A histologic evaluation of bone response to bur cutting with and without water coolant

Jeffrey Fister, D.M.D.,* and Bob D. Gross, D.D.S., M.S.**
Bangor, Me., and Shreveport, La.

Thirty-six bony cuts were made in the lateral aspect of the mandibles of mongrel dogs. Irrigation was employed in eighteen cuts, while the remaining eighteen were cut without irrigation. Histologic specimens were obtained at 1 hour, 1 day, 3 days, 1 week, and 3 weeks. Early specimens showed marked clot retraction from the bony walls in the nonirrigated cuts, while irrigated cuts demonstrated more firmly adherent and better organized clots. In later specimens, bone formation was less mature in the defects made without irrigation. Inflammation and necrosis of bone were minimal or absent in all sections. Defects made without irrigation exhibited delayed healing in this study.

It is generally accepted that a water coolant is necessary to prevent necrosis and its sequelae (inflammatory response, delayed healing, and potential infection) during bone cutting with rotary instruments. Studies involving tooth structure have demonstrated that temperatures in excess of 160°F can be developed in tooth structure cut with rotary instruments at about 10,000 r.p.m. It has been well established that heat has a significant effect on the dental pulp, which includes separation of the odontoblastic layer, edema, hyperemia, and inflammatory cell infiltration. The ultimate pulpal injury could result in abscess formation. Studies have also shown that the temperature rise in tooth structure can be limited to 20°F when a water coolant is used.

Although temperature studies have not been performed on bone, Hall has stated that there was neither bone necrosis nor delayed healing when the Hall air drill was used without a water coolant. His study, however, did not include a histologic comparison of the effect of bone cutting with and without a water coolant.

The purpose of the present study was to investigate histologically the degree of bone necrosis and associated inflammatory response, as well as to determine differences in the rate of healing in bone specimens cut with rotary instruments with and without a water coolant.

MATERIALS AND METHODS

Three mongrel dogs were used for this investigation. After adequate general anesthesia had been induced, the lateral aspect of the body of the mandible was exposed by means of an infralateral horizontal incision followed by development of a full-thickness mucoperiosteal flap. Six vertical cuts, 1 cm. in length and 1 cm. apart, were made on the lateral aspect of the mandibular body, by means of a No. 8 surgical carbide bur in a high-speed skew-driven handpiece (14,000 r.p.m.). The cuts were made posterior to anterior, in an alternating fashion, one cut without irrigation and one with 50 cc. of normal saline solution irrigation at room temperature. Following the bony cuts, the surgical field was irrigated with 550 cc. of normal saline solution at room temperature and the full-thickness mucoperiosteal flap was reapproximated and closed with 4-0 chronic continuous sutures. Blood and saliva were permitted to bathe the area in both situations. The procedure was performed bilaterally in all three animals, producing a total of thirty-six bony cuts. All cuts were made by the same operator, simulating the cutting pressure used in clinical practice and avoiding osseous tissue coloration changes.

*Teledyne Enesco, Englewood, N. J.
Fig. 1. A. Low-power view of bony cut made without irrigation, showing marked clot retraction in 3-day specimen. B. Low-power view of bony cut made with irrigation, showing clot firmly adhering to the bony wall in 3-day specimen.

change, vapor, or odor in the area of the cut. A new bur was used for each side of the mandible for each animal.

The animals were killed and histologic specimens were obtained at 1 hour, 1 day, 3 days, 1 week, 2 weeks, and 3 weeks. En bloc resections of the surgical area were performed and the specimens were fixed in 10 percent formalin. These were decalcified in 20 percent formic acid with citrate buffer, sectioned at 4 microns, and stained with hematoxylin and eosin for histologic examination.
Fig. 2. A. Low-power view of bony cut made without irrigation, illustrating moderate organization of the clot in 1-week specimen. Note persistent clot retraction. B. Low-power view of bony cut made with irrigation, illustrating substantial organization of the clot in 1-week specimen.

RESULTS

Histologic examination of one-hour specimens

One-hour specimens revealed no significant difference between those bony cuts made with and without irrigation.

Histologic examination of one-day specimen

The most significant finding in the one-day specimen was the observation that the clots had retracted from the bony walls in those defects made without irrigation, whereas those clots within the defects made with iron.
Fig. 3. A. Low-power view of bony cut made without irrigation, showing dense fibrous connective tissue with no bone formation in 2-week specimen. B. Low-power view of bony cut made with irrigation, showing immature woven bone in 2-week specimen.

