

Original Article

Conventional extraction vs. enucleation in anterior maxillary sites: a pilot study in humans

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Abstract: Background: Surgical extraction of ankylosed roots may cause severe defects of the alveolar crest. The aim of the present study was to determine the effects of flapless enucleation on the frequency of osteotomy and the maintenance of the alveolar crest width. Method: Ten patients (3 m, 7 f) requiring extractions in the anterior maxillary zone were included and randomly treated with conventional extraction and flapless microsurgical enucleation; osteotomy served as rescue technique in both groups. Socket preservation was performed using in situ hardening TCP bone substitute. Results: In the extraction group, 4/10 patients required osteotomy, in the enucleation group 0/10 ($P < 0.05$, chi-square test). The alveolar widths 3 mm below the gingiva before surgery, at 3 and 6 months were 11.50, 8.98, and 9.50 mm in the extraction group and 12.25, 11.35, and 11.25 mm in the enucleation group, respectively. Two of 10 control sites and 0 of 10 test sites required augmentation for implant placement. Conclusion: Flapless enucleation combined with socket preservation appears to provide adequate maintenance of alveolar structures for implant placement and may be an alternative for surgical extraction in ankylosed anterior maxillary sites.

Keywords: Conventional extraction, flapless enucleation, alveolar crest, socket preservation

Introduction

Currently, tooth extraction represents an intervention with major side effects that include the destruction of the periodontal ligament, the possible fracture of the surrounding alveolar bone, and the loss of esthetically important soft and hard tissues. These risks are particularly high in cases of surgical extraction with buccal osteoclastic access. Alveolar bone lamellae may be attached to the extracted tooth by local ankylosis and therefore may lead to primary bone loss that substantially exceeds the amount of post-extraction resorption. As a result of a surgical extraction, considerable bone loss and reduced bone volume in the orofacial dimension may be observed [1]. Previous observations have revealed that intraoperative trauma may be one of the major factors determining the volume required for later reconstruction with or without implants [2]. However, modern dentistry is based on conservative thinking

[3], which should also be adhered to in exodontia and thus applied for conservation of the alveolar structures.

The resorption process following extraction is well known [4-6]. Clinical and/or radiographic studies by Johnson [7, 8], Pietrokovski and Massler [9], Lekovic et al. [10, 11], and Schropp et al. [12] have demonstrated that marked alterations of the height and width of the alveolar ridge will occur following single or multiple tooth extractions. Studies have shown that large defects of the original buccal plate that occur due to periodontal disease or a traumatic extraction procedure do not completely heal [13, 14].

In the literature, little attention is given to the surgical procedure for exodontia and the possible prevention of tissue loss during the removal of a root. Recently, a paradigm shift has occurred toward atraumatic surgical tech-

