Chapter 1

Tips for Intraoral Bone Grafting Surgery

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First Published **January 29, 2018**

Abstract

Dental implants in the treatment of tooth deficiencies have been preferred with an increasing ratio. The amount of residuel bone in the toothless region is the most important factor for implant indication. In cases where the amount of alveolar bone is inadequate, it is necessary to use various augmentation techniques in order to obtain successful results, to apply the implants to the right angle and function, and to make an aesthetic and functional prosthesis as a result.

In cases where the alveolar bone width and / or height is insufficient, different reconstruction techniques are used depending on the size of the defect. In the treatment of alveolar atrophy and bone defects, autogenous bone grafts remain the most successful option and are easily obtained from the mouth. Although transplantation of autogenous tissue has some surgical and technical problems, as a rule, it does not have immunologic complications. The most important advantage is that fresh autogenous grafts contain osteogenic cells and do not cause immunological reactions.

Inadequate bone height and/or width are the most common problems encountered in dental rehabilitation of patients who are totally or partially toothless. It is essential that ideal relationship be formed between jaws before implantation surgery. Alveolar crest is one of the most challenging sites of human body in terms of reconstruction, since inside of the mouth is a moist and active area [1].

Implant treatment is known to be closely related with the amount of residual alveolar bone and the relationship between jaws (Figures 1-2). Besides residual bone mass and relationship between jaws, other possible limiting factors for implant surgery include anatomical properties such as the shape of alveolar bone, position of inferior alveolar nerve, and maxillary and nasal sinuses [2].

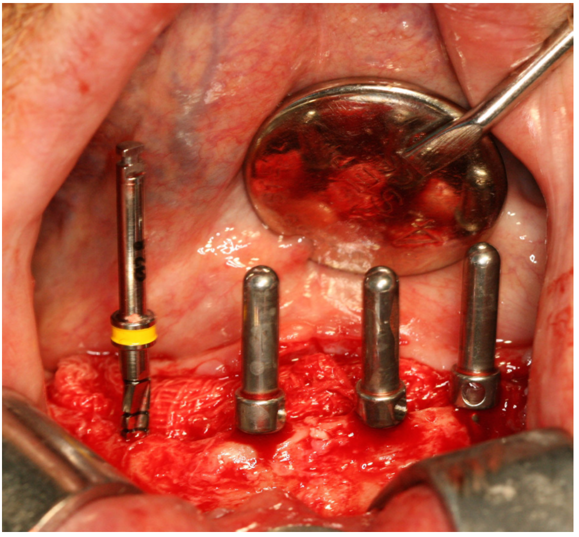

Figure 1: Implant surgery / lower jaw.

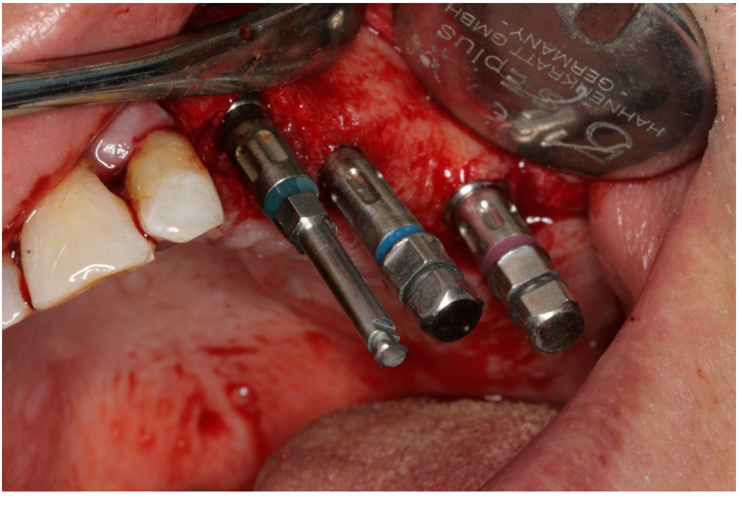

Figure 2: Implant surgery /upper jaw

Many surgeons on the global scale perform augmentation procedures aimed to increasing volume of atrophic crests for successful implant treatment both functionally and aesthetically. There are 3 objectives of atrophic crest augmentation: to create bone with adequate length and width to allow placement of implant in ideal restorative and functional position; to achieve ideal aesthetic appearance by providing adequate bone support to the soft tissue; and to contribute to long-term prognosis of the implant [2].

