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REVIEW ARTICLE

TYPES OF GRAFTS FOR SOFT TISSUE AUGMENTATION AROUND DENTAL IMPLANTS

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ABSTRACT

Objective: *The need for peri-implant soft-tissue augmentation procedures is more than ever before. The present review aimed to identify the various grafts available for clinical soft-tissue augmentation around dental implants. A literature search was carried out with a focused question, "What are the different types of grafts available for clinical soft-tissue augmentation around dental implants?".*

Methodology: *The search was narrowed down to, "soft-tissue augmentation", "keratinized-tissue", "tissue-thickness", "gingival-graft", "connective-tissue-graft", "free-gingival-graft", "acellular-dermal-matrix", "dermal-matrix-allograft", "collagen-matrix", "xenogeneic-collagen-matrix", "synthetic-matrix", "synthetic-scaffold", "implant", "dental-implant", "dental-implants", "dental-implantation" and "peri-implant". Relevant articles published between years 2000 and 2023 were selected. The commonest graft material reported for peri-implant soft-tissue augmentation were autologous grafts either connective tissue grafts (CTG) or free gingival grafts (FGG).*

Results: *The outcomes of both CTG and FGG were clinically favorable, and hence they are considered the gold standard. Also cadaveric (allogeneic) and animal based (xenogeneic) grafts are reported for clinical use which are predominantly acellular dermal matrices (ADM) or cross-linked collagen matrices (Types I and III). Use of allograft and xenograft for soft-tissue augmentation, although indicated clinically, is reserved wherein patients prefer to avoid a donor site surgery or have paucity of autologous donor tissue. Synthetic biomaterials though promising, are still in developmental stages.*

Conclusion: *Soft-tissue augmentation procedures around dental implants are imperative for patients with loss of Keratinized sift tissue (KST) thickness either due to resorption or because of thick gingival biotype, and is significant in the esthetic zone. The use of autologous CTG or FGG results in predictable clinical outcomes. Allograft and xenograft matrices may only be used as alternatives.*

Key Words: *Dental implant; peri-implant; soft-tissue; augmentation; keratinized tissue; soft tissue graft.*

This article may be cited as: Aloraini S. Types of grafts for soft tissue augmentation around dental implants. Pak Oral Dent J 2023; 43(4):211-217.

INTRODUCTION

Dental implants have become the first choice for rehabilitating edentulous alveolar ridges. Both immediate and delayed placement of implants after dental extraction have yielded reliable, predictable and reproducible clinical outcomes.[1] While delaying implant placement is often reported as a cause for horizontal and vertical alveolar ridge resorption, considerable reduction in ridge resorption has been achieved through immediate placement.[2] Nevertheless, bucco-labial cortical resorption and subsequent collapse of the mucogingival soft-tissue envelope is still a challenge faced in the dental implant treatment.[3] One of the major reasons cited for the above clinical conundrum is the difference in connective tissue attachment between natural teeth and dental implants.[4] Teeth are connected physiologically to the alveolar bone through a periodontal apparatus comprising gingiva, periodontal ligament and cementum, supplemented by a junctional epithelium, which acts as a harbinger of healthy periodontium, and alveolar bone. On the contrary, osseointegration, which retains dental implants within alveolar bone, is based on biomechanical bone deposition in close proximity to the implant surface. This results in a fragile peri-implant soft-tissue attachment that is characterized by parallel oriented collagen fibers, with fewer blood vessels and fibroblasts.[4,5] A combination of the aforementioned factors makes dental implants more susceptible to peri-implant inflammation due to plaque accumulation, than what would normally be seen with natural teeth. Per-implantitis or peri-implant inflam-

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Received for Publication: Oct 5, 2023
Revised: Nov 21, 2023
Approved: Nov 26, 2023

mation is primarily attributed to microbial invasion from plaque bacteria and leads to bone loss around the implant, which ultimately affects the clinical outcomes related to soft-tissue and esthetics.[6]