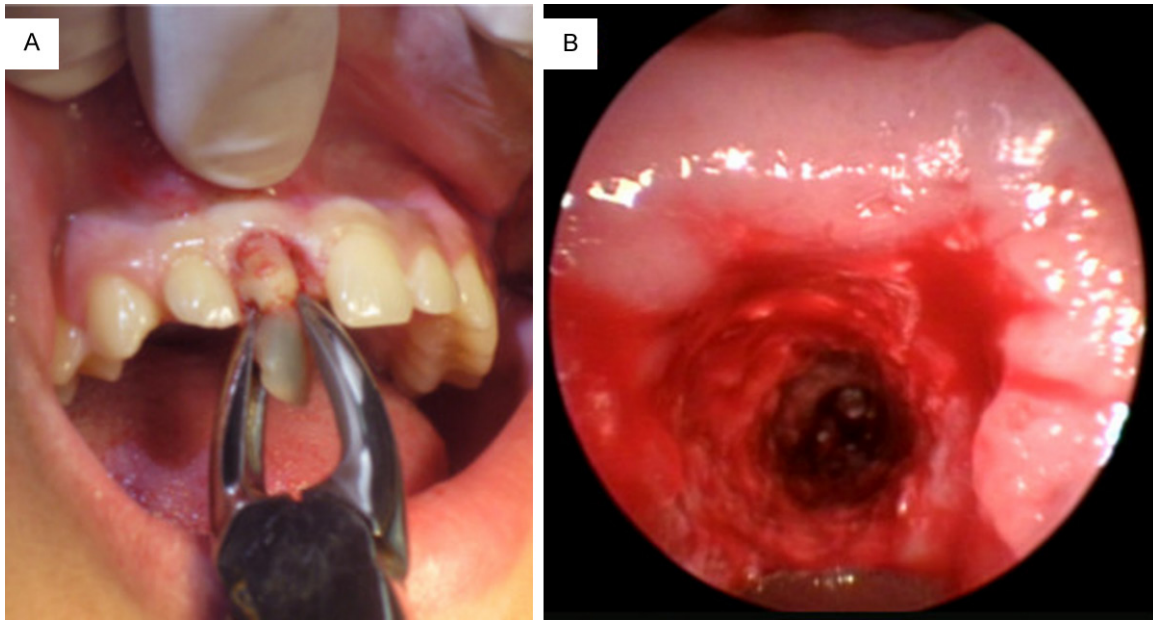


Figure 1. Extraction of a central incisor (left) and empty socket (control group) (right).



Figure 2. Socket preservation using an in situ hardening material (easy-graft® CLASSIC, Sunstar GUIDOR, Etoy, Switzerland).

niques in third molar surgeries that comprise odontosection [15-17] and the partial removal of third molar crowns [18]. In the anterior aesthetic zone, buccal bone loss has a very strong effect on implant treatment outcome [13] in terms of facial aesthetics. Hürzeler et al. [19] reported on a technique that involves the maintenance of buccal root fragments to stabilize the buccal bone plate. These authors [19] concluded that retaining the buccal aspect of the root during implant placement did not appear to interfere with osseointegration and may be beneficial for preserving the buccal bone plate.

Microsurgery of the alveolar socket with newly designed visual tools, such as loupes, micro-

scopes, and endoscopes, has become more popular. These tools have contributed to reducing the trauma of augmentation procedures, particularly sinus floor elevation [20, 21].

Concerning the use of support immersion endoscopy (SIE) for extraction socket assessment, Juodzbaly et al. [22] stated the following: SIE can be used as an adjunct tool for assessing the extraction socket morphology and bone conditions without flap elevation.

With improved insight into small, blood-filled intraoral cavities [23-25], it has become possible to use visual information to reduce osseous trauma in cases of tooth removal with the goal of minimizing trauma. Based on endoscopic visualization, an occlusal inward fragmentation of the roots has been described for partially retained third molars [26]. With this inward fragmentation technique, the socket can be enucleated internally rather than using an open buccal access for the removal of root remnants.

The aim of the present pilot study was to prospectively compare microsurgical enucleation with a conventional protocol for the removal of anterior maxillary teeth with grade 0 mobility.

The evaluation was focused on the following outcome parameters: the need for open sur-

