Simplifying implantation in socket and ridge preservation

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_Introduction

An adequate amount of bone in both the horizontal and vertical directions is required for successful oral rehabilitation with dental implants. Preservation of the alveolar bone structure following tooth extraction is a critical factor influencing the outcome of this procedure. Bundle bone, which depends on the periodontal tissues, is inevitably lost after tooth extraction.[1,2] As the buccal wall is often very thin and mainly composed of bundle bone, tooth extractions commonly result in a reduction of the alveolar process in the vertical and horizontal directions.[1,3] Such resorption is typically observed in the buccal walls of the upper jaw.[1,4]

A 50 percent reduction in the width of the buccal wall was observed following the extraction of molars and premolars in 46 patients at twelve months after extraction, with the atrophy being most severe within the first three months after extraction.[5]

By augmenting the socket with artificial bone, its shape can be conserved and predictable regeneration of bone can be achieved.[1,7] Notably, in the anterior upper jaw, an effective effort of maintaining the ridge is possible. The larger the bony defect, the more complicated is the augmentation procedure for implant placement. Therefore, it is obvious that preserving the alveolar ridge after tooth removal is of great importance.

This procedure is termed socket preservation (SP) if the bony walls are sound and ridge preservation (RP) in case of deficiency or absence of the bony walls of the socket. Further treatment options for the extraction site include socket seal surgery and ridge augmentation. The aim in such surgeries is to preserve the osseous dimensions and to limit resorption. This technique is applied more often in the upper jaw than in the lower jaw.

The primary importance of SP in the maxillary molar region is to optimize the hard tissue facing the sinus elevation Jakobs W. (2006) conference lecture DGI. A bone height of 4 mm at the sinus floor enables simultaneous augmentation and implantation. The greater the amount of remaining bone, the better is

Fig. 1_ Numbers of sockets treated by socket and ridge preservation by region.

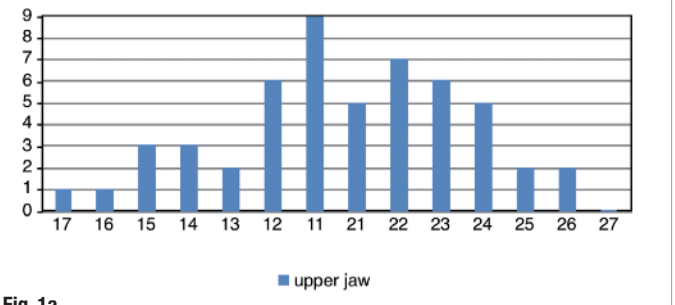


Fig. 1a

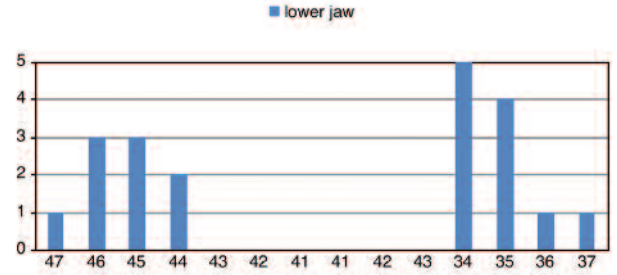


Fig. 1b

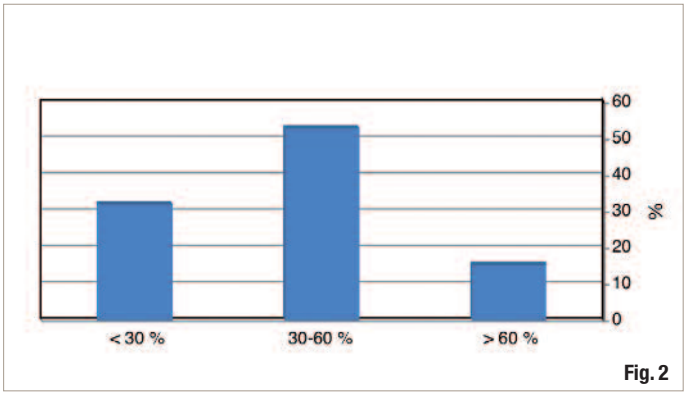
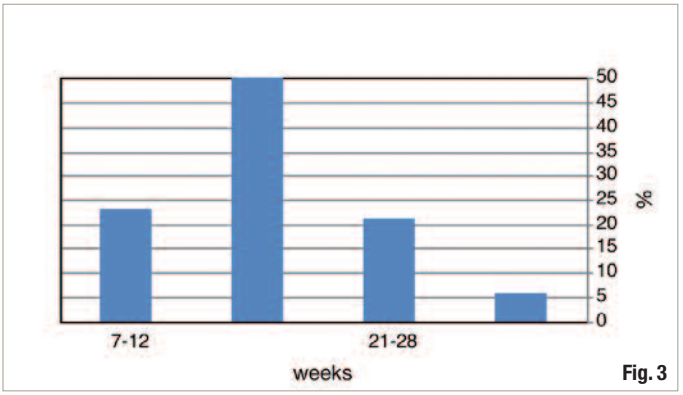


