Tunnel access for ridge augmentation: A review

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In traditional bone regeneration, the periosteal layer of the flap must be released to achieve tension-free primary wound closure. Several minimally invasive tunnel techniques have been introduced to augment the bone volume for prosthetic-driven implant placement, thus minimizing tissue trauma and patient morbidity. This literature review aimed at analyzing the available literature on ridge augmentation with a lateral tunnel access approach, and detailed the surgical protocols, materials, advantages, indications for use, disadvantages, and complications. The Medline and PubMed medical databases were searched for reports published between 2005 and March of 2021. Seventeen articles describing minimally invasive tunnel techniques for ridge augmentation were identified. Preservation of the integrity of the periosteum has been found to be the determining factor in reducing postoperative pain and improving wound vascularization. Studies have reported encouraging data on the bone volume obtained for implant-prosthetic rehabilitation using this technique. (JOURNAL OF DENTAL IMPLANT RESEARCH 2021;40(2):48-53)

Key Words: Lateral ridge augmentation, Tunnel GBR, Lateral access bone regeneration, Tunnel technique bone augmentation

INTRODUCTION

In alveolar ridge deficit, guided bone regeneration (GBR) has been shown to be an effective technique for reestablishing adequate bone thickness^{1,2}. Traditionally, GBR techniques involve the elevation of a mucoperiosteal full-thickness flap to provide direct access to the bone defect. After debridement of soft tissue remnants from the bone defects, a bone graft is applied on the buccal aspect of the alveolar process, and a membrane is adapted and fixed to the graft and the surrounding bone. The incisions are then sutured with tension-free wound closure^{3,4}. Regardless of the bone grafts and membranes used, these techniques use a periosteal incision to enable advancement of the mucoperiosteal flap. This incision has been associated with risks of complications, including wound dehiscence, membrane exposure, infection, swelling, and patient morbidity⁵.

Minimally invasive procedures with the tunnel technique have been suggested to decrease patient postoperative discomfort and morbidity. In the ridge augmentation tunnel technique, crestal incision and the release of the connective tissue are avoided in order to enhance the blood supply of the flap. This approach preserves the blood circulation and does not damage the periosteum⁶. Consequently, because the periosteum a source of progenitor and stem cells for tissue engineering⁷⁻¹², this method supports wound healing.

The tunnel technique further preserves peri-implant tissue by avoiding incision, thereby decreasing the possibility of scarring or esthetically undesirable defects on the soft tissue, which frequently occur with traditional bone regeneration procedures¹³.

Tunnel GBR may be more operator-sensitive than conventional approaches and may also result in poor membrane stabilization and the dispersion of graft particles,

Received April 8, 2021, Revised May 8, 2021, Accepted May 11, 2021.

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The authors thank Mrs. Fortunato Silvia, Mrs. Anna Cristino, Mrs. Anna Pace and Mrs. Sonia Conenna for their support and Dr. Micol Palma for her assistance in preparing this manuscript.

thus preventing the desired results from being achieved¹³⁻¹⁵. Employing growth factors associated with biomaterials is an alternative method to avoid the use of membranes and lead to a desired outcome in tunnel approach bone regeneration¹⁶⁻¹⁸.

This article examines the efficacy of the tunnel technique as an approach for ridge augmentation, including the materials and procedures, which can be applied to achieve prosthetic driven implant placement.

MATERIAL AND METHODS

The Medline and PubMed medical databases were searched for reports on tunnel access ridge augmentation published between 2005 and March 2021. The search strategy was limited to controlled clinical trials, prospective and retrospective studies, case series, case reports, and in vitro studies, published in English in dental journals. The following key words were used: lateral ridge augmentation, tunnel GBR, tunnel technique bone augmentation and lateral access bone augmentation. The electronic search was supplemented with a manual search of the following publications: International Journal of Oral and Maxillofacial Implants, The International Journal of Periodontics & Restorative Dentistry, Implant Dentistry, Journal of Oral Implantology, Quintessence International, International Journal of Oral and

Maxillofacial Surgery and Clinical Oral Implants Research.

Articles were first screened according to their titles and abstracts and a full text reading of all selected articles was then conducted.

RESULTS AND DISCUSSION

The search strategy yielded 16 articles retrieved by electronic search and 4 articles retrieved by manual search. One duplicate article was excluded. Two articles were excluded because the studies did not properly treat the ridge augmentation in the tunnel approach but instead used an injection mode^{19,20}.

