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EXPERIMENTAL PULPOTOMY IN HUMAN BICUSPIDS WITH REFERENCE TO CUTTING TECHNIQUE

by
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INTRODUCTION

According to *Seltzer* and *Bender* (1965) the pulp tissue is inevitably contused by surgical removal of a portion of the pulp. Owing to pressure and avulsion, cells are crushed, hemorrhage occurs, and dentine chips may be pushed into the remaining tissue. *Nyborg* and *Halling* (1963) and *Mejàre et al.* (1970), in human experiments, have shown that the pulp can be twisted or displaced when cut by rotating hand instruments.

For studies on the effect of different wound dressings on healing after surgical incision to be meaningful, it is important that the surgical technique causes as little trauma as possible. Further, from the research by *Masterton* (1966) on pulpotomy in monkeys, without application of an active wound dressing, the conclusion can be drawn that an extra-pulpal blood clot should be avoided. The aim of the present work was to devise a model for experimental pulpotomy, and to observe the tissue reaction after »physiologic» hemostasis without the influence of an extra-pulpal blood clot.

MATERIAL AND METHODS

Teeth. Nine human lower bicuspids which were to be extracted for orthodontic reasons were used. The teeth were caries-free or showed only early fissure lesions. There was no history of exposure to mechanical trauma.

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Preparatory measures. After mandibular anesthesia with 1,8 ml Carbocain ® Dental, rubber-dam was applied to the experimental tooth. The field of operation was cleaned with 30 % hydrogen peroxide and absolute alcohol and thereafter washed with 10 % tincture of iodine. All instruments and materials used in the operative work were sterilized according to methods advocated for endodontic procedures.

Cutting technique. The operative work was performed with diamond instruments. After removal of part of the occlusal surface enamel, a round and then a cylindrical diamond instrument were used to cut a hole through the dentine but without perforating the roof of the pulp chamber. The two latter diamonds had either a 3 mm or a 4 mm diameter depending on the size of the tooth. The final cut was made with a cylindrical instrument with smooth sides and diamond only on its base. Its diameter just exceeded the radius of the bore. By circulating movements the rotating instrument was gradually lowered into the tooth until the pulp tissue, surrounded by dentine, had been removed to about the level of its largest cross section (Fig. 1).

During all steps of the procedure, the tooth was irrigated with physiologic saline solution. High-speed equipment running at about 100,000 revolutions per minute was used for the initial cutting of enamel and the removal of pulp tissue. The cylindrical hole through dentine was cut with low-speed equipment run intermittently to keep the dentine moist.

Hemostasis. After the pulp had been cut, the wound surface was continuously irrigated with physiologic saline solution until the bleeding ceased. This was termed »physiologic» hemostasis. In most cases small blood clots were seen at the orifices of relatively large blood vessels in the flat cut surface of the pulp.

Cavity seal. After all fluid in the cylindrical cavity had been absorbed by means of paper points without the soft tissue being touched a disc of Teflon ® (polytetrafluoroethylene), approximately 0.2 mm thick, was placed on the dentine shelf. The diameter of the disc corresponded to that of the bore. The material, which has a low surface energy, is resistent to all chemical compounds except molten alkaline and heated fluorine (*Römpp*, 1958), and the vapour adsorption on it is but a small fraction of a monolayer (*Martinet*, 1958 — cited from *Glantz*, 1969). Further, intraperitoneal (*Calnan*, 1963) and compact bone implants (*Spångberg*, 1968) have been shown to cause minimal tissue irritation.

Wax of low melting-point was then melted onto the disc and towards the dentine wall to fill about half the depth of the cavity. A layer of Pharmatec ® (gypsum-like cement) was applied over the wax. Finally, the cavity was filled with zinc phosphate cement.

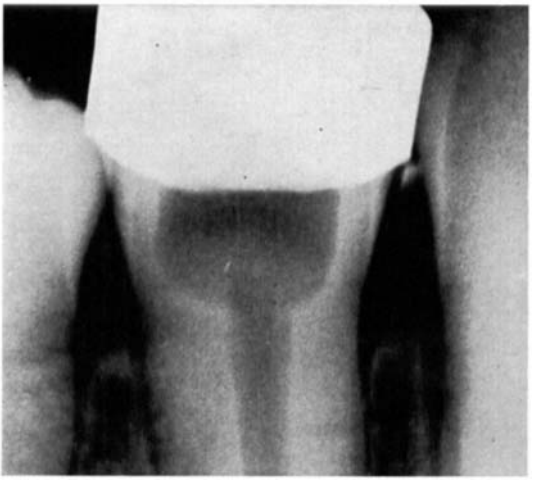


Fig. 1. A radiograph showing the cavity in case 3. Because of the angulation of the X-rays, the dentine shelf gives a three-dimensional appearance.