Fig. 2



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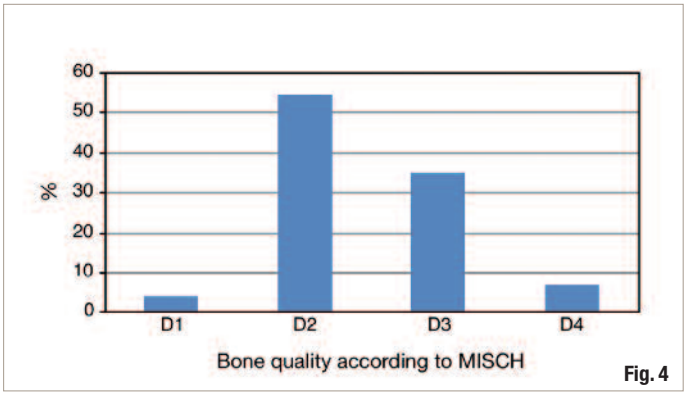


Fig. 4

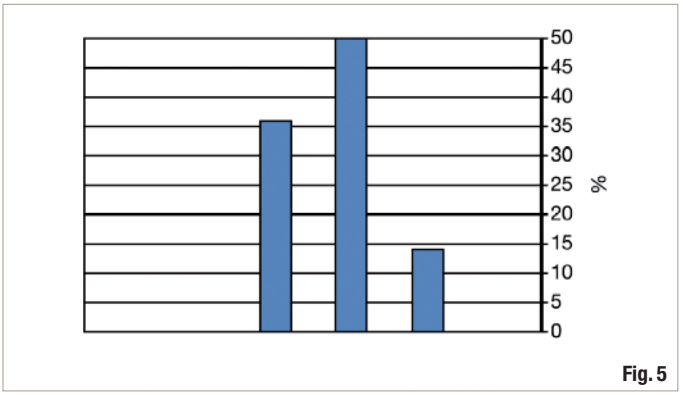


Fig. 5

the chance for simultaneous augmentation and implantation. And the greater the amount of remaining hard tissue, the better is the chance for a one-time procedure, with decreased morbidity.

The goals of socket preservation are conserving hard and soft tissues as well as expanding the tissue. This is not a bone augmentation procedure in the classical sense. The present analysis assessed a series of consecutive case treated with SP and RP in a private maxillofacial practice with day surgery. In particular, whether further augmentation procedures were required after complete healing of the socket was evaluated.

Biology of healing of the human dental socket

Immediately after tooth extraction, a coagulum is formed at the extraction site. After seven days, the socket is filled with granulation tissue; at 20 days, this is replaced with fibrous tissue. Remodelling leads to osteoid formation after seven days, which will ossify 2/3 of the alveolus within 38 days. Within four days, the epithelium germinates. Complete epithelisation requires at least 24 days.6

Canine studies have shown that the loss of bundle bone, vascularisation, and in-growth of woven bone occurs at 14 days after tooth extraction. Early-phase remodelling with a high degree of mineralisation combined with osteoclastic deterioration has been shown from day 30 onwards. At week eight, bone covers the coronal part of the socket and marrow develops in the central part.[1] Between days 60 and 180, the woven bone is replaced by bone marrow.[7]

Maintenance of the bone level by SP and RP following tooth removal occurs as follows: in the augmented alveolus, BioOss®-Collagen stabilises the mineralised bone matrix. The natural resorption of bone is compensated by the newly formed bone, and the profile of the ridge remains steady most widely. The loss of bundle bone cannot be eliminated completely.[8]

_Materials and methods

From March 2006 to October 2009, 52 patients (19 males and 33 females) were treated by SP and RP with a planned approach for implantation surgery in 72 cases. Informed consent was obtained from each patient. Clinical and radiological data for the degree of bone resorption, the quantity and quality of hard- and soft-tissues and augmentation procedure needed were collected from the time of extraction until the encoverage of the fixtures and patient's release for prosthetic therapy. All the cases were photographed, and the same physician performed all implant surgeries. The median age of the patients was 49.0 ± 15.9 years at the time of the first surgery. Statistical analysis included the description of the percentage distribution of the above named data in comparison to the necessary augmentative steps in consideration of the region and progress.