Oral soft tissue augmentation or grafting procedures are frequently required to achieve proper wound closure after deficits resulting from tumor excision, clefts, trauma, around dental implants, in periodontal surgical procedures for the treatment of gingival recessions and as adjunct procedures for some orthodontic patients with recessions.[7,8] Keratinized soft-tissue (KST) around implants and its thickness are key determinants of a healthy peri-implant region. The first clinical sign of reduction in KST thickness is the un-esthetic exposure of the underlying metallic, seen through the gingiva.[9] Consequently, it leads to greater inflammation through plaque accumulation and subsequent gingival recession and peri-implant bone loss.[9,10] The previously mentioned clinical problems are accentuated in individuals with thin gingival biotype and with implants placed in the esthetic zone. Periodontal and per-implant soft-tissue augmentation has gained clinical popularity, in an effort to minimize these esthetics, function and stability related problems arising because of reduction in KST thickness.[11,12] Peri-implant soft-tissue augmentation procedures may be carried out either before, during or after the different surgical and restorative implant phases. In spite of the lack of consensus with respect to the timing of the soft-tissue augmentation procedures surrounding implant treatment, clinical outcomes have been favorable. Similarly, in terms of the choice of material used for soft-tissue augmentation, several autogenic, allogeneic, xenogeneic and alloplastic biomaterials have been used clinically. Nevertheless, autologous free gingival graft and sub-epithelial connective tissue graft are considered as the clinical gold standards, and have been used to compare other alternatives for soft-tissue augmentation.[12-14]

The need for peri-implant soft-tissue augmentation procedures has increased proportional to the frequency of implant supported dental rehabilitation.[9-14] In this context, there is a need to know more about the different types of graft materials available for soft-tissue augmentation around the implants. Therefore, the present review was conducted with a focused question, "What are the different types of grafts available for clinical soft-tissue augmentation around dental implants?"

METHODOLOGY

To address the focused question, a literature search was carried out to identify suitable articles, which have reported on the different graft materials used in clinical soft-tissue augmentation around dental implants.

Popular scientific databases including PubMed, Scopus Elsevier and Embase were searched for relevant literature published in English, between the years 2000 and 2023. The following keywords were used in different combinations separated by Boolean operators [AND], [OR] and [NOT]: "soft-tissue augmentation", "keratinized tissue', "tissue thickness", "gingival graft", "connective tissue graft", "free gingival graft", "acellular dermal matrix", "dermal matrix allograft", "collagen matrix", "xenogeneic collagen matrix", "synthetic matrix", "synthetic scaffold", "implant", "dental implant", "dental implants", "dental implantation" and "peri-implant". Literature search and study selection process is schematically presented in the flow chart (Figure I).

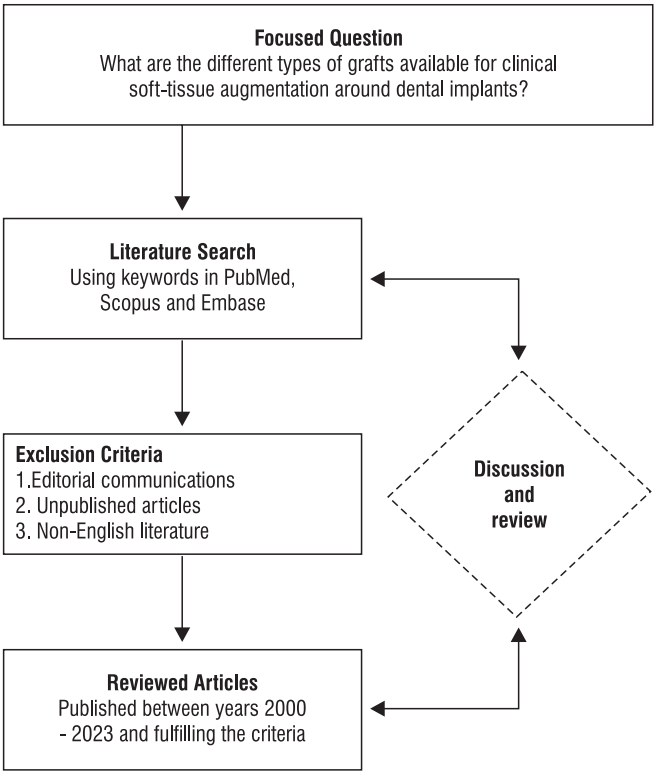

Fig 1: The articles selection process

RESULTS AND DISCUSSION

Autologous/Autoplastic Grafts

Soft tissue grafts called autologous grafts (AGs), commonly referred to as autoplastic grafts, are extracted from the patient's own oral mucosa (typically the palate or maxillary tuberosity).[15,16] The use of autologous soft tissue grafting for periodontal and peri-implant plastic surgery reconstructions for soft tissue health and esthetics is backed by a substantial body of research.[11,17] They are regarded as the gold standard for peri-implant soft tissue (PIS) augmentation due to their everal benefits over alternative graft materials, including;

