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Anatomy of the palate: Harvesting of free, connective, and rotated gingival graft Literature Review

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Abstract
The hard plate, as the donor area for harvesting gingival grafts, is chosen in most cases because is considered the gold standard anatomical structure for this procedure. This structure varies in its anatomy according to each patient. The palatal vault is classified as deep, average, or flat. Over the years, various surgical techniques have been proposed for taking free or connective gingival grafts, published by various authors. Some of these techniques are: harvesting of a free gingival graft, trap door, parallel incision, single-incision, deepithelialized free gingival graft, and roll technique. The complete healing of the tissue varies according to the scarring, whether it is first or second intention. This is completed 3 months post operation. During or after surgery, complications may occur that must be taken into consideration since the case planification.
The objective of this study is based on conducting a narrative literature review on the anatomy of the palate, anatomical considerations for graft harvesting, indications, and contraindications for the execution of the process, techniques for free, connective, and rotated graft harvesting, complications that could occur during treatment and healing.

Keywords: Palate, gingival graft, periodontal surgery

Introduction
Periodontal plastic surgery addresses deformities and mucogingival conditions that frequently occur within the practice [1]. These functional and aesthetic demands are an elementary part of the comprehensive treatment of periodontal treatments [2]. There are various treatment modalities such as: free gingival grafts, connective tissue grafts, pedicle grafts, acellular dermal matrix grafts and guided tissue regeneration. These are performed to cover denuded root surface, as well as increase the thickness and proportion of keratinized tissue [3, 4].
Over the years it has been shown that the autologous graft is considered the gold standard due to the high success rate and the predictability of the results, since it provides vascular support in its recipient bed [5, 6]. Even though there are various intraoral donor sites for taking gingival grafts, the palate is the preferred donor site due to its availability and ease of obtaining [7, 8].
The palate forms part of the upper wall of the oral cavity and the floor of the nostrils. It is formed by the hard and soft palate, the hard palate is composed of the palatine process of the maxilla in its two anterior thirds and in its posterior third of the horizontal plate of the palatine bone [9].
The main purpose of harvesting both free and connective grafts from the palate is focused on preventing or correcting defects in the gingiva or alveolar mucosa [2]. These defects can be caused by anatomical changes, traumatic or generated by a disease [5]. The method to treat these gingival deficiencies is by restoring or increasing the width of the keratinized tissue around the teeth or implants, increasing the gingival thickness, covering recessions and deepening the vestibule [10]. Identifying the safe area for graft harvesting is essential to reduce the complication of damaging the neurovascular bundle that is housed in the palate [11].

The objective of this study is based on conducting a narrative literature review on the anatomy of the palate, anatomical considerations for graft harvesting, indications and contraindications for the execution of the process, techniques for free, connective and rotated graft harvesting, complications that could occur during treatment and healing.

Materials and Methods

A narrative literature review was carried out with the search for the crossing of words "palate", "gingival graft", "periodontal surgery" in Spanish and English in the Pubmed, Google academic, Scielo databases where articles were included. Originals, clinical case reports and narrative and systematic literature reviews.

Background

In 1963, Björn reported for the first time the use of mucosa-free gingival grafts to thicken the gingiva for periodontal therapy. In 1964 King and Pennel properly introduced the free gingival graft technique in the United States taken from papillae with the gingivectomy technique. In 1966 Naber used the free gingival graft in buccal extension to gain attached gingiva and cover gingival recession. Sullivan and Atkins in 1968 described the surgical principles for taking gingival grafts during plastic surgery in relation to periodontal therapy [12].

In 1974 Edel introduced the "Trap-door" technique for taking connective graft from the palate with the aim of increasing the thickness of the keratinized gingiva and maintaining first-intention healing in the donor area [13]. In 1985, Langer and Langer modified the harvest to obtain epithelial and subepithelial tissue in the same graft [14]. Scharf and Tarnow in 1992 carried out changes in the “Roll Technique” technique, maintaining the epithelial tissue in the palatal portion and the rolled connective tissue in the vestibular portion [15]. In 1997, Studer and Allen showed the possibility of using the maxillary tuberosity as a donor area; however, its intake is limited [16].