Fig. 2_ Percentages of the degree of resorption of the buccal wall immediately after tooth removal.
Fig. 3_ Times of second-stage surgery after complete healing of the sockets. The percentages of the implants by time are shown.
Fig. 4_ Percentages of bone quality according to the Misch classification after the completion of socket healing at the time of the second-stage surgery.
Fig. 5_ Percentages of bone quantity according to the Cawood classification after the completion of socket healing at the time of the second-stage surgery.

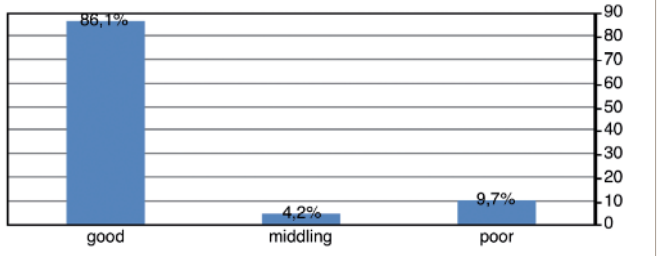


Fig. 6

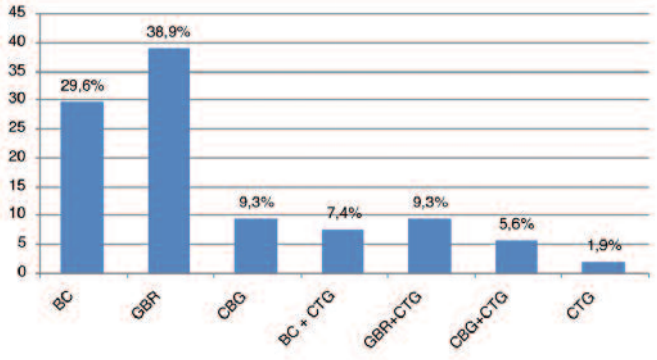


Fig. 7

Fig. 6_ Quality of the soft tissues after the completion of socket healing at the time of the second-stage surgery.

Fig. 7_ Percentages of additional augmentative procedures after the complete healing of the socket (BC = bone collector, GBR = guided bone regeneration, CBG = cortical bone graft, CTG = connective tissue graft).

Surgical procedure

The extremely thin buccal bone in the anterior region of the upper jaw most often undergoes resorption after tooth extraction. To minimise the resorptive processes, atraumatic extraction techniques with socket preservation are essential. A significant reduction in alveolar ridge resorption has been noted with the aid of socket preservation techniques.[9]

All teeth were removed using special periotomes and luxators (KLACK-Periotome®, Wegmann Dental, Germany). The periodontal tissues were exposed by straight slide-in movements, and the tooth was elevated. If removal was not possible (post-endodontic treatment/ankyloses), further efforts with luxators were attempted. A flap was prepared without damaging the papillae and the tooth removed by gently osteotomy.

In all, 72 teeth, which were not conservable were extracted. After the sockets were cleaned accurately, they were filled with Geistlich Bio-Oss® Collagen (Geistlich Pharma AG, Switzerland). The moistened combination of collagen and bone material can be formed easily. Depending on the size of the bony defect, 100- or 250-mg Bio-Oss blocks were used, with 100-mg being suitable for single-rooted sockets and 250-mg being suitable for the molar region. Bio-Oss® Collagen was placed at the height of the crestal bone. Wound closure was performed by single sutures. The quality of the hard tissue according to MISCH and the biotype of the soft tissue were documented after wound closure. The biotype was determined by probing the gingival margin with a WHO-dental probe. The biotype was considered to be thin if the probe appeared to shimmer through; if not, the biotype was recorded as thick (concept by Markus Schlee, Germany).

The sockets healed by secondary intention. Wound healing lasted for a minimum of seven weeks. On the day of second-stage surgery, the quality[10,11] and quantity[12] of the bone were documented to clarify the condition of the soft tissues. Depending on the structure of the bone bed, either the implant was inserted or augmentation to optimise the bone range in the horizontal and vertical directions was performed beforehand.