- They have high biocompatibility and low immu-

nogenicity because they come from the patient's own tissues.[16-18]

- They have a predictable outcome and a high success rate because they have a rich blood supply and can integrate well into the recipient site. [16-18]
- They can provide both, an increase in the width of the keratinized mucosa (KM) and the thickness of the peri-implant soft tissue (PIS), which are important factors for implant stability and aesthetics. [16-18]
- Because of the histological differences that exist in the peri-implant mucosa, AGs performance around a dental implant will perform better because it is derived from the patient's own oral cavity compared to other types of grafts. [16-18]
- However, AGs also have some disadvantages, such as:
- They require a second surgical site for collection, which can cause additional patient morbidity. [16-18]
- They have limited availability and quantity depending on the size and shape of the donor site. [16-18]
- They can undergo shrinkage and resorption over time, which can compromise the long-term results of augmentation. [16-18]
- There are different types of AGs that can be used for peri-implant soft tissue augmentation, depending on the nature and purpose of the procedure. The most common types are;

Free gingival graft (FGG).

It is a graft made up of connective tissue and epithelium removed from the maxillary tuberosity or palate. Shallow vestibule, periodontal pockets behind the mucogingival line, an excessive quantity of connected gingiva, frenum-related gingival traction, and localized gingival regression are the most frequent disorders treated with FGG. Additionally, it is employed to widen the keratinized mucosa (KM) bordering the implants, particularly when the gingiva is absent or the biotype is thin. At the recipient location, the FGG is positioned and then stitched in place. Either a bandage or collagen membrane is placed over the donor location, or it is allowed to heal naturally.[19]

Connective tissue graft (CTG).

It is a graft that consists only of connective tissue, taken from the palate by making an incision parallel to the gingival margin and separating the epithelium from the underlying connective tissue. It is primarily used to increase the thickness of the PIS around implants, especially in cases of thin biotype or recession defects. The CTG is placed under a flap that is elevated at the recipient site and sutured into place. The donor site is closed with stitches or covered with a bandage or collagen membrane.[20]

Pedicle graft.

This graft maintains its blood supply from the donor area and is still joined to the donor site on one side. Either a coronally advanced flap (CAF) pushed apically from the neighbouring area to cover the recipient site or a lateral pedicle graft rotated from the adjacent area can be used for this. Pedicle grafts are mostly utilized to address recession deficiencies surrounding implants or, in cases when the CM width is sufficient, to thicken the PIS. The recipient location is covered by pedicel grafts that are sutured in place. There is no need for additional medical care for the donor site.[21,22]

Autologous/autoplastic graft healing

The type of graft, the size and depth of the wound, the vascular supply, and the patient's condition all affect how quickly an AG heals. Some sources claim that the recovery period can last for a few weeks, many months, or even years.[23] For instance, a skin transplant may experience a return of blood flow in 4–7 days, but complete recovery may take months or even years. It could take a bone graft up to three months or more to recover. Additionally, conditions like infection, inflammation, smoking, diabetes, or drug use may have a negative impact on the healing process.[24] As a result, it's critical to adhere to the doctor's recommendations and routinely check the wound for any indications of complications. The type of graft utilized, the method utilized, and any additional materials employed all affect how long it takes for the oral soft-tissue grafting to recover. One to two weeks following the surgical soft tissue grafting, the healing process is typically complete.[16-24]

Since AGs are grafts made from your own body, they can be made from blood stem cells, skin, bone, or oral mucosa. Because they are made from your own tissues and share the same genetic make-up as you, they are typically well tolerated by your body and have a low chance of rejection. However, occasionally, your body may reject AGs for a variety of reasons that include:

An infection or inflammatory condition at the donor or graft site that could result in an immunological reaction against the graft.[25,26]

Graft cell damage or loss of viability during collection, processing, storage, or transplantation, which may affect how well they perform and integrate with the recipient site.[25,26]

Remaining host cells that could be hostile to the graft cells, particularly in situations where autologous transplants are performed after allogeneic transplants (transplants from a different person).[25,26]

The possibility of graft cells being affected by the underlying disease relapsing, particularly in cases of blood malignancies treated with autologous stem cell transplantation.[25,26]