Several reviews reporting treatment outcomes and complications of atrophic crest augmentation techniques, and success rates of augmented areas and of implants and prostheses placed at these sites emphasize that these techniques can be applied safely and effectively [3-5].

Different augmentation techniques are utilized for conditions when alveolar bone width and/or height are insufficient. Decision on the choice of augmentation procedure should be mainly based on the defect size. While small defects are treated with bone splitting and/or guided tissue regeneration, allografts or xenografts; large defects can be successfully treated with alveolar distraction osteogenesis (ADO) inlay or onlay grafting techniques using autogenous grafts obtained from outside the mouth such as iliac, tibial, scapular or calvarial regions, or from inside the mouth such as ramus, symphysis or tuber area [2].

A Brief Guidance on the Choice of Technique is Presented Below

For horizontal bone augmentation, if the crest width is more than 4 mm, and only a small dehiscence is expected as a result of implant placement, it is recommended that implant is placed at the same time with guided bone regeneration (GBR) [6] (Figure 3).

Figure 3a: Buccal dehiscence after implant insertion.

Figure 3b: Applying bone graft, simultaneously with implant insertion.

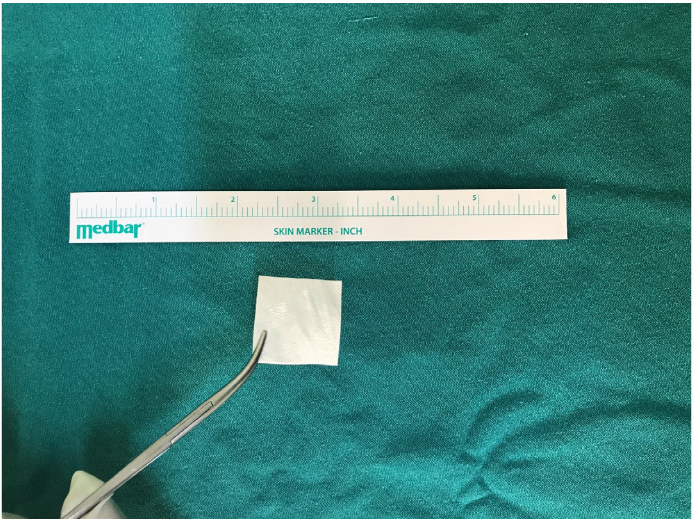

Figure 3c: Collagen Membrane for Guided bone regeneration for augmentated buccal site.

If alveolar crest width is smaller than 3.5 mm, delayed implant placement is recommended after completion of bone healing following crest augmentation with GBR or autogenous block grafts alone [6] (Figure 4).

Figure 4: Guided Bone Regeneration for delayed implant insertion.

For vertical bone augmentation, it is recommended to perform the GBR in defects smaller than 4 mm concurrent with implant placement, whereas two staged implant surgery is appropriate for augmentation of vertical defects larger than 4 mm [6] (Figure 5).

Figure 5a: Vertical deficiency on right posterior upper jaw on preoperative radiograph.

Figure 5b: Postoperative radiograph after intraoral symphysis bone graft augmentation.

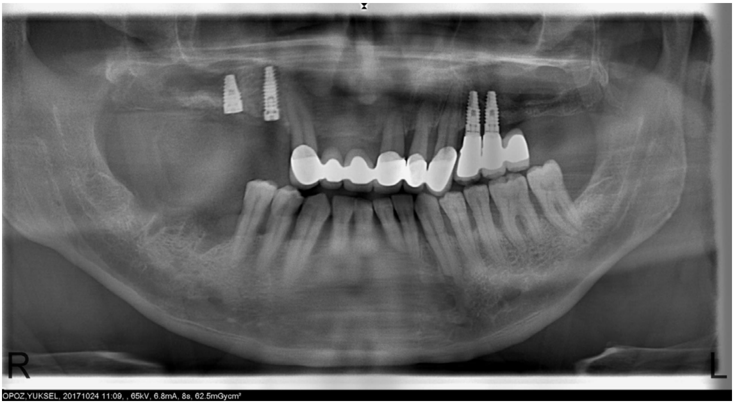

Figure 5c: Postoperative radiograph after implants insertion on augmented site.