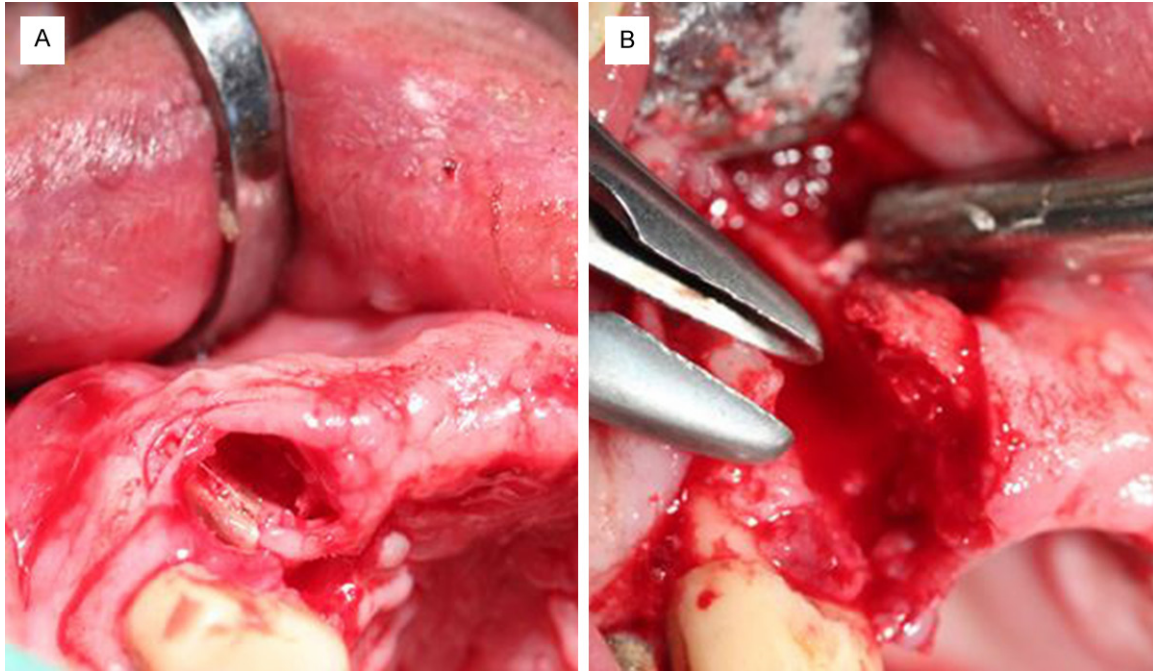


Figure 3. Open surgical procedure using osteotomy to remove an ankylosed root remnant (control group with rescue technique).

gery, changes in the alveolar width, and the suitability of the extraction site as an implant-bearing area.

Materials and methods

Ten patients were included in the present study (age 35-64, mean age 47.4 years, 3 males and 7 females). The test group consisted of 10 teeth (5 incisors, 1 canine, and 4 premolars), and the controls comprised 7 incisors, 1 canine, and 2 premolars. An indication for the extraction of at least one tooth in both of the anterior maxillary zones was taken as the inclusion criteria. Only teeth with mobility grades of 0 were included independently of the statuses the adjacent teeth. All subjects were generally healthy and had no underlying systemic disease as determined by examination of their medical history records. The indications for extraction included profound caries not suitable for conservative treatment or restoration with prosthetic anchors. Teeth that exhibited enlarged periodontal gaps on radiography were excluded. The study was registered by the Bioimplants Laboratory into the research project (PID 6120) and approved by the National University of Entre Ríos, Argentina (Res C.S N 364/12). The patients were informed about the

details of the surgery, and written informed consent was obtained. Before surgery, the experimental and control sites were randomly determined. The extraction sites were anesthetized with local anesthesia (4% articaine hydrochloride, (Ubistesin) 1:200,000; 3 M ESPE, Seefeld, Germany), and the following protocols were applied in single appointments.

Control site: extraction

Following the cautious mobilization of the marginal gingiva with elevators, extraction was performed with dental forceps by rotation or luxation according to the anatomical requirements of the extraction site (**Figure 1**). In cases of successful extraction, socket preservation was performed using a resorbable in situ hardening bone substitute (easy-graft® CLASSIC, DS, Sunstar, Etoy, Switzerland) according to the recommendation of the manufacturer (**Figure 2**).