Patients who undergo soft tissue grafting with AGs must adhere to the surgeon's recommendations and routinely check the graft for any signs of problems. Any signs of infection at the donor site or the graft site, including fever, discomfort, edema, bleeding, or poor wound healing, may prolong the healing process or possibly lead to graft failure.[27]

Allografts

An allograft is the tissue that is transplanted from one person to another. The use of allografts in periodontal plastic surgery has gained popularity as they help overcome one of the greatest demerits of autografts, namely donor site morbidity.[28] The first and foremost among allografts used for soft-tissue augmentation is the acellular dermal matrix (ADM), collagen matrix derived from the dermis of human cadavers. ADM processing involves harvesting of donor skin, de-epithelialization (epidermis only), freeze-drying and decellularization by washing in non-denaturing, buffered detergent solutions.[29] Some of the advantages of ADM include esthetics, biocompatibility, physiological resorption, promotion of cellular chemotaxis, neovascularization, capability of providing gingival thickness and coverage during soft-tissue augmentation. The ability of ADM to promote unhindered periodontal tissue healing and regeneration has resulted in it being used for guided tissue regeneration (GTR) around exposed roots and implants.[30] A clinical study comparing CTG and ADM for soft-tissue augmentation around immediate implants, reported that outcomes related to KST thickness were better with CTG than with ADM. However, ADM is still considered a superior graft choice for soft-tissue augmentation in patients with paucity of donor tissue, reluctance towards donor site surgical procedures and thick gingival biotype. One of the key disadvantages of ADM is its accelerated shrinkage upon healing, which has reportedly led to secondary gingival recession and loss of KST thickness.[28] This is attributed to the inability of ADM to promote keratinization of the overlying epithelium, due to the apparent lack of cellular elements. Another potential allogeneic graft material is human amniotic membrane (HAM), as it has a structure similar to ADM comprising layers of epithelium, basement membrane and collagen matrix. However, in contrast to ADM, HAM possesses cytokines capable of promoting soft-tissue healing such as epidermal growth factor, transforming growth factor and fibroblast growth factor. HAM though used in isolated clinical cases for treatment of burn injuries, it is still at stage of in vivo testing when it comes to peri-implant soft-tissue augmentation, mainly due to ethical considerations and the risk of transmission of infectious diseases.[28-30]

Xenografts

The term xenograft refers to a tissue or organ that is derived from a species that is different from the recipient of the specimen. The use of xenografts for soft-tissue augmentation has primarily been driven by the need for greater availability, reduction in cost and abundance of graft material to be harvested.[31] Xenogeneic collagen barrier membranes have been used for clinical GTR and guided bone regeneration (GBR) with considerable success. While their primary role in GTR and GBR is to act as a barrier preventing migration of fibrous tissue into periodontal and bony defects, their role in soft-tissue augmentation should be that of tissue formation within the matrix.[32] Several xenogeneic collagen based matrix grafts have been reported, and are similar in structure and properties to ADM. Comprised predominantly of collagen types I and III, these matrices are biocompatible, non-immunogenic, and are capable of promoting cellular chemotaxis, neovascularization and wound healing. When used clinically, most of these matrices are resorbed by the physiologic action of collagenase and protease enzymes derived from neutrophils, monocytes and macrophages.[31-33]

Mucograft (Geistlich Pharma AG, Wolhusen, Switzerland) is a bilayer, porcine derived collagen matrix, composed of type I and type III collagen. The superficial layer of Mucograft is a highly occlusive layer made up of compact collagen and has a smooth surface to promote cellular chemotaxis and adhesion.[34] The deeper collagen layer that comes in contact with the tissues, is porous to promote proliferation of cells and new blood vessels. Although mucograft has been shown to increase KST width, the lack of cellular elements and absence of growth promoting cytokines question its ability to increase soft-tissue thickness. For a possible solution of the aforementioned problem, in vitro and in vivo studies have suggested seeding of mucograft collagen with adjuncts such as growth factors and stem cells.[35]

Mucoderm (Botiss GMBH, Berlin, Germany) is a typical ADM derived from porcine origin (PADM), and is similar in all respects to allogeneic ADM, except for the biological source. Manufactured using processes similar to cadaveric ADM, Mucoderm acts as a scaffold for three-dimensional proliferation of soft-tissue fibroblasts and vascular endothelium.[36] When clinically used for periodontal soft-tissue augmentation, PADM has been shown to integrate with the surrounding tissues and helps repopulate epithelial keratinocytes, gingival fibroblasts and alveolar osteoblasts. Tissue engineered constructs of Mucoderm incorporated with cytokines such as fibroblast growth factor (FGF), platelet-derived

growth factor (PDGF), bone morphogenetic proteins (BMP) and vascular endothelial growth factor (VEGF) have also been reported based on in vivo studies.[37]