Delayed implant placement in vertical augmentation procedure with block grafts was reported to yield 4.7 mm bone acquirement and successful outcomes. Despite these successful results, procedure-related complications are frequent, and advanced clinical experience is required. If vertical bone acquirement is expected to be greater than 7 mm, ADO is a suitable treatment option. This technique has relatively higher complication rate when compared to onlay bone grafting [6,7].

Tips for Membrane Selection

The main obstacle in bone healing and new bone formation is initiation of connective tissue formation before osteogenesis [8]. Connective tissue cells move faster than cells with bone production potential, and try to fill the defect area [9]. GBR is a membrane technique that was developed with the purpose of allowing passage of only cells with osteogenic capacity to the defect area and preventing rapid connective tissue proliferation. This method is also called as 'membrane-protected bone regeneration [10]. Experimental studies indicate that the concept of GBR is successful. New bone is known to be consisting of periosteum and cells of bone marrow origin with osteogenic potential. In this sense, the basic function of the barrier membrane is to provide a suitable environment for a certain time period to allow bone regeneration. Besides acting as a selective barrier for the passage of cells, the membrane also functions to stabilize blood clot and particulate bone graft materials [11].

A successful bone augmentation requires preservation of graft integrity. Today, screws, collagen membranes and titanium mesh are widely utilized (4-8 Biomaterials used in the context of GBR technique are divided into two groups as non-resorbable barrier membranes and resorbable barrier membranes [8,12].

The major disadvantage of non-resorbable membranes such as polytetrafluoroethylene, nanopolytetrafluoroethylene, titanium and titanium-reinforced polytetrafluoroethylene is that these materials have to be removed with a second surgical procedure. This drawback has led the clinicians to develop resorbable membranes [1] (Figure 6). Other disadvantage of non-resorbable membranes is the risk of membrane exposure, which is greater than 31% [12]. In case dehiscence occurs at the incision line over the barrier membrane, the amount of expected bone formation can reduce by about 60%. This is due to the bacterial contamination of exposed membranes. The biggest advantage of the resorbable membranes is that they do not require a second surgery for their removal. The second advantage is that dehiscence at the incision line is less common, and when it occurs, it is more predictable to handle [13].

Resorbable membranes are grouped in 3 main categories as collagen membranes, polyactic/polyglycolic acid membranes and cell-free dermal matrix.

Among these, collagen membranes have recently been frequently preferred for their appropriate biological properties. Collagen membranes are generally type 1 and 3, and are produced from cattle or pig. They stop bleeding, they are compatible with the soft tissue, and act as a framework for migrating cells [14].

Taguchi et al. have shown the effect of collagen on osteogenesis. Although the exact mechanism of collagen membrane is not fully clear, the authors reported that it acts as a bed for osteoinductive factors leading to osteogenic differentiation [15].

Figure 6: Non- Resorbable polytetrafluoroethylene membrane.

In their study including 29 patients, Tawil et al. evaluated the effect of collagen membrane use on graft healing and implant survival. The authors concluded that utilization of membranes improved graft healing and implant survival [16].

In addition, utilization of collagen also brings other advantages such as weak immunogenicity, hemostasis and fibroblast chemotaxis. The resorption process and barrier function of the material of choice influence the healing of bone graft. In order for a membrane to act as a barrier in GBR procedure, it has to prevent entry of unwanted tissue cells to the bone augmentation site for at least 6-8 weeks. It has been recommended to apply resorbable collagen membrane as in two layers to prevent it from losing its barrier function at a relatively early period (4-8 weeks) [10]. Various methods have been proposed to create more area when necessary. For instance, non-resorbable membranes reinforced with titanium may be preferred, or screws and pins can be used to support the collagen membrane [11].

