutta-percha failures while extruded amalgam occurred in 43% of the failed amalgam repairs.

DISCUSSION

The success rate (54.4%) encountered in the present study correlates closely with several other studies (12, 13, 16, 38). Harris (39), however, reported a success rate of 89.3% using Cavit as a repair material. While this might suggest that Cavit is a better material for perforation repair than amalgam or gutta-percha, it should be noted that Harris (39) did not consider a case to have failed until after it had failed both nonsurgically

and surgically. He also did not categorize teeth anatomically and did not specify the location of the perforation or whether an immediate or delayed repair was done.

The results of Harris (39) have not been reproduced by other researchers who have used Cavit as a repair material. In fact, Jew et al. (40) and Lantz and Persson (8–10) have concluded that Cavit evokes an inflammatory response when used for this purpose.

The present study was limited to molar teeth and primarily to molars that had been perforated in the furcation. This is, according to ElDeeb et al. (41) as well as Stromberg et al. (38), an area with an extremely poor prognosis, regardless of the material utilized for repair. Kessler et al. (43) have reported that the furcation area of molars is the most likely area to be affected by iatrogenic perforation whenever flared preparative techniques are used. The data presented in this investigation would tend to support both of these contentions.

A disproportionately high percentage of the teeth that failed encompassed in this investigation were repaired with gutta-percha. This contradicts the findings of Lantz and Persson (8–10) who reported that gutta-percha was a more favorable repair material than amalgam. A possible explanation for this disparity is that gutta-percha repair is technique sensitive. This contention is supported by the finding that 15 of the 19 gutta-percha failures involved extruded filling materials. Vertical condensation of warm gutta-percha may, therefore, be more likely to extrude material through a perforation site than the obturation techniques utilized by other investigators.

A much more impressive success rate (74.1%) was found among the group that was repaired with amalgam. This is consistent with the findings of ElDeeb et al. (41) who reported that amalgam was the most suitable of the materials evaluated for furcation perforation repair.

The 100% success rate of the five surgically treated teeth suggests that either amalgam or gutta-percha can be used successfully to repair perforations, provided extrusion of materials does not occur. As previously stated, all of the failing teeth healed after the extruded materials were removed, regardless of the repair technique used.

Delay in repairing perforations did not affect the prognosis in the cases under consideration. In fact, when all cases are considered collectively as in Table 1, delayed repairs had a slightly better outcome than immediate repairs. This is surprising as delay in repair has been reported to decrease the healing prognosis as noted by Bhaskar and Rappaport (11) as well as Seltzer et al. (12). Periodontal breakdown is known to occur adjacent to unrepaired perforations (11) and this may make the extrusion of materials into the defect more likely. In the present study, delayed repairs were done with amalgam rather than gutta-percha which minimized the extrusion of repair materials. This may account for their success rate being better than anticipated. Lantz and Persson (8–10) reported success rates similar to those encountered in this investigation.

Another unexpected finding of this investigation was that perforation failures tended to occur relatively early in the evaluation period. All of the failed cases had been identified by the 24th month, and the majority had been identified by the 12th month. This early failure tendency lends validity to some of the earlier studies (24–36) which evaluated success or failure for relatively short periods. This is not intended to imply that prolonged recall periods are unnecessary for perforation cases. The prognosis for teeth that have been iatrogenically perforated and repaired must be considered questionable and early identification and treatment of failing cases is recommended. The prognosis for surgical treatment is felt to be better if it is completed before a communication is established between the oral cavity and the osseous defect associated with the perforation. The nature of the "healed" tissue adjacent to the perforation repair is not known. No histological evaluation of this area can be accomplished in a human study of this kind where healing is defined primarily as the absence of radiographic abnormalities or clinical signs and symptoms. Due to the limitation imposed by radiographic interpretation, a long recall period is required.

SUMMARY AND CONCLUSIONS

Fifty-seven molar teeth with iatrogenic perforations were repaired with amalgam or gutta-percha and evaluated using a radiographic and clinical examinations at periods ranging from 3 to 72 months. The overall success rate for internal nonsurgical repairs was 54.4%. Several obserations can be made within the scope of this study:

1. Gutta-percha repairs failed more often than amalgam repairs.
2. Approximately 69% of all failures occurred when repair materials were extruded beyond the root surface.
3. Surgical intervention in failing teeth resulted in healing of all of the teeth treated in this manner.
4. Delay of repair had no significant effect on the prognosis of the cases considered.
5. Amalgam was found to be a more acceptable repair material than vertically condensed warm gutta-percha.
6. Additional clinical studies are recommended in order to evaluate further the influence of materials and techniques on the healing prognosis.

This study was submitted by Dr. Benenati as partial fulfillment of the requirements for a certificate in endodontics from the Veterans Administration and was presented at the 1984 Annual Meeting of the American Association of Endodontists.

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