Two more xenogeneic collagen matrices available for clinical use are Fibrogide (Geistlich Pharma AG, Wolhusen, Switzerland) and Dynamatrix (Keystone Dental, Burlington, MA, USA), both of which are composed of porcine derived extracellular collagen matrix, but are processed to undergo cross-linking. Using a combination of physical, chemical and biological processes the collagen component in these matrices is cross-linked to achieve mechanical stability and sustained biodegradability. In addition to enhancing tensile strength, cross-linking the collagen renders the graft elastic and helps retain shape of the material even after absorption of body fluids.[38] Concomitantly, the porous nature of these xenograft materials aids in cellular migration, proliferation and neovascularization. One major post treatment challenge faced with all periodontal and peri-implant soft-tissue augmentation procedures is the loss of graft volume in the short-term, due to bio-resorption. While this is minimized largely because of collagen cross-linking, the associated delay in biodegradability has also been reported to induce inflammatory and foreign body type reactions.[39] Further, it is to be noted that these cross-linked xenogeneic collagen matrices require full epithelial coverage as they only allow healing in a submerged fashion.[38-40]

Synthetic Biomaterials

Synthetic polymer based scaffolds and matrices have gained popularity as biomaterials for tissue engineering, owing to their porous nature, enhanced surface area, and favorable biomechanical properties. Additionally, they negate the risk of disease transmission associated with allogeneic and xenogeneic grafts and could be either resorbable or non-resorbable.[41] Some of the commonest used synthetic biomaterials for manufacturing a scaffold or matrix include polycraprolactone (PCL), polylactic acid (PLA) and polylactic co-glycolic acid (PLGA).[42,43] These materials when designed in the form of a scaffold, resemble the porous extracellular matrix and enable ingrowth and proliferation of fibroblasts and endothelial cells. Several manufacturing processes including electrospinning, three-dimensional (3D) bio printing, and computed aided design/manufacturing (CAD/CAM) have been used to produce synthetic biopolymer based matrices. Studies have also reported in vitro bio-modulation of the synthetic scaffolds by incorporation of adjuncts such as vitamins and drugs with pleiotropic tissue stimulating effects.[41-43] Nevertheless, the synthetic scaffolds and matrices have only been proven for use in animal models and their clinical extrapolation would require further long-term studies. The greatest challenge with all the reported synthetic scaffold/matrix biomaterials is their inability to mimic the topography and bio-functional properties of collagenous matrix that renders them unsuitable for clinical soft-tissue augmentation.[44]

Summary

While CTG based techniques offer the highest predictability for achieving complete root coverage (or soft tissue dehiscence coverage), together with high esthetic results, the FGG technique is still regarded as the approach of choice for increasing soft tissue thickness and keratinized tissue/mucosa at teeth and dental implant sites. For peri-implant health, adequate tissue thickness and keratinized tissue width appear to be essential elements. The approaches used by AGs that are graft-based can be thought of as the most successful in accomplishing peri-implant soft tissue augmentation. Although the use of allograft and xenograft ADM and collagen matrices have been reported clinically, they seem to be only of significance in scenarios wherein there is paucity of donor tissue for soft-tissue augmentation, or when second surgical procedure is not acceptable for the patient. While ADM is used for soft-tissue augmentation in a similar fashion to that of CTG, cross-linked collagen matrices are used with submerged healing to provide bulk for the area of augmentation. In both cases, outcomes related to vertical coverage of exposed implant surfaces is not clinically favorable with allografts and xenograft. Given the above evidences from literature, the following conclusions may be arrived at:

Soft-tissue augmentation procedures around dental implants are imperative for patients with loss of KST thickness due to either resorption or thick gingival biotype; and it is significant in the esthetic zones.

The use of autologous CTG or FGG results in predictable clinical outcomes, in comparison to all other types of graft materials.

Although allograft and xenograft matrices are available for clinical use and are relatively easier to acquire, they may only be used as alternatives when there is no option for the use of autologous grafts.

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Saleh Aloraini is the single Author. He has done all the review work and wrote the article & did proof reading