In a retrospective study published by Poly et al., the results of a 12-88 months follow-up after augmentation procedures performed using particulateautogenous bone grafts and titanium mesh showed a soft tissue dehiscence rate as 8%, implant survival rate as 100%, and amount of bone atrophy as 1.7-1.9 mm [17].

In their systematic review on alveolar ridge reconstruction with titanium mesh, M. Rasia – dal Polo et al. reported rate of dehiscence at soft tissue as 16%, implant survival rate as 100%, and amount of vertical bone acquisition as 4.91 mm [18].

G. Lizio et al. reported soft tissue dehiscence as 71%, rate of total loss of augmented bone as 24%, and statistically significant atrophy of augmented bone [19].

M. Roccuzzo published 10-year results of implants placed at the augmented site obtained following vertical augmentation, and reported 94.2% survival, and 0.58 mm vertical bone atrophy [20].

Another technique that has recently become popular is the open membrane technique developed by Funakoshi [21]. In 2005, Funakoshi introduced "Open Barrier Membrane Technique" as novel minimally invasive GBR technique using non-expanded, high-density PTFE (d-PTFE) membrane. Expanded polytetrafluoroethylene (e-PTFE) has been used for guided bone regeneration (GBR) for 20 years. Barrier membranes have such complications as wound dehiscence and membrane exposure that causes infection. Funakoshi et al. claimed that a significant advantage of d-PTFE membranes is impenetrable for bacteria because of its surface characteristics (0.2μm low porosity). Because of this smooth surface, this membrane can be left intentionally exposed and primary closure is not required. Because no primary coverage is necessary, there is no need for periosteal releasing incisions causes swelling and pain [22].

Another point that requires mentioning in the context of membrane selection in GBR is platelet rich fibrin (PRF), which has been used increasingly common in recent years. Over 15 years ago, PRF was introduced as an autogenous source of blood growth factors that could serve as a tool for tissue regeneration in modern medicine [23]. (Figure 7).

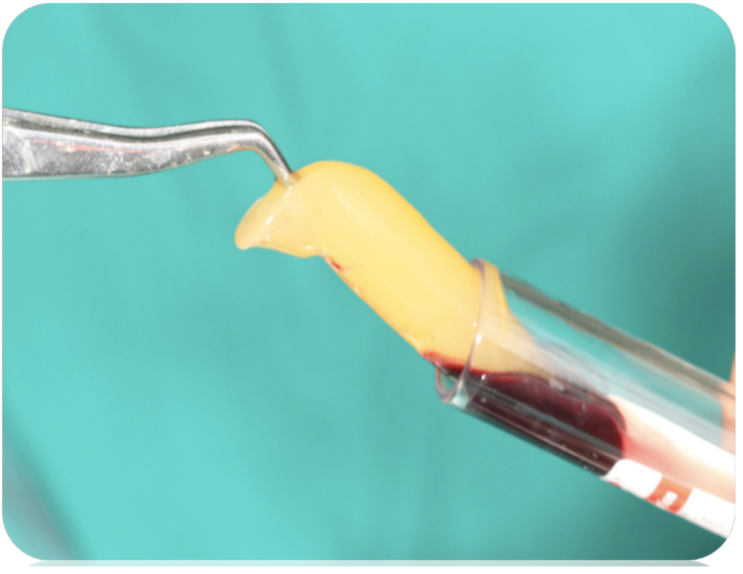

Figure 7: Platelet Rich Fibrin (PRF).