After the initial screening phase, 17 articles were eligible for full text reading and were selected for the review (Fig. 1).

The search protocol identified case reports, case series, and descriptive studies (Table 1)²¹⁻³⁷.

The articles describe many surgical protocols. Fourteen articles describe lateral access from one vertical full-thickness incision in the mesial aspect of the bone defect from the free gingiva to the mucogingival junction^{10-12,14-17,19,20,22-24,26}, two studies performed two vertical incisions, one mesial and one distal to the defect^{13,25}, and one study use three incisions, one vertical, one intra-sulcular to the proximal teeth and one midcrestal to gain

Fig. 1. Flow diagram of study inclusion.

Table 1. Summary of the literature reviews

Authors	Study design	Materials	Technique	Volume analysis procedures
Kfir E et al. 2007. ²¹	Descriptive+Case series (n=11)	Biodegradable membrane, autologous fibrin, synthetic bone.	1 vertical incision/tunneling with balloon/decortication/material insertion	- CT scan/panoramic and periapical Rx before surgery and after 5~6 month.
Hasson O et al. 2007. ²²	Case report (n=7)	Bovine bone, collagen membrane.	1 vertical incision/tunneling by surgical instrument/decortication/material insertion	- CT scan before and after 4 month from surgery.
Kakar A et al. 2018. ²³	Case series (n=9)	Synthetic bone.	1 vertical incision/tunneling by tunnel control instrument set/decortication/material insertion by syringe	- CBCT before surgery and after 4 month. - Histological and histomorphometric analysis.
Ponte A et al. 2006. ²⁴	Descriptive+Case report	Autologous block bone.	2 vertical incision/block removed from mandibular ramus and fitted to defect	- Clinical and Rx valuation.
De Azevedo RA et al. 2017. ²⁵	Descriptive	Autologous bone.	1 crestal incision/decortication/adapted the graft removed from mandibular arch	- CBCT valuation before and after surgery
Kim HS et al. 2016. ²⁶	Retrospective study (n=25)	Autogenous demineralized dentin matrix/allograft/xenograft.	1 vertical or horizontal incision/tunneling by periosteal elevator/bone graft placed	- Panoramic and standardized periapical radiographs pre- and postoperatively - 1 case evaluated with CBCT before and after bone graft.
Li J et al. 2013. ²⁷	Prospective study (n=9)	Bovine bone block.	1 vertical incision/tunneling by periosteal elevator/stabilized block bone	- Clinical and Rx evaluation and 6 month after surgery CBCT. - Histological analysis.
Nevis ML et al. 2009. ²⁸	Case series (n=12)	rhPDGF-BB in combination with: bone allograft, bovine bone, mineralized collagen bone.	1 vertical incision/tunneling by periosteal elevator/decortication/graft insertion by syringe	- Preoperative and post operative CT scan. - Micro CT and histomorphometry at 14 weeks.
Johnson TM et al. 2018. ²⁹	Descriptive+Case report	Bone allograft, dPTFE membrane.	3 incision: 1 vertical, 1 infrastatural of proximal teeth, 1 midcrestal/tunneling by a surgery kit/insertion of materials	- CBCT before surgery. - Clinical and Rx periapical control after 8 month.
Block MS et al. 2013. ³⁰	Descriptive+Case report	Collagen membrane, bovine xenograft.	1 vertical incision/tunneling by periosteal elevator/material insertion	- CT scan after 6 month from surgery.
De Stavola L and Tunkel J. 2013. ³¹	Prospective study (n=10)	Autogenous bone block.	1 vertical incision/tunneling by surgical instrument/fixed bone blocks and bone chips	- Radiograph pre e post-surgery.
Lee EA 2017. ³²	Prospective study (n=21)	bovine bone mixed with rhPDGF-BB.	n° of incision depending of the extension of the defect/tunneling by surgical instrument/insertion of graft	- CBCT before surgery and after 3/18 month. - Histology
Venet L et al. 2017. ³³	Case series (n=6)	Allograft block bone.	1 vertical incision/tunneling by periosteal elevator/piezo surgery decortication/placed allograft block	- CBCT pre operator and 6 month after surgery.
Karmon B et al. 2019. ³⁴	Descriptive+Case series (n=3)	Bovine xenograft, collagen membrane.	1 vertical incision/tunneling by dedicate surgical set/insertion of material bag	- CBCT pre operator and 6 month after surgery.
Deeb GR et al. 2016. ³⁵	Retrospective cohort study (n=21)	1:1 allograft bone and xenograft bone.	1 vertical incision/tunneling by periosteal elevator/graft insertion by syringe	- CBCT pre operator and 6 month after surgery.
Alghamdi R et al. 2020. ³⁶	Case report	Allograft bone block	2 vertical incision/decortication/fixed bone block	- CBCT pre operator and 4 month after surgery.
Soltan M et al. 2010. ³⁷	Case report (n=2)	Hidroxiapatite or allograft+stem cells	1 incision/periosteal elevator is used to dissect/graft insertion by syringe	- Histology

access to the cortical bone and achieve correct membrane placement.