Extraction. Before extraction, the teeth were anesthetized with 1.5 ml Carbocain ® Dental by mandibular injection. After extraction with forceps the tooth was immediately immersed in distilled water, the apical third of the root cut off with a diamond disc, and the tooth placed in 10 % neutral formalin.

Histologic preparation. The teeth were decalcified in Versene ®, pH 7.4, at 60°C. Every third or fourth slide with 3 serial paraffin sections, 7—8 μm thick, was stained with haematoxylin and eosin and further slides were stained according to Weigert — van Gieson.

Composition of the material. The material was grouped according to experimental variations.

Cases 1 and 2

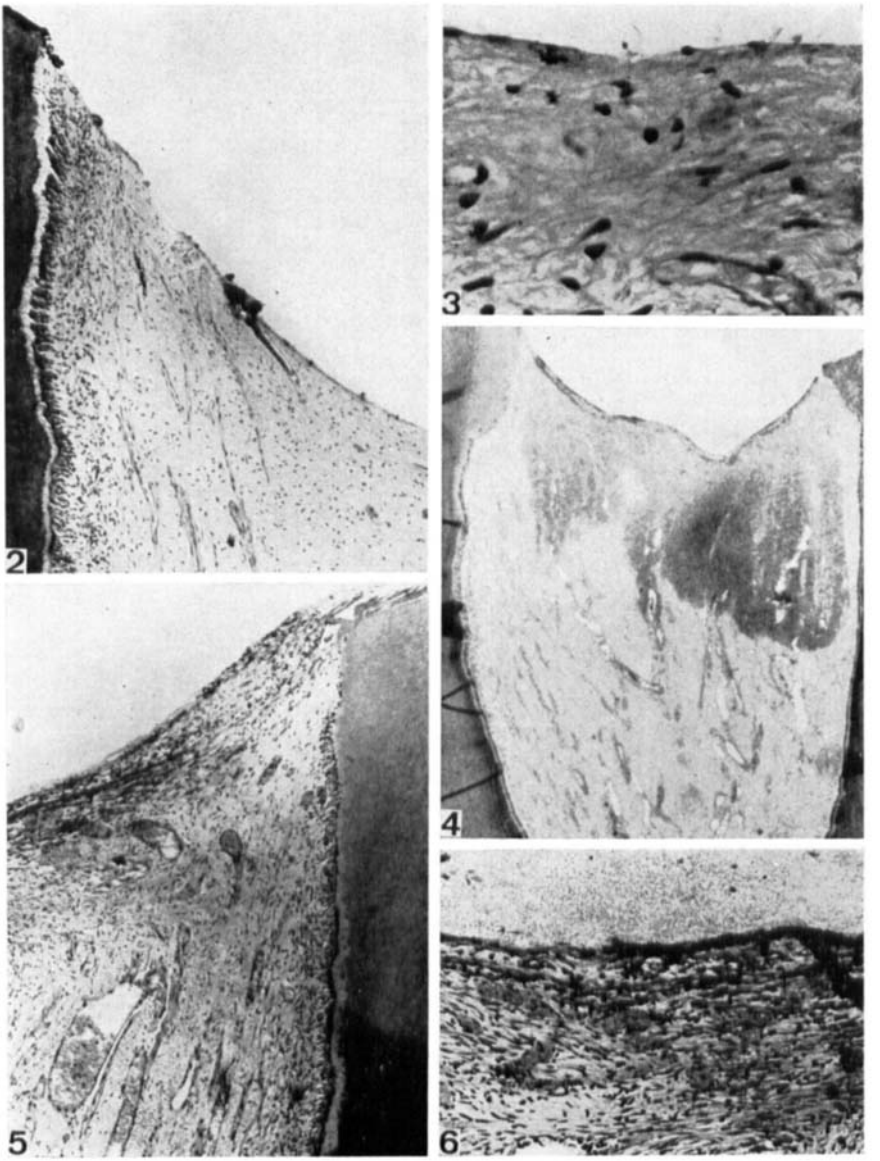
Extraction immediately after physiologic hemostasis. The bleeding time was 34 and 8 minutes respectively.

Cases 3 and 4

Extraction after 24 hours; physiologic hemostasis; bleeding time 25 and 23 minutes respectively.

Cases 5—8

Extraction after 4 weeks; physiologic hemostasis; bleeding time 15, 15, 60, and 11 minutes respectively.



The histologic pictures (Figs. 2—10) are described in the text under *Results*.

