Healing Following Transplantation of Periodontitis-Affected Roots with Calcium Sulfate in the Extraction Socket

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I. INTRODUCTION

Autogenous tooth transplantation is transferring a tooth to a different position in a same individual[1, 2]. That is, transferring an impacted, embedded or erupted tooth to an extraction site or a surgically prepared socket[3]. The autogenous transplantation, with a sound understanding of the indications, can be an effective clinical approach for the replacement of a lost tooth. However, in many cases, root resorption results in a loss of the transplanted tooth mostly within 1 year of the therapy[4~10].

The factors influencing the root resorption include a developmental stage of the tooth, a donor tooth type, an extraoral storage of the graft[10, 11], a morphological compatibility of the transferred tooth[12] and the recipient socket and the nutritional supply to the root surface[13].

Studies on the tooth replantation reported that the cells from the bone granulation tissue had a potential to induce root resorption and ankylosis[14~16].

In a study by Karring et al.[17, 18], periodontitis-affected roots were transplanted to surgically prepared bone recipient sites following a root planing. They found that the granulation tissue from the bone was the main factor producing root resorption and ankylosis, and that the cell type repopulating the wound area could disrupt the new connective tissue attachment. Aukhil et al.[19], also stated that the connective tissue from the bone had a high potential to induce root resorption.

Löe & Waerhaug[15] stated that the success of the transplantation might depend on the presence of a vital periodontal membrane.

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Nyman et al.[20] said that only the periodontal ligament cells had the ability to reestablish the connective tissue attachment.

The recipient bed of the extraction socket in tooth transplantation is surrounded with the alveolar bone, and therefore the source of the granulation tissue established during the healing phase may likely be the cells from the bone. Therefore, a successful transplantation may require a blockage of the cells from the bony wall of the extraction socket.

Calcium sulfate has been considered a safe bone replacement material in orthopedic surgery since 1950's, and in the last 30 years has been used in dentistry. Peltier[21] reported that calcium sulfate in the radius fracture healing of dogs produced no inflammatory response, resorbed completely within 2 months and only transiently raised the serum calcium level, although no bone formation was induced. Radenz, Colling[22] and Bell[23] reported that calcium sulfate grafted in the alveolar bone of dogs resulted in the resorption of the graft within 3 to 6 weeks and new bone formation within 12 weeks. Shaffer & App[24] showed that calcium sulfate grafted in human alveolar bone resulted in no bone formation although the graft was biocompatible and rapidly resorbed.

These reports suggest that if calcium sulfate is grafted along with a transplanted root, the graft can block the granulation tissue from the bone during its resorption and effectively prevent root resorption.

The purpose of the present study is to investigate whether calcium sulfate grafting can delay the root resorption and ankylosis of periodontitis-affected roots of dogs transplanted into extraction sockets following root planing.

II. MATERIALS & METHODS

The mandibular right and left 2nd and 3rd premolars of four adult mongrel dogs approximately 1 year of age weighing about 15kg with healthy periodontium have been selected. Medical grade calcium sulfate was used as the graft material.

Surgical procedures were performed under intravenous sodium pentobarbital anesthesia (30mg/kg). Surgical sites at mandibular second and third premolars also received infiltration anesthesia with 2% lidocaine HCl. Experimental periodontal defects were created by elevating buccal and lingual mucoperiosteal flaps and removing alveolar bone with surgical burs and chisels so that furcation areas were exposed. Elastic orthodontic ligatures were placed at the cervical areas to induce plaque accumulation, and the flaps were sutured. Animals have been monitored for 8 weeks, and the artificially created chronic periodontitis was confirmed.

Animals were anesthetized again with same protocol as previously mentioned, and the flaps were elevated. The exposed root surface was root-planed. The apical extent of exposed root surfaces were marked by placing notches with burs. Coronal portions of the premolars were removed down to furcations with high speed burs.

The roots were carefully extracted, and split in half along the axis. Pulp tissue was carefully removed(Fig 1). The roots from the left side were transplanted to the extraction sockets on the right side with calcium sulfate

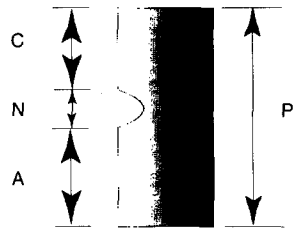

Fig 1

graft(control specimens), and the roots from the right side were transplanted to the left with no graft(test specimens). The roots were inserted with the cut side facing labial, and flaps were sutured so that the roots were completely submerged under the flaps.

Sutures were removed after 1 week. Animals were sacrificed after 12 weeks and the block sections including 2nd and 3rd premolars and adjacent tissues were removed.