Use of surgical instruments and periosteal elevators for mucoperiosteal elevation of the flap was common among all the techniques. Kfir et al. additionally describe the use of a balloon inflated in the pocket to complete the tunneling.

Some authors describe decortication to harvest inductive bone cells from the marrow space^{10-12,14,17,22,25}. Venet et al. used piezo surgery for this passage.

The grafts inserted in the defects and the combinations of materials used were the most divergent aspects among the techniques described in the articles.

The application of a membrane as a structural support for the graft is described by five articles. A collagen membrane was used in association with autologous fibrin, synthetic bone¹⁰, and bovine xenograft^{11,19,23}. The use of a dPTFE membrane is described by Johnson et al. in combination with allograft bone.

Five articles report the insertion of a bone block adaptation to the defect area and fixation with a titanium screw are described for a bovine bone block¹⁶, allograft bone block^{22,25}, and autogenous bone block harvested from the external oblique ridge of the mandible^{13,20}.

Other authors report their experience in the insertion in the pocket of synthetic bone¹², rhPDGF-BB in combination with bovine bone^{17,21}, allograft bone^{15,24,26}, xenograft bone^{15,24}, stem cells in combination with hidroxiapatite²⁶ and autologous bone removed from the mandibular arch¹⁴.

To assess the volume, most authors of the identified articles, used two-dimensional measurements of the pre-intervention CBCT compared with those of the same segments after 4/6 months.

Three studies provide evidence of the histological quality of the new tissue. The histological analysis by Li et al. showed that the xenograft particles were embedded in the woven bone 9 months after bone block insertion¹⁶.

Moreover, histological analysis revealed new bone formation when rhPDGF-BB was used in combination with bone allograft, mineralized collagen bone¹⁷, and bovine bone²¹.

The main advantage of the tunnel approach in bone regeneration is the ability to avoid the crestal incision while

minimally compromising the blood supply in the flap and reducing damage and trauma to soft tissue^{13,26}.

This aspect is particularly important for patients with vascular problems, such as those who smoke, have diabetes and have scar tissue²⁶.

Lateral access facilitates the placement of a large amount of graft material through a small incision, and primary wound closure is easily accomplished¹⁰⁻²⁶.

Primary wound closure without tension on the suture line results in a lower risk of membrane exposure or need for antibiotic treatment than open-flap techniques²⁴.

Suture line opening and early membrane exposure were not observed by any authors.

Decreased patient morbidity and discomfort are the most common factors reported in the clinical studies^{10,13,19,21-26}.

To execute each technique, clinicians require adequate training. Furthermore, the use of appropriate instrumentation and biomaterials cannot be overemphasized.

Extreme caution must be exercised during the tunneling phase to avoid tissue perforation and to maintain the integrity of the periosteum. The absence of a direct view of the alveolar crest can be a limitation of the lateral approach in ridge augmentation.

Avoiding the use of membrane can make the procedure less invasive for patients and easier for the clinicians. One study has described the need to perform more incisions for the correct management of a dPTFE membrane¹⁸.

The stability of the graft can be compromised thereby determining the final result. One study describes a patient who experienced bone resorption of the graft, owing to mobilization of a customized bone block²².

Regardless of the bone grafts and membranes used, all studies except one achieved the prosthetic rehabilitation with implants. In one article, implant placement was not possible in two patients, owing to immature bone quality and limited bone volume, and three other implants did not achieve osseointegration¹⁷.

CONCLUSION

Alveolar ridge augmentation using subperiosteal tunneling is a minimally invasive procedure that provides

access to the lateral ridge while preserving the integrity of the periosteum, thus decreasing postoperative discomfort, swelling, complications, and mobility.

Through this approach, regardless of the materials used, adequate bone volume is obtained for the insertion of implants.

However, further studies are necessary to determine the implant survival rate in tunnel ridge augmentation, because no long-term follow-up was performed in the analyzed articles.

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