Inflammation were firmly adherent to the bony walls. No inflammatory infiltrate was evident in either specimen.

Histologic examination of 3-day specimens

Bony cuts made without irrigation consistently displayed marked clot retraction with failure to fill the entire bony defect. Those defects made with irrigation displayed a well-organized clot which filled the entire defect. There was little inflammatory infiltrate in any specimen. Osteoblasts within the adjacent bone appeared to be viable in all sections, indicating no bone necrosis (Fig. 11).
Fig. 4. A, Low-power view showing formation of immature bone in cut made without irrigation in 3-week specimen. B, Low-power view showing formation of marked woven bone entirely filling bony cut made with irrigation in 3-week specimen.

Histologic examination of one-week specimens

One-week histologic specimens revealed a presence of substantial organization of the clot as evidenced by the formation of capillaries and maturing fibroblasts in defects cut with irrigation. However, bony cuts made without irrigation displayed a clot with a lesser degree of organization. Inflammatory infiltrate was not noted on either specimen (Fig. 2).

Histologic examination of 2-week specimens

The presence of immature woven bone was a consistent finding in those specimens in which irrigation was
used. Dense fibrous connective tissue with little bone formation was evident in those defects made without irrigation (Fig. 3).

**Histologic examination of 3-week specimens**

Bone formation was obvious in all specimens at this time (Fig. 4). However, bone in those sections made without irrigation appeared to be less mature. This was evidenced by greater cellularity (Fig. 5).

**DISCUSSION**

Although a water coolant is used frequently during bone-cutting procedures, there are several disadvantages to its use. These include back splash which may...
cause contamination of an otherwise sterile field, bacterial (air-borne) dispersal while operating in an infected site, decreased vissability of the surgical field caused by excessive amounts of irrigation or improper suctioning, laryngospasm in nonanesthetized patients resulting from reflex stimulation, and, finally, the need for extra personnel since it is difficult for one assistant to retract, suction, and irrigate simultaneously. Despite these possible complications, most surgeons elect to irrigate with copious amounts of water coolant to prevent bony necrosis and subsequent delayed healing. The significant factor in the production of necrosis is the generation of heat. The production of heat is influenced by (1) size, shape, and composition of the bur, (2) speed of the bur, (3) amount and direction of pressure on the bur, (4) amount of moisture in the operative field, (5) length of time the bur is in contact with the bone, and (6) the type of tissue being cut. The generation of heat can be reduced significantly simply by controlled light intermittent pressure of the bur against the bony surface. The lateral aspect of the body of the mandible was selected for this study, as it consists of a thick cortical plate simulating the dense bone encountered in third-molar-impaction surgery.

The results of this study indicate that osteoclastic bone can be avoided when a water coolant is not used, as necrosis was not evident in any specimens. Careful use of rotary instruments without a water coolant produced a minimal inflammatory reaction in the surrounding bone when compared to bone cutting with water coolant.

There are three observations, however, which may prove significant in the clinical situation. First, throughout the period of clot formation and organization, there was a substantial amount of delayed clot formation and increased clot retraction (from the bony walls) in those surgical sites cut without a water coolant. This finding was consistent and not an artifact produced by the fixation and staining procedure. Second, bone sites at which a water coolant was not used during the cutting process had a significant amount of bony spicules incorporated within the clot, despite irrigation after the surgical cuts. Finally, there was a period of delayed healing in those surgical sites that were cut without a water coolant. This delay in healing was approximately 1 week in duration. Clot and bone formation appeared consistently less mature in these specimens.

It is interesting that all postoperative wounds healed uneventfully and that no clinically observable infection was noted. The significance of the aforementioned findings cannot be determined by this study. However, one might speculate that they may contribute to prolonged postoperative discomfort, dry socket syndrome, and delayed healing when bone cutting is performed without irrigation.

SUMMARY

Thirty-six bony cuts were made in the mandibles of mongrel dogs. For half the cuts irrigation was employed, while the other half were made without irrigation. Histologically, the sections made without irrigation demonstrated delayed clot formation and increased clot retraction (from the bony walls) when compared to those cuts made with irrigation. Appearance of immature bone and formation of mature bone was delayed on sections made without irrigation.

The authors wish to express their appreciation to Dr. Leslie Culter, Associate Professor and Head of the Department of Oral Diagnosis at the University of Connecticut Health Center, for his assistance in interpretation of the histologic specimens.

REFERENCES


Reprint requests to:
Dr. Jeffrey S. Frazier
37 Bower St.
Bangor, Me 04401