Fig. 2. Case 1; immediate extraction; htx—eosin; × 65
Fig. 3. Case 1; htx—eosin; × 445
Fig. 4. Case 3; extraction after 24 hours; htx — eosin; × 20
Fig. 5. Case 5; extraction after 4 weeks; htx — eosin; × 65
Fig. 6. Case 5; htx—eosin; × 115

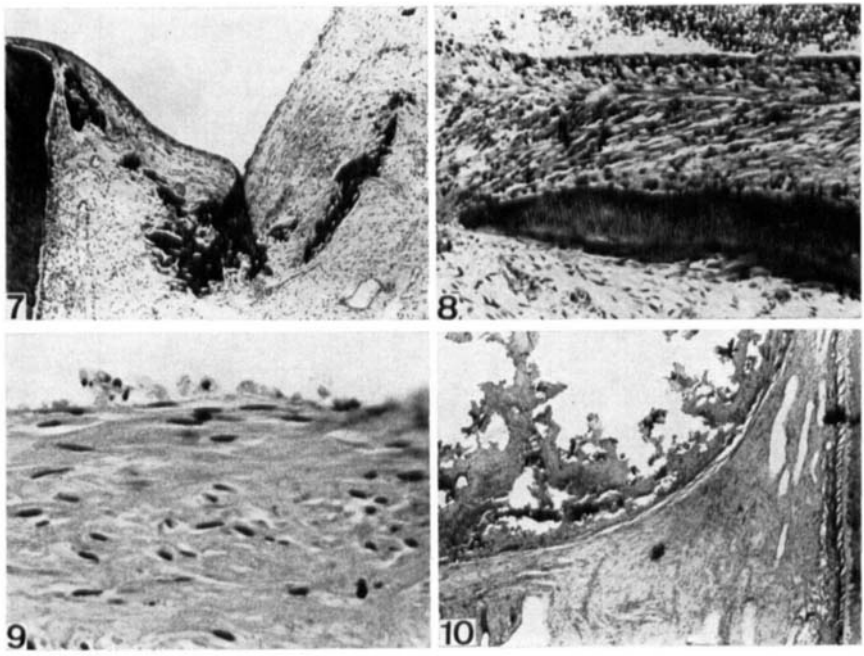


Fig. 7. Case 6; extraction after 4 weeks; htx — eosin; × 45
Fig. 8. Case 7; extraction after 4 weeks; Weigert — van Gieson; × 115
Fig. 9. Case 8; extraction after 4 weeks; Weigert — van Gieson; × 295
Fig. 10. Case 9; extraction after 1 week; no hemostasis; htx — eosin; × 45

Case 9

Extraction after 1 week; no physiologic hemostasis; Teflon®-disc applied directly onto the bleeding pulp.

RESULTS

The results are illustrated in Figs. 2—10.

Cases 1 and 2

The pulps had very little damage. Fig. 2 shows a practically unaltered odontoblast layer right up to the surgically cut (ground) surface. In this, there is a clot at the orifice of a blood vessel. Just below the surface the blood vessels are contracted. Fig. 3 shows detail of the smooth surface.

Cases 3 and 4

The cut surfaces were smooth. Both teeth showed intra-pulpal hemorrhage extending from the surface down to a depth of 2—3 mm (Fig. 4). A large

number of granulocytes and some lymphocytes were present around the hemorrhages. The underlying pulp tissue was normal.

Cases 5—8

The cut surfaces were smooth in each case. The pulps exhibited mild inflammatory changes such as dilated blood vessels and increased numbers of histiocytes in the deeper parts. No signs of tissue destruction were seen. Scattered, fresh erythrocytes at about the level of newly aspirated odontoblast nuclei indicated extraction trauma.

Fig. 5 shows an odontoblast layer up to a short distance from the wound surface. Fig. 6 is from the same case and shows dilated vessels and some lymphocytes in the centre of the pulp near the surface. Above the surface of the pulp there is a confined extra-pulpal blood clot undergoing decomposition. Fig. 7 shows the same type of changes seen in Fig. 5 and proliferation of connective tissue over the dentine shelf. Furthermore, the upper part of the pulp contains some calcifications. Centrally, there is a fold caused by the histologic preparation. Above the tangentially sectioned dentine wall in Fig. 8, which is from the third case in this group, horizontally-arranged condensed connective tissue can be seen. Fresh erythtocytes are present over the surface. Finally, in Fig. 9 from the last 1 month case, an area of densely packed collagen can be seen just below the surface.

Case 9

The treatment had provoked pain which was felt at bedtime for some days and tenderness on chewing during the whole week. The pulp was markedly compressed with obvious signs of degenerative changes (Fig. 10) such as vacuolation in the odontoblast layer and loss of cellular detail in general.