Hürzeler and Weng in 1999 implemented the technique of harvesting a connective tissue graft, making a single incision in the palatal area and maintaining first-incision healing [17]. In 2010, Zucchelli performed the free gingival graft technique, de-epithelializing it extra orally [18]. Zufia and Blasi in 2019 proposed the “four layer” technique, which consists of grafting epithelialized, sub-epithelialized connective tissue, cortical bone, and spongy bone [19].

Indications and contraindications

The indications for harvesting a free gingival graft from the palate are:

1. Increase in keratinized gingiva around the tooth,
2. Increase in keratinized gingiva in the peri-implant area,
3. Increase the vestibule depth,
4. Coverage of gingival recessions,
5. Increase of the alveolar ridge [1].

Regarding the indications for harvesting a connective tissue graft from the palate, they are:

1. Coverage of recessions.
2. Increased thickness of peri-implant soft tissues.
3. Immediate implant placement.
4. Dehiscence of peri-implant soft tissues.
5. 5 Increase of the alveolar ridge [1].

The contraindications for his surgical procedure are:

1. Wide and shallow palate, since early contact with the palatine artery may occur.
2. Excessively glandular or fatty palatal submucosa.
3. Uncontrolled systemically compromised patients (ASA III) [20, 21].

Anatomy of the palate

The palate has a concave dome shape in both anteroposterior and transverse directions. In the midline there is a palatine raphe which goes from the incisal papilla to the uvula [22]. In its anterior and lateral portion are the transverse palatine folds or palatine roughness. In the posterior portion, the uvula and the abutments are found. This is covered by masticatory mucosa, lined by stratified squamous epithelium [9].

The oral cavity, mainly the palate, is irrigated by branches of the maxillary, facial and ascending pharyngeal arteries which originate from the external carotid artery. The greater palatine artery flows into the greater palatine foramen of the hard palate which is located between the second and third molars [23]. In the posterior part of the palate (in the soft palate), there are the minor palatine foramina where the branches of the minor palatine artery exit. These arteries irrigate a large part of the hard and soft palate [11]. The branches of the greater palatine artery are in charge of irrigating the mucosa, the periosteum and the palatine gingiva before entering the incisor foramen to generate an anastomosis with the nasopalatine artery. The nasopalatine artery enters the incisive canal to irrigate the anterior portion of the hard palate [24]. The lesser palatine nerve enters the lesser palatine foramen, and the greater palatine nerve exits through the greater palatine foramen. The innervation of the anterior area of the palate arises from the nasopalatine nerve that flows in the same way through the incisive foramen [23].

Anatomical considerations for graft harvesting

The height, length and thickness of the graft harvest varies according to the anatomical variations of each patient's palatal vault. A probe is used to determine the thickness of the graft following the application of anesthetic [25]. At present, there are several methods to identify the position of this foramen using ultrasound and magnetic resonance; however, its use is not practical in dental offices [10].

The neurovascular bundle is located at 7 to 17 mm from the cement-enamel junction of the maxillary premolars and molars in the apical direction. The greater palatal foramen is palpated to determine the area to be left free when making the incision so as not to violate the space of the neurovascular bundle [24]. In the presence of a flat palatal vault, the neurovascular structures are located at approximately 7 mm from the cement-enamel junction. When the patient has an average palatal depth, the distance is approximately 12 mm. And finally, when the patient has a very deep palate, it is indicated that the vessels are located at an estimated distance of 17 mm [25]. As it advances towards anterior, the neurovascular bundle follows its trajectory to the nasopalatine foramen; for this reason, incisions should be avoided in the anterosuperior area [26].

According to Tavelli (2019), the greater palatal foramen is 57% of the time apical to the third molar, 21.3% of the time it is between the second and third molar and 13.5% of the time it is distal to the third molar. To perform graft harvesting safely, the area from the second premolar to the second molar is considered the safest and the area from the first premolar to the canine is considered the least safe. An average graft height

in the safe zone is 8 mm in most cases (93%); however, the safety of the zone should be calculated by performing the following formula: subtraction of the standard deviation of the mean from the mean distance from the cement-enamel junction to the greater palatal artery in each dental organ and subtraction of 2 mm corresponding to the gingival margin corresponding to the biological thickness. (Safe zone = - standard deviation-2) [10].

