A new biological concept for optimizing implant sites

Introduction

Extraction of a tooth regularly induces resorption processes that can lead to a significant loss of alveolar tissue structures. Various, usually augmentative techniques have been established for preparation and improvement of the subsequent implant site. However, these methods are invasive, cost-intensive and require a high level of experience. Furthermore, increasing complexity reduces the predictability of the result. Due to these facts, a superior method of avoiding resorption of the bony socket after tooth extraction was sought. It has been known for a long time that a replanted tooth has a remarkable bioregenerative potential.

The objective of this pilot study was to research a therapeutic procedure that included the replantation of a tooth or root segment with subsequent orthodontic extrusion after tooth extraction. The aim was to examine whether this method could help preserve the jaw bone and gingiva.

Material and methods

In the present pilot study 10 non-conservable teeth in 8 patients were extracted and resected about 2 mm below the fibrous apparatus. The remaining clinical crowns of three teeth were also removed. The thus shortened teeth or root segments were immediately replanted. After a short healing phase 6 segments in 5 patients were orthodontically extruded. Photo documentation, models, radiographs and DVT images were employed to examine tissue preservation and/or tissue regeneration.

Results

Clinical observation as well as DVT evaluation and 3D model analysis showed that the alveolar structures, especially the buccal lamella, which is usually resorbed, were preserved almost completely by the replantation. Extrusion of the segments induced vertical tissue apposition.

Conclusion

The method presented facilitates preservation and regeneration of all osseous alveolar structures after an extraction. The subsequent implant site provides a sufficient basis for prosthetic treatment within a curtailed treatment period, which is stable in the long term and esthetically sophisticated. Further studies are necessary in order to investigate the full potential of this new method.

Keywords: tissue preservation; tissue augmentation; regeneration; buccal bone lamella; esthetics; extraction; resection; replantation; extrusion; implantation

Introduction

Extraction of a tooth regularly leads to resorptive processes, which may be associated with considerable loss of alveolar tissue [2, 7]. The resulting deficits can make subsequent implantation and prosthetic restoration much more difficult. Various augmentation techniques to avoid or diminish this problem have now become established [12]. All of these techniques are invasive, most involve bone substitutes and, especially in the case of larger defects, they require great surgical skill [3, 22]. It has been known for a long time that an extracted tooth has a remarkable bioregenerative potential if replanted [8, 10, 18, 25]. This fact is utilized in the technique presented here. Root segments of the previously extracted tooth are replanted and extruded after a short healing period [9, 19]. The objective of this pilot study was to research this new therapeutic procedure.

Material and methods

In the present pilot study 10 teeth in 8 patients were selected, 5 upper anteriors, 2 upper posteriors and 3 lower posteriors. None of the teeth was conservable.
The reasons included deep destruction of coronal tooth substance, irreversible apical changes and a subgingival tooth fracture with infractures in the residual preparation. All teeth had an intact circular cuff or periodontal tissue. Local periodontal defects were limited to pocket depths of up to 4–5 mm.

Clinical procedure

Prior to extraction, supragingival plaque was removed with ultrasound from the tooth to be extracted and from adjacent teeth. The subsequent extraction was performed as gently as possible and without mechanical division of the gingival adhesion. Following extraction, the apical region of 7 teeth had to be revised through the socket because of inflammatory processes, but this did not affect the later result. The extracted tooth was placed in sterile normal saline until use. All teeth were then resected about 2 mm below the supra-alveolar fibrous apparatus or below an intact circular periodontal cuff to produce a biologically active replantation segment (a segment or apical part of the residual tooth) about 2–3 mm in height (Fig. 1). After resection, the lumen of the root canal was prepared with a cylindrical diamond bur (012) and sealed with RelyX (3M Espe) or Clearfill SA cement (Kuraray). The root segments were then replanted in their original position and covered with a dressing film. In the case of one multi-root upper molar with extensive denudation on the distobuccal root, another segment for replantation had to be obtained from the mesiobuccal root of this tooth (Fig. 2). This segment was chosen as it provided the greatest congruence of shape and volume with the corresponding socket. After a healing or fixation period of roughly 10 days, the replanted root segments of 6 teeth in 5 patients were extruded about 2 mm over a 2–5 day period. Extrusion was obtained with elastic rubber rings and a set of extrusion and bar units (TMC Set Extrusion, Komet) (Fig. 4 and 7). Subsequent fixation for 6 to 10 weeks was obtained using a composite splint. In 3 patients, the root segments of 4 teeth in the maxilla were only replanted and not extruded (Fig. 3).
The entire treatment was documented using photos, radiographs, DVT images and models. The models underwent 3D analysis with computer-assisted scanning. Changes in the gingival structures and alveolar bone were recorded and analyzed using these parameters and the DVT images (Fig. 3).