Section were rinsed in saline, fixed in 10% buffered formalin for 7 days, decalcified in 5% formic acid for 2 weeks, and embedded in paraffin. Serial sections, 5㎛ thick, were cut and stained with hematoxylin/eosin. Sections were analysed under Leitz-Laborlux light microscope.

III. RESULTS

The transplanted roots of the control and the test speciemens were histologically observed in their coronal, apical and pulpal portions.

Coronal portion

In the control specimens, no signs of true regeneration could be seen, and repair through root resorption and ankylosis as well as resorption by the infiltration of gingival connective tissue were observed(Fig 2, 3). In many cases, resorption was severe enough to obliterate the notch made at the time of the surgery.

In the test specimens, root resorption was observed but not ankylosis. A space between the root and the socket wall where calcium sulfate might have existed was observed in addition to loose connective tissue. New cementum, connected to the socket bone by the periodontal ligament was seen around the notch area.

Apical portion

In some of the control(Fig 2) and the test specimens(Fig 6, 7), regeneration was evident, while in others inflammatory resorption can be seen.

Pulpal portion

The signs of inflammatory resorption with resorption lacunae containing the multinucleated cells were observed in the control(Fig 4) and the test specimens(Fig 8). The inflammation may be caused by the pulp remnant from the surgery.

IV. DISCUSSION

The present study shows that when a periodontitis-affected root is root planed and transplanted along with calcium sulfate graft, root resorption and ankylosis may be delayed while the graft material is being resorbed, although regeneration was minimal on the diseased sites and the pulpal side of the root. This result may suggest that even if the granulation tissue originating from the alveolar bone, which is known to be the major factor inducing root resorption of the transplanted root, is blocked, regeneration may not occur

unless the appropriate environment for the growth of periodontal ligaments such as an adaquate space for the ligament cells to grow can be provided.

The diseased coronal portion of the control specimens showed the evidence of repair through root resorption and ankylosis or root resorption by the infiltration of gingival connective tissue. On the other hand, the same sites on the test specimens showed that, although some root resorption was evident, some loose connective tissue and a void, which is probably the space previously occupied by calcium sulfate graft were observed between the root and the bone. Since calcium sulfate is rapidly resorbed completely within 2 months of grafting[21-24], the same graft material used in the present study may be completely resorbed, leaving an empty space and some loose connective tissue of unknown origin. As Shaffer & App[24] reported, calcium sulfate may be biocompatible and rapidly resorbed, but does not result in bone formation.

It is not clear exactly how long it took for the calcium sulfate to be completely resorbed, but had the observation period be longer than 12 weeks, we may observe bone formation as well as root resorption and ankylosis. However, the use of calcium sulfate graft may block the granulation tissue from the alveolar bone, thereby delaying the root resorption.

Since the infiltration of gingival connective tissue did occur in the control specimens, it may be speculated that the calcium sulfate graft can effectively block the connective tissue infiltration when a gap existed from the morphological difference between the transplanted root and the recipient site.

Just as in other similar studies[25-27], some of the specimens showed new cementum formation coronal to the notch. According to Melcher[28] & Line[29], this phenomenon may be the result of a coronal migration of the ligament cells from the apical portion of the root. Since the test specimens of the present study showed the void instead of the connective tissue attachment coronal to the notch, it may be presumed that calcium sulfate may not induce the proliferation of periodontal ligament cells.

Both the control and the test specimens showed resorption lacunae and severe inflammatory resorption on the pulpal portion. This may be the result of incomplete removal of pulpal tissue, although the exact cause is unknown.

Apical to the notch, either the reestablishment of periodontal ligaments or the replacement resorption and the inflammatory resorption were observed. The inflammatory resorption may be the extension of the inflammation of the pulpal portion, and the replacement resorption may be the result of periodontal ligament tissue unable to survive the surgical trauma.

Nethander et al.[13] reported that the nutritional supply to periodotal ligament and cementum might affect the success of the transplantation. He maintained that this nutritional supply might be interrupted at the time of the extraction, and until the circulation was reestablished, the nutrition was supplied via diffusion. In the present study, the evidence of ligament reestablishment could be seen in the apical portion, and therefore calcium sulfate does not appear to disrupt the

diffusion of nutritions.

The results of the present study suggest that although regeneration of new cementum and periodontal ligament failed to materialize, root resorption and ankylosis could be effectively delayed by calcium sulfate graft which can block the granulation tissue from the alveolar bone.