The implants (RatioPlant® Implants, HumanTech Germany GmbH, Germany) were placed according to the manufacturers' protocols. In cases of minor bone loss, such as filtering through of the thread, bone meal out of a bone collector (Bone Trap®; Fa. Astra Tech, Sweden) was used to augment the defect. In the event of a larger bony defect (uncovered thread size 2–4 mm), a modified guided bone regeneration applying Geistlich Bio-Oss® Granules (Geistlich Pharma AG, Switzerland) mixed with autologous bone meal covered by a membrane (Geistlich Bio-Gide®; Geistlich Pharma AG, Switzerland) was performed. Very large bony defects required a two-stage procedure. At first, a block graft from the angle of the mandible was fixed in the affected area. Then implants were inserted in the lower and upper jaws after three and four months, respectively. If required, a connective tissue graft from the palate was transplanted on the buccal site of the fixture. The referring dentists created prosthetic devices. When the fixture exhibited good osseointegration both radiologically and clinically, the surgical implant therapy was deemed completed.

Table 1_Percentages of the amount of bone according to the Cawood classification at the time of the second-stage surgery in sound bony walls (SP) and sockets with osseous defects (RP) at the time of tooth removal.

Cawood classification	SP (%)	RP (%)
I	0	0
II	0	0
III	60,9	24,5
IV	34,8	57,1
V	4,3	18,4
VI	0	0

_Results

Overall. 72 percent of the extraction sockets were localized in the upper jaw with 63 percent being in the anterior regions of 14 to 24 (Fig. 1).

One extraction socket was treated in 37 patients, two in eleven, and three in three patients. A thin biotype was present in 60.9 percent of the patients treated with SP and 87.8 percent of the patients treated with RP. In the majority of the participants, the buccal bone height was reduced by more than 30 percent due to preexisting defects or extraction trauma (Fig. 2).

The buccal bone was considered satisfactory in 32 percent of the patients (resorption ≤ 20 percent). Antibiotics were administered postoperatively in 28.9 percent of the cases.

The second stage of surgery was performed at 13–20 weeks in approximately 50 percent of the patients (Fig. 3).

One patient became pregnant shortly after SP; therefore, the implant-surgery was extremely delayed.

The handling of the collagen blocks was rated 'easy' by the surgeon and the amount of bone substitute for the size of the sockets always was sufficient. Healing was uneventful in any patient.

The sockets had healed completely at the time of the second surgical procedure, and 88.9 percent of the treated regions exhibited a bone quality of D2 or D3 according to Misch (Fig. 4). No significant differences were observed between the SP (D2 or D3 in 91.3 percent) and RP (D2 or D3 in 87.8 percent) groups.

There was no significant difference between the SP (D2 or D3 in 91.3 percent) and RP (D2 or D3 in 87.8 percent) groups.

The bone quantity according to the Cawood was III or IV in 86.6 percent in the SP group (Fig. 5), whereas the RP group included a lower number of patients at the III and IV levels (Table 1).

The texture of the soft tissues was rated as "good" in the majority of cases (Fig. 6).

The criteria for this rating (good) included the absence of inflammation and a broad band of keratinized and stippled gingiva. The criterion for 'fair quality' was a thin biotype with partial superficial redness that was sometimes caused by coverage with a temporary prosthesis (i.e. contact mucositis). Implant insertion was not hindered in any of the cases.

In 75 percent of the regions, complementary measures were undertaken to augment the hard or soft tissues (Fig. 7).

Mainly, hard tissue augmentations were required (76.4 percent). However, block grafts (with or without soft tissue augmentation) had to be carried out in 14.8 percent of the cases, and all of these sockets featured bone deficits (RP group). In five of eight sockets, resorption was distinctive with percentages ≥ 70 percent.

In most cases, augmentation-using bone meal from the collector or performing GBR with Bio-Oss® and a Bio-Gide® Membrane were sufficient for treating the existing defects. Combined augmentations of hard and soft tissues were undertaken in 20.4 percent of the regions. In the RP group, augmentation of the hard and soft tissues had to be performed more often than in the SP group (RP, 28.2 percent; SP, 6.3 percent, Table 2).