PRF has been proven to contribute to healing of soft tissue and hard tissue; however, it cannot be an alternative to collagen membrane that is frequently used for GBR. Its barrier properties are not as good as collagen membrane, and it is resorbed before completion of the bone healing process. However, PRF application over resorbable or non-resorbable membranes used during GBR has been reported to have favorable results. Similarly, mixing PRF between particulate synthetic- or xenografts in the shape of chips provides the following benefits to these particulate grafts. Major advantages include having completely immune-compatible growth factors collected at relatively no costs without anticoagulants [24-27]. While initial and early experiments revealed PRP contained high concentrations of autologous growth factors (up to 6 to 8 times higher than normal blood concentrations), including platelet-derived growt factor (PDGF), vascular endothelial growth factor (VEGF), and transforming growth factor (TGF)-b1, [28]. PRF can also release higher total growth factors over a more extended period of time [29]. It also boosts the volume of the graft material, and facilitates its manipulation by making it sticky.

Tips for Donor Site Surgery

Mandibular ramus and symphysis areas are the most preferred regions among intraoral donor site. Mandibular bone grafts have been routinely used for alveolar repair to allow implant placement with short healing times and high favorable results [30]. Cortical, cancellous, or corticocancellous grafts can be obtained from the symphysis area. The height of the rectangular block graft that can be obtained from this region is 45,36 ± 4,82 mm, width 10,31 ± 2,18 mm and thickness 9,63 ± 1,10 mm [31]. More cortical or corticocancellous grafts can be obtained as a block than the ramus region [32]. Studies show that the procedure of obtaining only cortical bone grafts from the ramus shows that the possibility of damage to the mandibular canal is almost zero. Grafts of rectangular shape with a length of 35 mm, a width of 10 mm and a thickness of 4 mm can be taken from ramus region [31]. Intraoral autogenous bone grafts provide advantages such as easy access, low morbidity risk, minimal graft resorption, and no cutaneous scar formation. Studies related bone graft harvesting procedure confirmed the superiority of the ramus over the symphysis as an intraoral donor site, since it has less associated morbidity [32] (Figure 8).

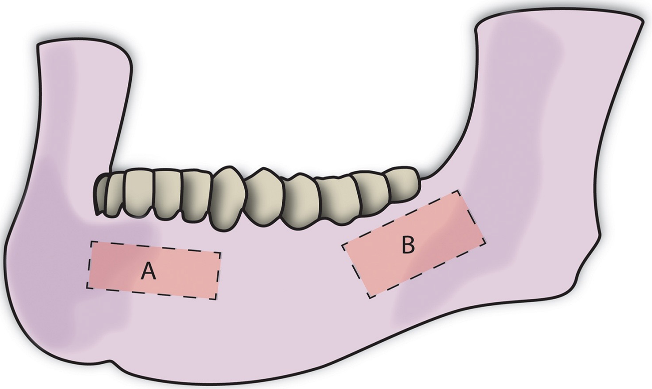

Figure 8: Intraoral mandibular autogen graft sources:Mandibular symphysis and ramus.

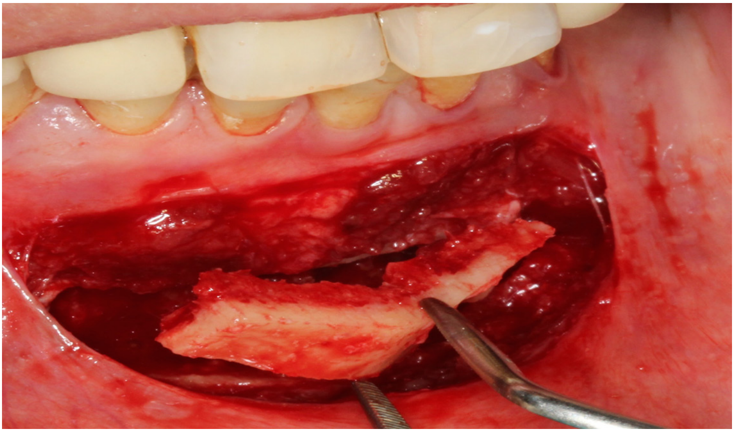

Figure 8a: Block graft harvesting from mandibuler symphysis.