In cases in which extraction trial with forceps and elevators failed, a buccal exposure with a mucoperiosteal flap, osteotomy, and subsequent flap reposition served as the rescue technique (**Figure 3**). A mucoperiosteal flap was elevated, and buccal osteotomy was performed to expose two-thirds of the root. Buccal luxation

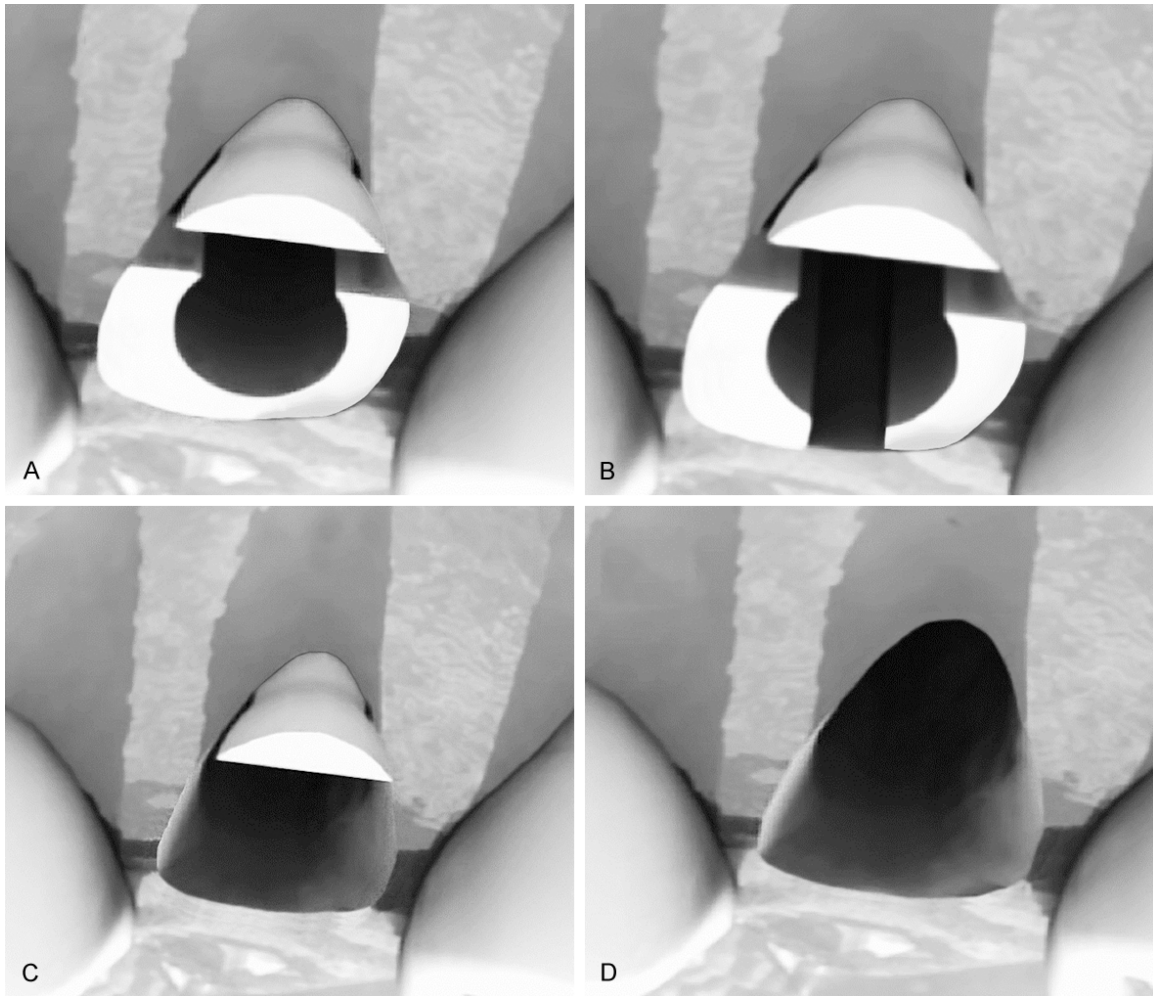


Figure 4. Principle of enucleation. A. Separation of the buccal root lamella; B, C. Separation and removal of the oral root fragments via inward fragmentation; D. Empty socket.

was then achieved using straight elevators. Following apical wound revision, the flap was reflected and sutured using 4-0 silk interrupted sutures.