V. SUMMARY

The purpose of the present study is to investigate whether calcium sulfate grafting can delay the root resorption and ankylosis of periodontitis-affected roots of dogs transplanted into extraction sockets following root planing. The alveolar bone around the 2nd and 3rd premolars of four adult dogs were removed to expose bifurcations following the flap elevation, and experimental chronic periodontitis was induced by elastic ligatures for 8 weeks. Following the crown resection and the root hemisection, roots were instrumented and extracted. The roots were split in half, and each piece was transplanted into either the right recipient sites with calcium sulfate or into the left recipient sites without the graft as controls. The results were analyzed histologically after 12 weeks. Coronal to the notch, root resorption and ankylosis occurred in the controls while loose connective tissue and the space that has been occupied by calcium sulfate were found, and root resorption was delayed in the test specimens. With the limitation of this study, the use of calcium sulfate in tooth transplantation can block the granulation tissue from the alveolar bone and may delay the root resorption and ankylosis.

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논문 사진부도 설명

Fig 2 A control specimen shows advanced root resorption with obliteration of the notch. Root resorption and ankylosis are evident in the coronal portion, and the inflammatory resorption can be seen in the coronal and the pulpal portions(H-E×20).

Fig 3 A coronal portion of a control specimen shows ankylosis(H-E×100).

Fig 4 An apical portion of a control specimen shows inflammatory resorption(H-E×100).

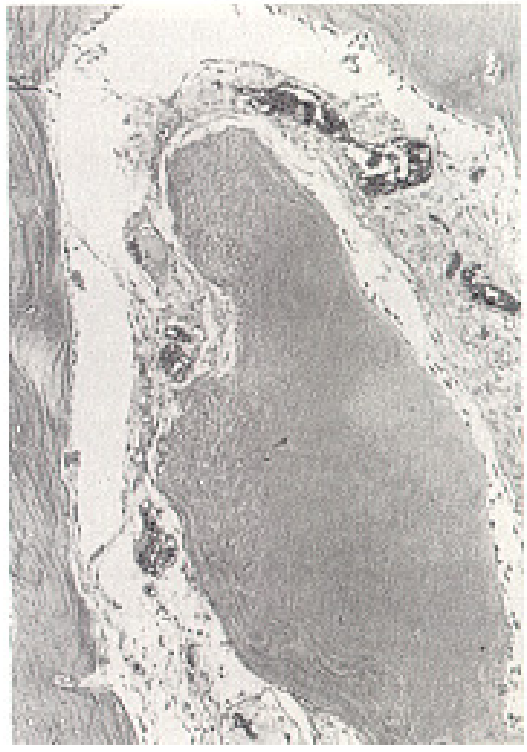
Fig 5 A test specimen showing the definite outline of the notch and the newly formed cementum connected by periodontal ligament to alveolar bone. The coronal portion shows some loose connective tissue and a space previously occupied by calcium sulfate. The apical portion shows the evidence of repair in the periodontal ligament while the pulpal portion shows inflammatory resorption(H-E×20).

Fig 6 A test specimen showing the newly formed cementum connected by periodontal ligament to alveolar bone near the notch(H-E×100).

Fig 7 A test specimen: Apical healthy cementum side shows newly formed healthy periodontal ligament connected by newly formed alveolar bone(H-E×100)

Fig 8 The pulpal side of a test specimen showing inflammatory resorption(H-E×100).

Fig 3



-국문요약-

Calcium Sulfate가 성견 발치와내에서 치주질환이환 치근이식과 치조골 재생에 미치는 영향

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이 연구의 목적은 치주질환에 이환된 성견의 치근을 활택술 후 발치와에 이식하였을 때 calcium sulfate 골이식이 치근흡수와 치근유착을 지연시키는가를 알아보고자 하는 것이다. 성견의 제2, 제3 소구치 주위의 치조골을 제거하여 분지부를 노출시키고, 8주간 교정사를 결찰하여 실험적 만성치주염을 유발하였다. 치관을 제거하고, 치근을 반분하고, 활택한 후 발치하였다. 발치된 치근을 둘로 나누어 각각을 우측에는 calcium sulfate와 함께, 좌측에는 이식재 없이 이식하였다. 12주간의 치유 후 조직학적으로 관찰하였다. 대조군에서는 흠의 치관쪽으로 치근흡수와 치근유착이 일어났고, 실험군에서는 성견 결합조직과 calcium sulfate가 위치하였던 공간이 관찰되었고 치근흡수는 지연되었다.

이 연구에 나타난 바에 의하면, 치근 이식시 calcium sulfate의 사용은 치조골로부터의 육아조직을 배제하고 치근흡수와 치근유착을 지연할 수 있는 것으로 생각된다.