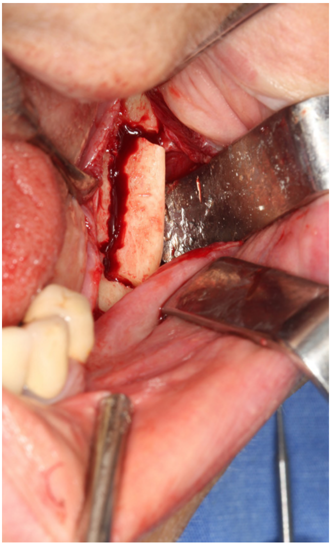

Figure 8b: Block graft harvesting from mandibuler ramus.

Cordaro et al. [33] reported significantly higher paresthesia of the oral mucosa adjacent to the mandibular symphysis bone harvesting site than the mandibular ramus site as assessed with the pointed–blunt test. In another study, block bone grafts obtained from ramus or symphysis were applied to anterior maxilla of 26 patients before dental implant treatment, and postoperative pain and treatment satisfaction at 5th year after operation were compared. It was reported that ramus grafts were associated with higher success rates [33].

The mandibular symphysis donor site showed a higher incidence of minor sensory disturbance of the mucosa and the teeth than the mandibular ramus donor site. The incidence of the temporary paresthesia of the skin and the oral mucosa neighboring symphysis was lower whether bone graft was harvested via piezoelectric surgery. The easier and safer alveolar bone harvesting via piezoelectric surgery reduces the morbidity of mandibular donor sites [34] In addition, the loss of vitality of adjacent teeth, and the necessity for root canal treatment were also found lower when symphysis bone graft harvesting is performed by piezoelectric surgery. If the acceptable morbidity rate and the subjective moderate complaints are considered, bone harvesting from the mandibular symphysis remains a good option for the reconstruction of local bone defects (Figure 9).

Figure 9: Harvesting bone block from mandibular sypmysis via piezosurgial device.

Undesirable changes in the lower face esthetics, such as increase in lower incisor exposure, were reported after the bone graft harvesting from mandibular sypmysis [35]. These changes were attributed to ptosis of the soft tissue surrounding donor sites. Previous studies about the subject focused on graft properties rather than the soft tissue around the surgery site. Similar esthetic problems were also observed after genioplasty operations. Chaushu et al. [35] showed that precise reattachment of the mentalis muscle during genioplasty operation prevented the ptosis of the soft tissue. Altiparmak et al. [36] used the reattachment technique that explained in Chaushu et al's [35] study during bone graft harvesting operations from mandibular symphysis to prevent the soft tissue effects after bone graft harvesting in a recent study. Their results indicate that precise reattachment of mentalis muscle after bone graft harvesting prevents the change in vertical parameters of the soft tissue around mandibular symphyseal area. The increase in lower incisor exposure, which was considered as a major esthetic problem, was also prevented. The authors claimed that it is possible to overcome the negative esthetic effects of the harvesting operation with a simple and reliable method [36].

Tips for Recipient Site Surgery

Cortical perforation on recipient site can accelerate bone regeneration because it allows cells migration and increase angiogenic potential of augmentation [37]. Several studies recommend to perform cortical perforations at recipient area during augmentation with onlay bone graft to improve bone integration; while, some other studies showing that cortical perforations are not effective in bone regeneration [38-40].

Dayangaç et al. performed onlay bone graft augmentation in 7 adult pigs using cortical autogenous bone grafts. Left side of the lower jaws of pigs was assigned to be the experimental group, while right side was assigned to be the control group. In experimental group, cortical perforations were made to the recipient site before graft fixation, whereas in control group, the autograft was fixated without any perforation to the recipient site. After twelve weeks healing period, the pigs were sacrificed and the graft areas were resected. The resected specimens were examined first radiologically, and then histopathologically. In radiological assessments, no significant difference was found between experimental and control groups ($p>0.05$). Histopathological examination revealed significant difference between experimental and control groups with regard to graft thickness ($p<0.05$). Graft thickness was reduced in areas where onlay graft was applied in the cortical perforation group. There was no significant difference between experimental and control groups in terms of remodeling at upper and lower halves of the recipient site, or regarding osteoblastic activity at the grafts ($p>0.05$). According to results of this study it was concluded that cortical perforations created at the recipient site during augmentation with mandibular onlay bone graft did not contribute significantly to bone healing [38].