In 77.8 percent of the treated regions, implants could be fixed immediately, whereas a bone block had to be grafted beforehand in 15.3 percent of the regions. No dental fixtures were placed in 6.9 percent of the regions. In regions without relevant bone deficits of the socket (SP), implants were inserted in almost all the cases (95.7 percent) during the second-stage surgery. In contrast, only 69.4 percent of the sockets preserved by RP could undergo immediate implantation during the second-stage surgery.

Fig. 8_ Planned socket preservation regio 13 in a 70-year-old patient.
Fig. 9_ X-ray of the non-conservable tooth 13.
Fig. 10_ Moistening of the BioOss® Collagen block 100mg (Geistlich Pharma AG, Switzerland).
Fig. 11_ Gentle tooth removal of the fractured tooth.

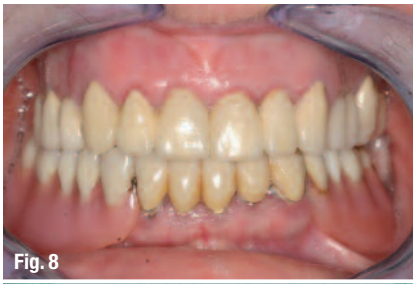
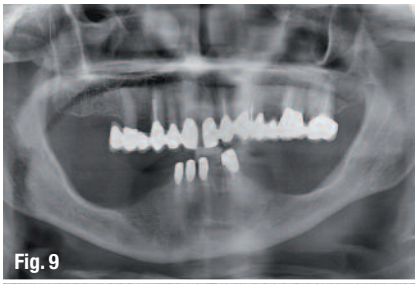


Fig. 8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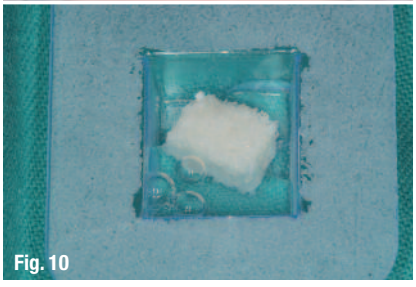
Fig. 10

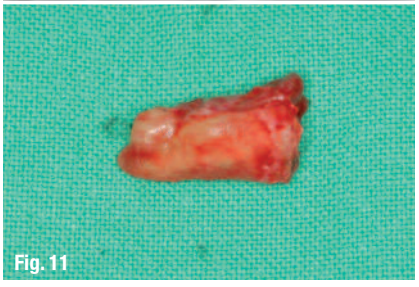
Fig. 11

	SP (%)	RP (%)
Only hard tissue augmentation	87,5	71,8
Only soft tissue augmentation	6,25	0
Hard and soft tissue augmentation	6,25	28,2

Table 2_Percentages of augmentation procedures at the time of the second-stage surgery in sound bony walls (SP) and sockets with osseous defects (RP) at the time of tooth removal.

One of the patients underwent partial resection of the tongue and floor of the mouth with adjuvant radiotherapy due to squamous cell carcinoma. Although surgical preparation and wound closure was difficult due to fibrosis, the patient successfully received implants. The prosthetic device has been in place for more than six years without trouble. The clinical progress and prosthetic outcomes are shown in Figures 8–18.

_Discussion

In the present analysis, SP and RP were successfully carried out in 52 patients in order to improve the hard and soft tissue beds before implant placement. In these treated alveoli, dental fixtures could be inserted as planned in a one-step procedure without prior bone grafting. Existing bone deficits were mostly of minor or moderate classification and could be augmented simultaneously by placing bone meal or a guided bone regeneration. Only a few patients required additional connective tissue grafts. In patients with pre-existing defects of the bony socket walls (RP), implantation had to be performed delayed, compared to patients with intact bony walls (SP). In addition, a greater number of augmentations, using bone meal and/or artificial bone source were required in the RP group.

Fig. 12_ Insertion of a moistened Bio-Oss® Collagen block 100mg (Geistlich Pharma AG, Switzerland).
Fig. 13_ Preoperative X-ray (cone beam) following four months of healing. The former Bio-Oss Collagen® block that supported hard and soft tissues and averted the collapse of the tissues is marked out.
Fig. 14_ Insertion of three RatioPlant Avantgarde® (Humantech, Germany) fixtures.
Fig. 15_ Insertion of a Mucograft® matrix (Geistlich Pharma AG, Switzerland) to support the soft tissue biotype.