DISCUSSION

The result of the treatment in cases 1 and 2 suggests that the surgical procedure had caused insignificant trauma. The hemorrhage in the 24-hour cases is confusing. It can possibly be due to the pulp tissue having been so weakened by being cut that the trauma of the extraction caused vessel ruptures.

Cases 5—8 illustrate that a pulpotomized tooth that has not been treated with an active wound dressing need not undergo such pathologic changes as chronic pulpitis with abscesses, fibrous degeneration, and irregular calcification that *Masterton* (1966) found after leaving an extra-pulpal

blood clot behind, if the wound surface is kept free from such a clot. The lymphocytes just below the surface in Fig. 6 are probably associated with the decomposed extra-pulpal clot. The case with the Teflon ®-disc applied directly onto the bleeding pulp illustrates the unsuitability of this procedure.

The pulp has apparently a potential for formation of a fibrous barrier towards a foreign environment. One case showed a large amount of dense newly-formed collagen and another case showed a smaller amount of the same material.

Concluding the results, the present model for experimental pulpotomy can be said to fulfil high requirements for studies of pulp healing.

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SUMMARY

The objectives of this study were to devise an experimental model for investigations of pulp healing after surgical incision, and to study the tissue reaction after »physiologic» hemostasis without the influence of an extra-pulpal blood clot.

The technique involved the cutting of a cylindrical hole from the occlusal surface of the experimental teeth, which were all bicuspids to be extracted for orthodontic reasons. By means of a cylindrical instrument with smooth sides and a diamond layer on its base the pulp was ground away to the level of its largest cross section. The residual pulp tissue in teeth extracted immediately after physiologic hemostasis appeared normal. In particular, the odontoblast layer appeared undamaged. Teeth extracted after 4 weeks showed that the pulps did not undergo pathologic changes, when the wound surface was kept free from an extra-pulpal blood clot.

RÉSUMÉ

PULPOTOMIE EXPÉRIMENTALE DANS DES PRÉMOLAIRES HUMAINES: TECHNIQUE DUDL. SECTIONNEMENT

Ce travail a eu pour but l'élaboration d'un modèle expérimental pour l'étude de la cicatrisation pulpaire après incision chirurgicale, et l'étude des réactions des tissus après hémostase «physiologique» en l'absence de l'influence d'un caillot extra-pulpaire.

Cette méthode a comporté l'ouverture d'une cavité cylindrique à partir de la surface occlusale des dents expérimentales, qui étaient toutes des prémolaires devant être extraites pour raisons orthodontiques. Au moyen d'un instrument cylindrique dont les côtés étaient lisses et dont la base était couverte d'une couche de diamant, le tissu pulpaire a été enlevé par meulage jusqu'au niveau où l'étendue de sa section transversale était maximum. Le tissu pulpaire résiduel des dents extraites immédiatement après hémostase physiologique s'est révélé normal. En particulier, la couche des odontoblastes a semblé ne pas être endommagée. Dans les dents extraites au bout de 4 semaines, les pulpes ne présentaient pas d'altérations pathologiques lorsque la surface de la plaie était gardée sans contact avec un caillot extra-pulpaire.

ZUSAMMENFASSUNG

EXPERIMENTELLE PULPAAMPUTATION BEI MENSCHLICHEN BIKUSPIDEN MIT RÜCKSICHT AUF SCHNITT-TECHNIK

Die Absicht dieses Studiums war, ein experimentelles Modell zur Erforschung des Heilprozesses der Pulpa nach einem chirurgischen Eingriff herzustellen und die Reaktion des Gewebes nach »physiologischer» Hämostasis ohne den Einfluss eines extrapulpalen Koagels zu studieren.

Die Technik bestand darin, eine zylindrische Öffnung von der ocklusalen Fläche von Bikuspiden aus, die aus orthodontischen Gründen extrahiert werden sollten, zu schaffen. Mit einem zylindrisch geformten Instrument mit glatten Seitenflächen und einem Diamantlager, das die Basis bedeckte, wurde die Pulpa bis zum Niveau ihres grössten Querschnittes weggeschliffen. Das restliche Pulpagewebe sah bei den Zähnen, die unmittelbar nach der physiologischen Blutstillung extrahiert wurden, normal aus. Besonders das Odontoblastenlager erschien unverletzt. Zähne, die nach 4 Wochen gezogen wurden, zeigten, dass die Pulpa keine pathologischen Veränderungen aufweist, wenn die Oberfläche der Wunde von einem extrapulpalen Koagel freigehalten wird.

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