Test site: enucleation

Enucleation was performed as shown in **Figure 4A-D**. Following decoronation and root canal trepanation, the root was sectioned mesiodistally (**Figure 4A**). The mobile parts of the root were removed by sectioning and inward fragmentation (**Figures 4B, 4C** and **5A**). The apical alveolus was inspected, and the root remnants were enucleated with small elevators (**Figure 5B, 5C**). In cases of existing ankylosis, diamond round burs were used for the complete removal of the root tissue under direct endoscopic vision (**Figure 6B, 6C**). Following enucleation,

socket preservation was performed using a resorbable in situ hardening bone substitute (easy-graft® CLASSIC, DS, Sunstar, Etoy, Switzerland) according to the recommendation of the manufacturer.

If the complete removal of the root structures via the transalveolar access could not be achieved, an open buccal flap with an ostectomy served as the rescue option. All patients received amoxicillin (3×750 mg) and paracetamol (500 mg) every 6 hours. Regular follow up visits were held at 7 days and after 3 and 6 months.

Evaluation

The combined hard and soft tissue alveolar dimensions were measured from plaster casts

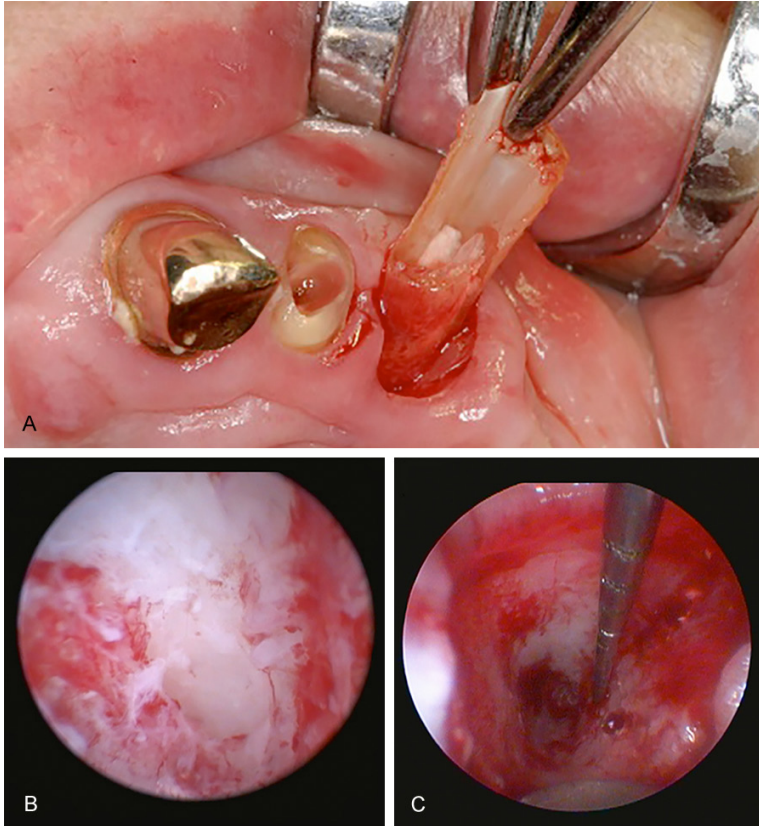


Figure 5. Clinical example of enucleation. A. Removal of a root fragment via inward fragmentation; B. Management of apical root remnants identified by endoscopic inspection; C. Empty socket following enucleation.

using a reference plate (RP) on a silicone rig (**Figure 7A, 7B**). Casts were taken as follows: (1) Immediately prior to surgery. (2) Three months after surgery. (3) Six months after surgery before implant insertion.

The following measurements were taken from the plaster casts:

Vertical distance of the gingival level to the reference plane (DGM).

Alveolar width (AW3) at 3 mm below the original gingival level before extraction and at 3 and 6 months following surgery.

The numbers of osteotomies necessary in each group were recorded.

The bone volumes at the time of implant placement were judged to be sufficient, marginal, or insufficient.