In literature, most frequently encountered complication at the recipient site following augmentation of localized alveolar defects using block grafts is reported to be dehiscence occurring at the incision line [41].

In order to minimize the graft exposure rates and maintain the soft tissue closure several surgical techniques have been developed. Tunnel incision technique is a minimal invasive technique defined for increasing the success rate of augmentation procedures with autogenous or synthetic bone grafts. Ponte and Khoury [13] reported complication rate of tunnel technique in a case series, including 173 reconstruction with autogenous block grafts. They reported 1 major complication due to flap necrosis and 2 minor complications due to minor exposure of graft. In this case series, low rates of bone graft exposure were related not to use crestal incisions by researchers. A recently published clinical study results showed that tunnel technique significantly decreases soft tissue dehisence and graft failure. In this prospective clinical study, all patients underwent operations by the same surgeon, performed consecutively using the crestal incision technique (crestal group) or tunnel incision technique (tunnel group). Autogenous bone block grafts were harvested with a piezoelectric surgical device, and the grafts were fixed at the recipient sites by two titanium screws in both two groups. Minor exposure, transient paresthesia, major exposure, permanent paresthesia, gingival recession at adjacent teeth, surgery time, and visual analog scale scores of augmentation procedures were evaluated. A tunnel incision was used in 38 augmentations (27 horizontal, 11 vertical), and a crestal incision was used in 37 augmentations (27 horizontal, 10 vertical). As a Conclusion authors stated that the tunnel technique significantly decreases soft tissue dehiscence and graft failure and minimally invasive tunnel technique can be used as an alternative to the frequently used crestal incision technique [42] (Figure 10).

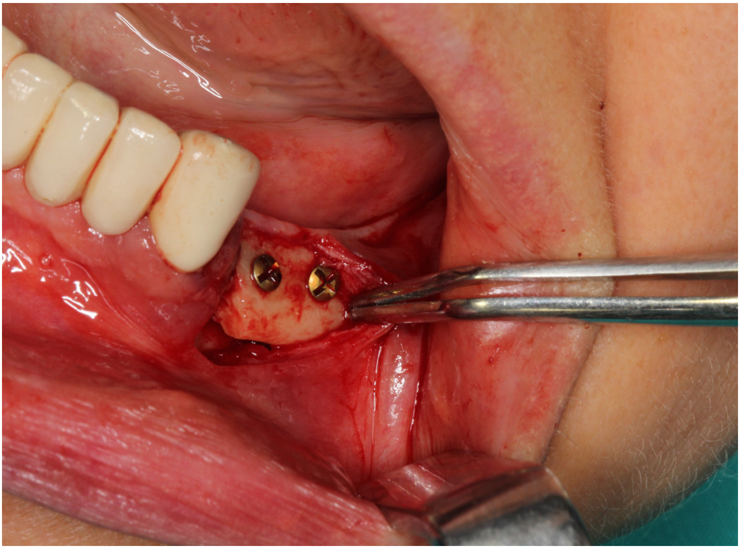

Figure 10: Block graft augmentation through the tunnel incision.

Tips for Further Clinical Studies

Schwartz et al. shown that tooth roots reveal a structural and biological potential to serve as alternative autografts for ridge augmentation procedures in an animal study [43]. Schwartz et al. also reported a case of alveolar ridge augmentation with the root of upper wisdom teeth. They separated and rigidy fixed the tooth root at the defect site following the removal of cement tissue from the root surface. The gain ridge was 4.5 mm and allowed for a successful implant insertion [44]. This novel approach may be further investigated in atrophic ridge augmentations.

Conclusion

Intraoral bone grafting to allow implant installation in deficient alveolar ridges is a predictable and reliable technique. Treatment outcomes of atrophic crest augmentation procedures by intraoral bone grafting, success rates of augmented areas, implants and prostheses placed at these sites showed that these techniques can be applied safely and effectively. The most important step in treatment planning is to decide the most effective technique considering all the conditions for the patient.

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