Nearly all stages of treatment were performed with conventional instruments. The teeth were dislocated with Bein elevators and extracted with anatomically shaped forceps. The subsequent resection was performed horizontally with a diamond separating disk or in scalloped manner with a Lindemann drill, cooling with sterile saline.

Newly developed special manual instruments (Nemris/Zepf) were used only for wound revision, fixation of the segments when preparing the root canal lumens and replantation of the root segments. Revision of the apical region and excochleation of the sockets were also performed with special newly designed raspatories and curettes (Fig. 8). Their special cutting edge allowed the inner cortex of the socket to be treated very gently and the often very thin buccal bone lamella was preserved in full in all cases.

The root canal lumens were prepared with forceps, the arms of which were curved over the surface.

This allowed the root segment to be grasped securely over the resection surfaces and the circular periodontal ligament around it was spared. The root segments were replanted with forceps, the branches of which permitted the replanted segment to be held securely while optimally sparing the ligament and gingival cuff (Fig. 8).

Results

Clinical observation as well as DVT evaluation and 3D model analysis showed that the alveolar structures, especially the buccal lamella, which is usually resorbed, were preserved almost completely by the replantation. Extrusion of the segments induced vertical tissue apposition.

All replanted root segments healed within 10 days without complication. A longer healing period was observed with the replanted segment obtained from a different root of the same tooth so that it did not match the alveolar volume exactly (Fig. 2).

As the photographs show, the width of the attached gingiva is nearly the same after replantation of the root segments (Fig. 4). The subsequent extrusion of the replanted root segments led in all 6 cases to coronal movement of the gingival margin and the widening of the attached gingiva. The change accounted for roughly 80% of the extrusion movement (Fig. 4 and 5).

The 3D model analysis showed that the alveolar soft and hard tissue structures were very largely preserved by the replanted root segments. Palatal and lingual tissue loss was greatest in the vertical dimension at 0.3 mm and was least in the horizontal dimension at 0.2 mm. In the region of the labial and buccal bone lamella, the maximum tissue loss was 0.5 mm in the vertical and 0.6 mm in the horizontal dimension (Fig. 3).

In all cases, extrusion of replanted root segments led to vertical movement of the adjacent alveolar tissues structures (Fig. 4, 5 and 6). The vertical gain in bone was identified over the entire socket and the labial and buccal bone lamella (Fig. 6). The vertical changes were less marked in the palatal and lingual bone margins.

The vertical “follow-up” corresponded to the figures of about 70–90% of extrusion movement (Fig. 4, 5 and 6) given in the literature.

The radiographs and DVT images showed that the sockets were entirely filled with bone after a period of 6–10 weeks (Fig. 6).

Discussion

The structural quality, quantity and stability of peri-implant tissue are of fundamental importance for a stable long-term and esthetically attractive outcome. It is therefore very important to insert implants in a stable bony bed and to prepare the implant site as well as possible.

Since extraction of a tooth leads within a relatively short time to extensive loss of alveolar tissue, surgical augmentation methods have been developed to replace the lost tissue adequately [2, 7]. The disadvantages of these treatments include the increased patient burden due to one or more additional procedures, the increase in required materials including the associated costs, and the fact that the outcome depends on the surgeon’s skill [3, 12, 15].

The new biological approach sees the periodontal ligament as the key to preserving, developing and regenerating alveolar structures. The tooth or a segment of the tooth may influence the preservation or regeneration of alveolar structures via the periodontal ligament [6, 20, 21]. It has repeatedly been shown that extrusion of a tooth causes coronal movement of all oral hard and soft tissue structures bordering the tooth [4, 11]. This fact is used, for instance in correction of the “gingival contour line” to achieve a very attractive appearance in esthetic treatments [26, 27]. Even in the case of teeth with advanced periodontal disease, regeneration of lost alveolar structures is possible by means of extrusion [1]. Based on this structural and functional association, various authors have employed extrusion of a tooth to prepare an implant site [5, 13, 14]. The positive influence on both alveolar tissue structures should be emphasized [17, 23, 24].