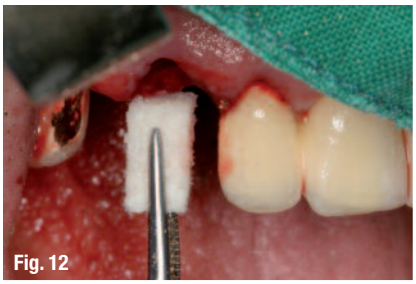
Fig. 12

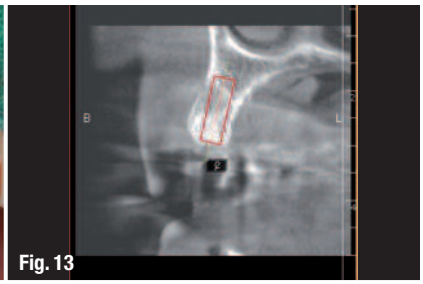
Fig. 13

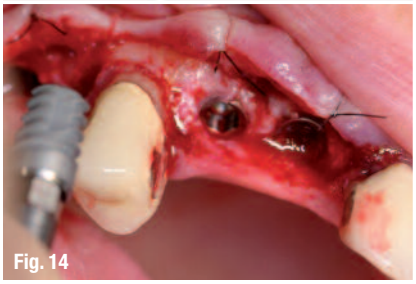
Fig. 14

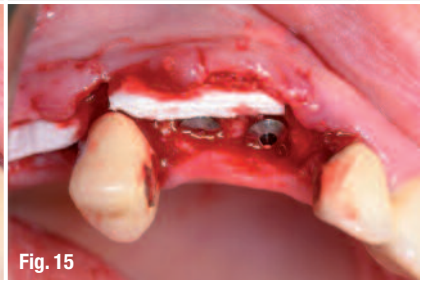
Fig. 15

The main region of treatment comprised the upper anterior jaw. In addition to the functional aspects of implant-treatment, the aesthetic perspective is just as crucial. To achieve optimal functional and aesthetic results for implant therapy, the buccal wall should be 2 mm wide.13,14 However, the buccal wall is often less than 1 mm wide.[15] Moreover, 52 percent of the width and 2–4 mm of the height of the buccal wall were lost in the first year following tooth extraction. The majority of such resorption is known to occur in the first three months.5 If such an occasion arises, extensive augmentative measures are inevitably required.

Elevation of the periosteum has been previously noted to lead to a median of 0,7 mm resorption at the buccal site. In the present study, SP could achieve better results than RP, although resorption of the vestibular bone could not be eliminated completely.

Currently, the focus is on preserving the bone-volume and optimizing soft tissue conditions.[7] To reduce or avoid the loss of bone volume after extraction, tooth removal should be performed very carefully; the alveolus can be treated by SP or RP with Bio-Oss® Collagen further.[16,17] Subsequently, hard and soft tissue volumes can be preserved to a large extent, and losses can be reduced to simplify implantation. It should be noted that the process of resorption after extraction occurs in the crestal part of the tissue.1 It is not necessary to fill the socket completely to the apex with Bio-Oss® Collagen. However, the apical void was confirmed to be well ossified by imaging using cone-beam CT in this case series.

Aesthetic outcomes were not assessed in this study since many different referring dentists performed the prosthetic treatments. In addition, after the incorporation of the crown or bridge, patients were not compliant about the time frame for prosthetic treatments. Therefore patients were documented during standard treatment in our clinic. Consequently, no comparison with a group of patients without SP or RP was planned. Therefore, data analysis was performed on the basis of the quantity and method of augmentation needed to perform the standard procedure of tissue enlargement as described below:

1. If the primary stability of an implant has been achieved and the threads shine through, bone meal gathered by a collector is attached in order to widen the lateral wall up to 2 mm.
2. If the primary stability of the implant has been achieved but the vertical bone defect of the buccal wall measures 2–4 mm, GBR with Geistlich Bio-Oss® Granules mixed with bone meal is performed and covered with a Geistlich Bio-Gide® Membrane.