This information was then processed by Wilcoxon Mann-Whitney and chi-square tests using

SPSS® statistical software. Biometrical testing involved descriptive statistics and non-parametric comparisons that were evaluated at the 0.05% level of significance.

Results

The results are shown in **Table 1**. Preoperatively, the alveolar width 3 mm below the gingival margin ranged between 12.25 mm (test) and 11.50 mm (control). These values were 11.85 mm in the test group and 8.98 mm in the control group after 3 months and 11.75 mm and 9.50 mm, respectively, after 6 months. Before the surgeries, there was no significant difference, and at 3 and 6 months, the differences were significant (**Table 2**).

The control group had four osteotomies that exhibited severe reductions in alveolar width compared with simple extraction sites, and these

osteotomies were responsible for the greater loss of width in the control group. The frequency of osteotomy in the control group was significantly higher than that in the test group in which all roots were removed without buccal access. In the test group, all sites were suitable for the receipt of implants, and the control group contained eight suitable extraction sites that did not require augmentation and two sites that required lateral augmentation following osteotomy. There were no significant differences between the test and control groups (**Table 2**). One test site exhibited local periapical inflammation during the early observation period.

Discussion

The main result of the study was that the enucleation technique performed in the test group prevented the need for open surgery in all cases. Therefore, socket preservation can be applied in both the enucleated and extracted sites and lead to similar results at the time of implant placement. The results of the crest

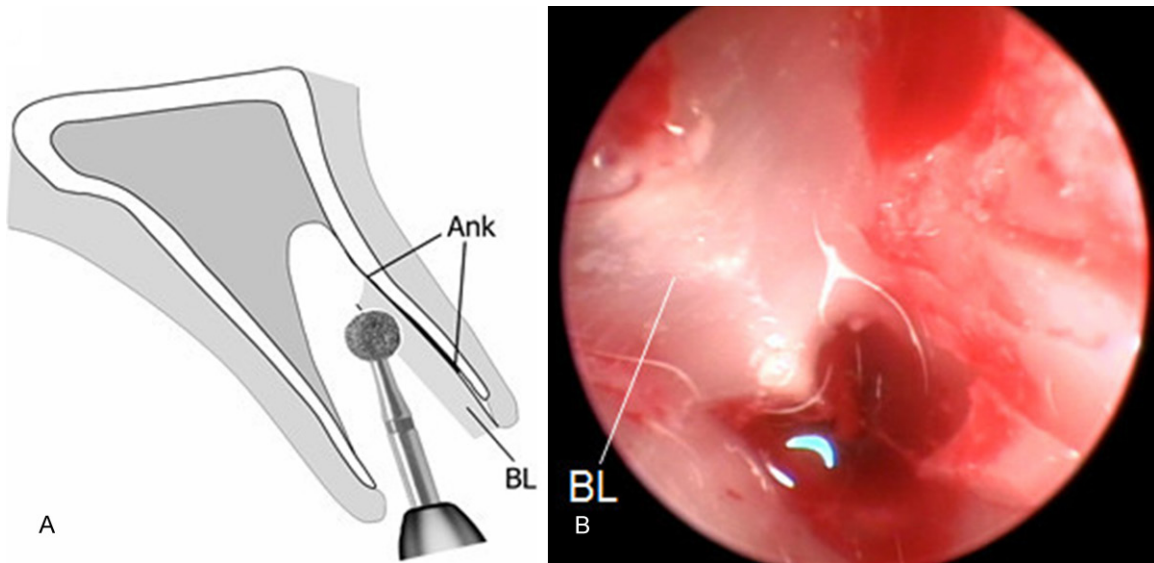


Figure 6. Reduction of ankylosed root remnants. A. Position of the instrument; B. Clinical view of an ankylosed buccal lamella (test group).