Surgical Techniques

There are several surgical techniques to perform gingival grafting according to the type of tissue to be grafted (epithelium and connective or only connective).

The first technique is free graft harvesting described for the first time by Björn, where four incisions are made in the palatal area (2 vertical and 2 horizontal) for tissue extraction. The graft consists of epithelium and lamina propria. After harvesting, the donor area is sutured [27].

The Trap-door technique was proposed by Edel, its objective is to extract the connective graft and maintain primary closure of the donor site.

The first method consists of:

1. Performing a partial flap in the palatal area at the level of the molars, with a wider base than the free ends using a No. 15 scalpel blade, obtaining two vertical incisions and one horizontal.
2. The flap is reflected, and a portion of submucosa is dissected approximately the size of the receptor bed.

a) Do not dissect too deep to avoid the inclusion of palatine mucosal glands.
b) If they are included, the tissue must be cut before placing it in the receptor site.

3. The flap is repositioned, and pressure is applied for 2 minutes to avoid a vacuum under the flap.
4. The flap is sutured using interrupted stitches and maintained for 1 week [13, 28].

The second method consists:

1. Making an incision towards the osseous ridge in the direction of the axial axis of the tooth, close to the marginal gingiva.
2. The flap is lifted to full thickness and a second incision is made to thin the flap internally.
3. The resulting tissue portion is cut and used as a graft.
4. The palatal flap is repositioned, sutured and stitches are removed in 1 week.
5. Surgical dressing is placed if required [13].

The Parallel-incision technique was described by Langer and Langer, which describes the harvesting of connective tissue graft in conjunction with a band of keratinized tissue. The incision length is determined by the amount of tooth to be covered. The technique consist:

a) Making a horizontal incision at a distance of 5 to 6 mm from the marginal gingiva at the level of the maxillary molars with a length according to the size of the surgical bed. The incision is made with a reverse bevel towards the alveolar bone.
b) A second horizontal incision is made at 1.5 to 2 mm coronally from the first horizontal incision.
c) Vertical incisions are made on both sides of the horizontal incisions to remove adjacent tissue and aid in wound closure.
d) All the connective tissue and epithelium between the two horizontal incisions is removed and the fatty tissue is removed.
a) When rim augmentation is sought, the fatty tissue is not removed.
e) The portion of epithelial tissue is used to cover recessions since it provides a smooth junction with adjacent epithelium [14, 29].

The Single-incision technique was described by Hürzeler and consists:

1. A horizontal incision is made at a distance of 2 mm from the palatal gingival margin in the direction of the bone.

a) The length of the incision depends on the size of the recipient bed.

2. The scalpel is placed at an angle of 135° and continues dissecting the tissue towards the midline starting where the first incision was made.
3. As movements are made along the incision line, the steeper angle is made until a position parallel to the bone surface is reached.

a) The partial cut should be observed, as an attempt is made to elevate the tissue as the tissue is being cut. It helps not to perforate the tissue.
b) Dissect until the desired size of the graft is obtained.

4. The connective tissue is separated by making an incision towards the bone, cutting mesially, distally, and medially. The tissue is removed and a 1.5 to 2.9 mm thick graft is obtained.
5. The flap is repositioned and sutured using horizontal suspensory stitches to secure the flap and the entire donor area [17, 30].

The free gingival grafting technique (de-epithelialized), described by Zucchelli and collaborators, consists of taking epithelial and connective tissue, extra orally removing the epithelium. This technique is performed as follows:

1. Two horizontal incisions are made, the most coronal one is made at 1-1.5 mm apical to the gingival margin.
2. It continues with two vertical incisions, delimiting the area of the graft.
3. Along the horizontal plus horizontal incision, the scalpel is placed at an angulation as parallel to the bone as possible, maintaining the same thickness along the graft.

a) Care should be taken not to remove the periosteum that resurfaces the palatal bone.

4. With the extraoral flap, the adipose tissue is removed (seen in yellow color).
5. The palatal wound is covered with collagen membrane and sutured using 5-0.
6. The graft is de-epithelialized using the 15c scalpel blade and kept hydrated with saline.
7. The epithelium reflects lighter than the connective tissue, so the difference can be noticed [18].