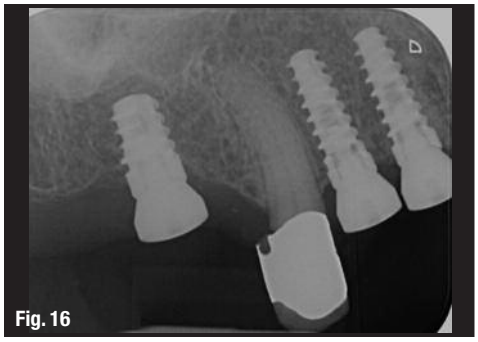
Fig. 16

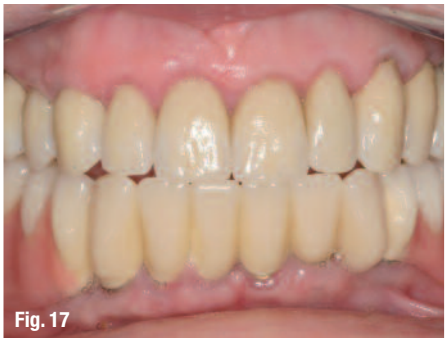
Fig. 17

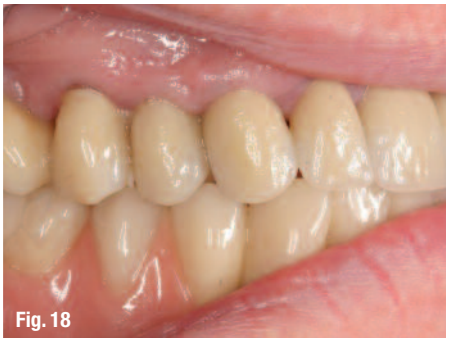
Fig. 18

3. In the case of a larger bone deficiency in the vertical and horizontal directions (Cawood IV–V), a 2-stage procedure must be performed, with bone blocks from the angle of the mandible being used for augmentation. The lower and upper jaw implants are placed after four months, respectively.

The results of the analysis suggest that following SP in most cases, a one-stage procedure (type 1 or 2 in the list shown above) could be chosen to provide a sufficient amount of hard tissue for the implant; in sockets with sound bony walls (SP), this rate was higher than that in regions with a deficit in the vestibular wall (RP).

Similar results were obtained by Shakibaie in a prospective clinical study with 32 patients and 142 recently extracted sockets.[18] On comparing the degree of preservation in three dimensions after three to five months of healing without (control group) and with SP/RP (test group), the control group exhibited a significantly higher rate of resorption (65 percent) than the test group.

Combining our subjective grading and the above-mentioned comparison with previous results from our practice, we consider that the bone bed is improved by SP/RP, thereby decreasing the numbers of required block grafts. Bioswitching of the soft tissues after SP/RP with Geistlich Bio-Oss® Collagen is feasible. Connective tissue grafts were only required in a few cases in our study, resembling the results by Ackermann, who described comparable outcomes concerning soft tissues.[16]

SP and RP had certain advantages: these are straightforward procedures with little risk, involve no shift of the muco-gingival border, and lead to minimal trauma and shortened treatment time as compared with cortical bone grafts, which may be considered avoidable.[18] Curettage of the alveolus must be carried out diligently, since the obturation of the socket with Bio-Oss® Collagen poses a greater risk for the development of a residual cyst.

_Conclusion

In this consecutive case series, fresh extraction sockets were treated with SP or RP to improve the hard and soft tissues of the implantation bed in order to render the proposed implant placement easier to perform. In larger augmentation procedures that require intricate surgical techniques and long treatment times, with higher risks of complications and morbidity, SP/RP could positively influence the need for such complex augmentations, enabling simpler procedures. This aim was well achieved in our patient population - more so in patients with intact bony walls (SP) than in patients with osseous defects (RP). Most of our patients required only small bone augmentations, which could be performed simultaneously with the implantation. This one-stage procedure represented a substantial clinical improvement as compared with bone block transplantations. The chances of successful RP decrease with increasing loss of the lateral bony wall. In cases of high resorption of the buccal wall (70-100 percent), BioOss-Collagen® acts like an expander for the soft-tissues but cannot help to prevent a two-stage augmentation procedure.

Bio-Oss® Collagen is very well suited for SP/RP since it supports hard and soft tissues, is easy to handle, and presents only a minor risk of complications. SP/RP reduces the necessity of complex augmentations and is an ideal pre-conditioning regimen for guided surgery cases. Based on our findings in these cases of SP/RP, the use of Geistlich Bio-Oss® Collagen is a reliable approach for simplifying and optimising implant therapy._

Fig. 16_ X-ray of the osseointegrated RatioPlant® fixtures at four months after implantation.
Figs. 17 & 18_ Prosthetic crowns (upper yaw) and removable partial dentures (lower yaw) completed by Dr. Katharina Dietz-Epple (Aalen, Germany).

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