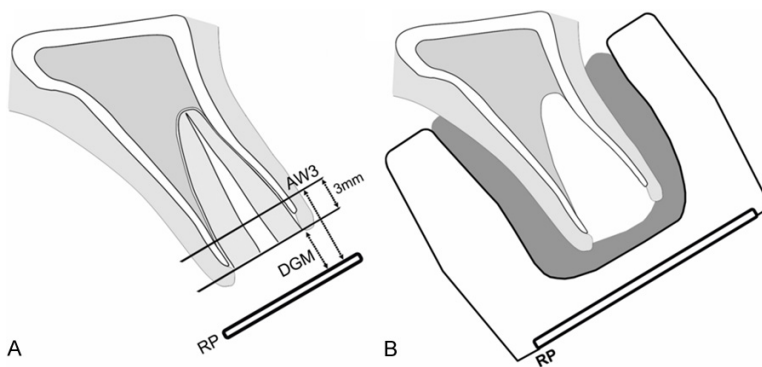


Figure 7. Evaluation. A. Cast section with a reference plate in situ; B. Assessment of the alveolar crest dimension using a reference plane (RP) attached to the adjacent alveolus on the plaster casts. DGM: distance of the pre-extraction gingival margin to the reference plane. The DGM served as the vertical reference for the subsequent transverse measurements: AW3: alveolar horizontal width at 3 mm below the gingival margin (DGM + 3 mm distance). All follow-up measurements were taken at the DGM + 3 mm level.

measurements did not reveal significant differences in the overall changes in the hard and soft tissue widths of the enucleated sites and the conventionally extracted sites without osteotomy. Thus, it may be concluded that osteotomy was the most critical factor that led to bone loss in cases of anterior maxillary teeth with grade 0 mobilities.

The data also revealed that the enucleation sites and the simple extraction in conjunction with socket preservation sites exhibited only moderate degrees of transverse alveolar crest reduction. Although complete maintenance was not observed at 3 or 6 months compared

to the dentate alveolus prior to surgery, our data revealed a comparatively low degree of horizontal reduction, which may have been due to the use of an in situ hardening bone filler for the socket preservation procedure. Using this material, no unintended side effects were reported by the patients in the follow-ups. Occasionally, some discharge of bone filler particles was observed early after tooth removal without signs of inflammatory reactions at the extraction sites.

Due to the present study design, it is important to correlate alveolar contour changes not only with post-extraction situations but also with the original preoperative situations, which in turn required a modified protocol that has yet to be applied in recent studies in this field [27].

Adequate emphasis should be placed on the protocol for measuring the preoperative site at the starting point to enable further evaluations of alveolar crest contour changes rather than beginning the observations after the extraction. The use of a simple reference plate integrated in a silicone rig allowed the achievement of this sequence of measurements without 3D imaging; however, in future studies, 3D imaging

Conventional extraction vs. enucleation in maxilla

Table 1. Alveolar width measurement in mm

	Group	Mean	n	Max	Min	SD
Preoperative	Test	12.25	10	15.00	10.50	1.59
	Control	11.50	10	12.50	10.00	0.69
	Ctr/Ex	11.58	6	12.50	10.00	0.86
	Ctr/Ost	11.38	4	12.00	11.00	0.48
3 months	Test	11.85	10	15.00	10.00	1.65
	Control	8.98	10	13.00	6.00	1.69
	Ctr/Ex	10.83	6	13.00	10.00	1.17
	Ctr/Ost	6.25	4	7.00	6.00	0.50
6 months	Test	11.75	10	15.00	10.00	1.81
	Control	9.50	10	15.00	6.00	2.57
	Ctr/ Ex	10.92	6	13.00	10.00	1.20
	Ctr/Ost	6.25	4	6.50	6.00	0.29

Test: Test group; En: Enucleation; Control: Control group; Ctr/Ex: Control subgroup requiring extraction only; Ctr/Ost: Control subgroup requiring osteotomy as rescue technique.