The rotated graft technique described by Scharf and Tarnow consists:

1. Define the flap design according to the dimensions of the alveolus. The mesiodistal distance of the incision is related to the dimension of the alveolus in vestibulopalatine relation.
2. Make a vertical incision on the palatal border approaching the alveolus.
3. Make a horizontal incision at 2-3 mm from the gingival margin.
4. Make a second horizontal incision parallel to the first

one, from the limit of the vertical incision to the proximal end of the alveolus.
5. Finally, make a small oblique terminal incision to facilitate the rotation of the flap [15].

Complications

The most frequent complication during graft harvesting is bleeding during or after surgery, generated by a lesion in the palatal vessels [10]. Other complications that may occur are paresthesia or anesthesia in the palate due to invasion of the greater palatine nerve or nasopalatine nerve [25].

Tavelli and collaborators divide complications into intraoperative and postoperative according to the action being performed during surgery or according to a certain time after surgery. These complications are reflected in Table 1 [31].

Table 1: Intraoperative and postoperative surgical complications [31]

Intraoperative Complications	**Incisions**	**Flap preparation**	**Graft havervesting**	**Hemostasis**
	1. GPA injury 2. Bleeding	1. GPA injury 2. Flap laceration	Inadequate graft	Bleeding
Postoperative complications	2 weeks		Months	
	Early complications		**Late complications**	
	1. Bleeding 2. Flap sloughinig/necrosis 3. Infection 4. Change of feeding habits 5. Sensory disorders 6. Bone exposure		1. Persistent sensory dysfunction 2. Epithelial cyst formulation	

Source: Tavelli *et al*. 2022.

Cicatrization

The healing of palatal tissue consists of four phases: hemostasis, inflammation, granulation, and maturation [32]. The process begins with the formation of the clot, which seals the wound against dehydration and infection, allowing the migration of cellular matrix. Within hours, inflammatory cells (neutrophils & macrophages) debride the wound and prevent microbial invasion and proliferation. Macrophages secrete growth factors and cytokines that stimulate fibroblasts and other cells to promote connective tissue biosynthesis [33]. Subsequently, a provisional fibrin clot formed by platelets, neutrophils and red blood cells is formed. Fibroblasts proliferate and form granulation tissue and extracellular matrix components (fibronectin, collagen and hyaluronic acid). At 7-10 days, some fibroblasts differentiate into myofibroblasts which contact the wound [32, 34].

For donor sites with first-intent closure, re-epithelialization occurs within the first few hours. Epithelial cells migrate and seal the lesion within 24 to 48 hours. With the approximation of the wound edges, the healing clot and eschar shell is formed, which helps to repel the entry of microorganisms. The multilayered mucosa is formed by day 5. Donor sites with second intention closure need more time to heal and are more susceptible to infection due to tissue deficit. Complete epithelialization is obtained within 3 to 5 weeks [31].

In the last phase of maturation and remodeling, there is a reduction of blood vessels and apoptosis of fibroblasts, myofibroblasts, epithelial cells and macrophages. The alternation of synthesis and degradation of extracellular matrix proteins generates fibrous scar tissue. This has a lower biomechanical capacity compared to the original mucosa [31, 32].

The volumetric changes in the palatal donor area after taking a free gingival graft are obtained in the first 3 postoperative months. These dimensional changes, after healing, decrease in 6 to 12 months [35].

Conclusion

The knowledge of the anatomy of the palate is elementary to perform the harvesting of a free and/or connective gingival graft. Locating the greater palatine foramen, the nasopalatine foramen, as well as the passage of the neurovascular bundle greatly reduce the possible complications that could occur during surgery. The average distances vary according to the patient's palatal vault anatomy.

There are multiple surgical techniques for the harvesting of free and/or connective gingival grafts. To select such technique, the following factors should be taken into consideration: the type of graft to be obtained, the anatomy of the palate, the size of the recipient bed, the location of the recipient bed, the patient's cooperation, the type of healing desired in the donor area (first or second intention), among other factors.

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