In this biological concept, the use of root segments is completely new. The results show clearly that the potential for preservation and regeneration of replanted and extruded root segments is similar to that of whole teeth.

Another advantage of the new technique is the possibility of opening and revising apical processes directly through the open socket, that is, minimally invasively and without gingival incisions. This is important especially in difficult esthetic situations, for example, a high smile line.

The results show clearly that ossification of the socket is complete after just 6–10 weeks.

The waiting period for implantation after orthodontic therapy proposed by Zachrisson can therefore be markedly reduced, leading to a much shorter treatment period [16].

The implantation of one-piece Aesthura Immediate implants (Nemris) in the regions treated with the new method did not show any differences compared with the classic procedure of delayed implantation after 6 months [10].

The low level of variation in the achieved tissue preservation was striking, suggesting that the result of treatment is reproducible and predictable. This treatment method may allow manipulation and optimization of the gingival contour line for esthetic reasons during implant-based prosthetic rehabilitation.

The presented method facilitates preservation and regeneration of all osseous alveolar structures after an extraction. The subsequent implant site provides a sufficient basis for prosthetic treatment within a curtailed treatment period, which is stable in the long term and esthetically sophisticated (Fig. 9). Further studies are necessary in order to investigate the full potential of this new method.

Conclusions

1. Replantation and extrusion of root segments facilitates preservation and vertical regeneration of functionally important alveolar hard and soft tissues. Natural wound healing potential and extrusion-induced tissue regeneration are evidently utilized.

2. The results are predictable and demonstrate a very small volume deficit.

3. They meet both functional and high esthetic demands and are equivalent to augmentation techniques.

4. The procedure is simple, saves time and money, and is minimally invasive.

5. Further studies are necessary in order to establish the full potential of this new method.

Conflict of interests

The authors state that there are no conflicts of interests in the meaning of the ICMJE.

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References

Figure 1 Formation and replantation of a root segment: extracted tooth 24 **(a)**, forming the root segment with a surgical milling cutter **(b)**, replantable root segment **(c)**, root filling with RelyX® **(d)**, replanted root segment **(e)**, covering and protecting it with a vacuum-formed foil **(f)**

Figure 2 Different healing processes of congruent and incongruent root segments in region 16: after replantation **(a)**, delayed healing with incongruence of form **(b)**

Figure 3 Preservation of the alveolar volume after replantation of root segments, 3D profiles of the scanned models: initial clinical situation **(a)**, clinical situation after 15 months **(b)**, model
view before extraction **(c)**, model view after 2.5 months **(d)**, model view after 10 months **(e)**, model view after 15.5 months **(f)**

Figure 4 Extrusion of a coronal root segment: healed segment **(a)**, fixed extrusion pivot **(b)**, extrusion using an elastomeric ligature **(c)**, segment fixed **(d)**, radiograph showing replantation **(e)**, radiograph showing extrusion **(f)**

Figure 5 Coronal movement of the soft tissue caused by extrusion: start of extrusion **(a)**, end of extrusion after 2 days **(b)**

Figure 6 Coronal movement of the alveolar bone caused by extrusion, labiopalatal view: after extrusion **(a)**, “follow-up” of the buccal bone lamella after 6 weeks **(b)**

Figure 7 TMC extrusion set: pivot unit **(a)**, mechanism of action **(b)**

Figure 8 Tissue-conserving instruments for wound examination and replantation: curettes **(a)**, barrel forceps: anterior or posterior tooth **(b)**, fixation forceps **(c)**

Figure 9 Case presentation: initial clinical situation with severely fractured teeth 12, 11 and 21 **(a)**, DVT of region 11 with deep fracture line **(b)**, result of restoration of region 13–23 with conservative treatment of 12 and implant-based treatment of 11 and 21 **(c)**, DVT of the prosthetic treatment with preservation of the buccal bone lamella **(d)**