Table 2. Statistical results: Group vs. control comparisons at the 0.05% level of significance

	P	Significance	Test
Test vs. control preoperative	0.190	No significant	Wilcoxon Mann-Whitney
Test vs. control 3 months.	0.04	Significant	Wilcoxon Mann-Whitney
Test vs. control 6 months.	0.02	Significant	Wilcoxon Mann-Whitney
Frequency of osteotomy	0.025	Significant	Chi-square

with cone beam tomograms may additionally be used to differentiate between the hard and soft tissue contributions to the crest configuration.

A detailed analysis of the vertical crest dimension was not performed in this study due to missing preoperative references. Clinical observations revealed that the vertical dimension was always well above the measurement level 3 mm below the original gingival margin prior to surgery. Thus, severe vertical reductions can clearly be excluded. This observation is in accordance with studies that have reported relatively minimal vertical alveolar atrophy following extraction. A recent systematic review [12, 28] evaluated alveolar bone dimension changes in extraction sockets in humans. This study found a width reduction range of 2.6 to 4.6 mm and a height reduction range of 0.4 and 3.9 mm. The width of the alveolar ridge was reduced by 50% from a mean of 12 mm to 6.1 mm at 12 months. Two-thirds of this loss occurred in the first 3 months [29].

In our study, transverse reductions of 0.75 to 2.52 mm were also observed. The relatively minimal loss of alveolar width may have been because socket preservation using an in situ hardening bone filler was applied in all cases without open surgery, which provides evidence that in atraumatic enucleation procedures, such as those applied in the test group, and uncomplicated extractions, such as those applied in the control group, high degrees of alveolar crest maintenance may be possible.

Recent studies have provided some evidence that the maintenance of the periodontal ligament and the crestal root lamella may exert preventive effects against alveolar bone resorption, and these suppositions can be taken as arguments

in favor of flapless internal enucleation. Additionally, the open flap procedure always causes postoperative discomfort in patients undergoing exodontia. Kim et al. [30] reported that the flapless removal of third molars significantly reduces postoperative swelling, the use of analgesics, and the duration of pain. Based on our experience in the field of third molar removal [26, 30], we believe that flapless procedures are only acceptable if the advantages for the patients are evident. Therefore, workgroups should be encouraged to conduct similar clinical studies to evaluate the degree of crest maintenance, which according to our present experience, appears to be obvious and may lead to changes in exodontia paradigms for aesthetically critical sites in the near future.

Bone defects caused by conventional osteotomy may be reduced by the use of immediate augmentation; however, this treatment variation was not included in our study because this additional factor may have required a number of patients that was far beyond the scope of a pilot study. However, we admit that the use of

socket preservation material in the cases of immediate application in the control group might have improved the outcomes of the osteotomy group.

Among the 20 interventions, one periapical infection was observed. This infection may have been due to local bone trauma following the transalveolar removal of an apical root remnant. However, the majority of the persons treated in this manner reported no hematoma or swelling after enucleation. This finding is in accordance with that of Kim et al. [30] and appears to be a strong argument in favor of flapless procedures, such as enucleation.

The present report is part of an ongoing study in this field to demonstrate that the systematic transradicular approach for the enucleation of extraction sites is comparable to the preparation of an implant cavity in terms of the degree of trauma and postoperative discomfort. The procedure is in full accordance with a recent shift in paradigm toward atraumatic surgical techniques in third molar surgeries, such as odonto-section [8-10], and the partial removal of third molar crowns. Finally, it should be stressed that previous studies of post-extraction changes in the alveolar ridge [14] have not focused any attention on the role of the periosteum attached to the external surface of the marginal bundle bone. It may be assumed that any trauma to the periosteum may lead to increased marginal bone resorption; such traumas occur frequently and can be avoided technically using the enucleation procedure.

Conclusion

Enucleation appears to reduce the need for open osteoclastic tooth extraction.

Enucleation leads to less transverse crest reduction compared to conventional extraction procedures of teeth with grade 0 mobilities.

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Disclosure of conflict of interest

None.

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Conventional extraction vs. enucleation in maxilla

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