Connective Tissue Grafts in Periodontal Surgery

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The application of connective tissue grafts has become a widely accepted therapeutic option in aesthetically oriented periodontal plastic surgery. The harvesting techniques as well as the fields of application have changed and further developed since the first description of a free connective tissue graft three decades ago. This article will provide an overview of techniques for graft harvesting and its therapeutic use as well as future developments.

Key words: connective tissue graft, periodontal plastic surgery, recession coverage, soft tissue augmentation

INTRODUCTION

The autologous connective tissue graft (CTG) is an indispensable therapeutic tool in mucogingival periodontal surgery and implantology from the functional and aesthetic point of view. Since it was first described by Edel in 1974, the technique has continued to develop steadily in terms of its indications, usage and harvesting methods. While it was originally used only to increase the width of the keratinised gingiva, its current range of uses has now expanded to include coverage of gingival recessions, soft tissue augmentation in edentulous areas, tissue thickening around teeth and implants and cosmetic measures (papilla reconstruction, scar correction, etc.).
With the aid of clinical examples, this article will provide an overview of techniques for graft harvesting, indications and success rates as well as future prospects relating to possible alternatives to the free CTG.

HARVESTING TECHNIQUES

The original publication by Edel (1974) not only described the possibility of harvesting a free CTG but also presented three different harvesting techniques:

- the palate using a three-sided 'trapdoor' incision
- from the underside of a mucoperiosteal flap and
- from the crestal area of an edentulous maxillomandibular saddle

Palatal harvesting in the region between canine and first molar has now become established as the standard procedure and, to enhance postoperative patient comfort, the graft is usually harvested from the same side as the recipient area. Periodontal prophylaxis in relation to the teeth adjacent to the harvesting area demands a distance of 3–4 mm between gingival margin and the first incision along the palatal course of the dental arch. Other anatomical limitations to connective tissue harvesting are the area of the palatine rugae (anteriorly), the palatal root of the first molar (posteriorly) and the neurovascular bundle emerg-

Fig 1 An incision is made along the palatal course of the dental arch.

Fig 2 The layers of connective tissue are undermined and sharply separated from each other.

ing from the greater palatine foramen (medially). With respect to the form of the palate and the associated position of the palatine artery, Reiser et al (1996) identify three possible anatomical variants of the palatal arch: flat, normal or high. Based on measurements of the arch, the neurovascular bundle is located at a distance of 7, 12 or 17 mm from the adjacent teeth according to this classification. An adequate distance from these structures should be maintained in order to avoid intra-operative bleeding. This is easier to do because the neurovascular bundle lies in a shallow channel.

Once the harvesting area is decided, there are various possible types of incision that will provide access to the subepithelial connective tissue. A decisive factor initially is whether or not a strip of epithelium is to be removed along with the graft. Leaving an epithelial strip on the graft was originally intended to provide a better transition to the existing epithelial border when treating recessions (Langer and Langer, 1985, 1993). It was found, however, that the presence of a band of epithelium made no difference to the aesthetic end-result and the outcome merely depended on the grafted connective tissue not necrotising on the root surface (Bouchard et al, 1994). As the covering epithelium necrotises anyway within the first 5 days (Oliver et al, 1968; Lange and Bernimoulin, 1974), the underlying connective tissue will determine the nature, shape and colour of the newly formed epithelium (Karring et al, 1975). For all indications where the CTG is completely covered by the overlying flap of the recipient bed, the epithelium included in the graft must already be removed beforehand. In terms of practicability, it therefore does not make sense to leave an epithelial strip on the CTG, as recommended in earlier publications or as in harvesting techniques involving special scalpels (Langer and Calagna, 1980, 1982; Langer and Langer, 1985; Raetzke, 1985; Harris, 1992). Primary wound healing in the donor area is no longer possible after harvesting of a CTG with an epithelial strip because of the rigidity of the palatal tissue, which means greater postoperative discomfort (re-bleeds, pain) for the patient. Attempts are often made to relieve this discomfort with additional measures, such as wound plates or haemostatics (Seibert, 1983; Langer and Langer, 1985; Harris, 1997).

If an epithelial strip is not harvested with the graft, access can be achieved with one (single-incision technique), two (angular-incision technique) or three (trapdoor technique) incisions. The more incisions that are made in the particular technique, the wider the view of the underlying connective tissue, but the more the blood supply to the covering flap is reduced, which can lead to postoperative necrosis of the overlying flap (Edel, 1974; Mörmann and Ciancio, 1977; Harris, 1994, 1997).

Recent approaches to connective tissue harvesting favour a single-incision technique (Hürzeler and Weng, 1999). The procedure, similar to the harvesting of a free mucosal graft, involves starting from a single incision along the gingival margin (Fig 1) to a layer thickness of 1–1.5 mm and undermining to sharply separate the connective tissue layers from each other (Fig 2). After preparation, the deep-lying connective tissue is separated from its surroundings by incisions reaching to the bone and is detached from the bone with a periosteal elevator (Fig 3). After removal of the connective tissue, the harvesting site is closed with horizontal compression sutures (Fig 4).

Fig 3 The connective tissue graft is detached from the bone with a periosteal elevator.

Fig 4 Wound closure with horizontal compression sutures.

The advantages of the single-incision technique lie in optimal vascularisation of the cover flap, a small number of sutures, no necessity for additional haemostatic or compressive measures, primary and hence relatively painless wound healing and the possibility of obtaining grafts of variable dimensions.

INDICATIONS AND SCIENTIFIC BACKGROUND

Autologous connective tissue grafts are firmly established in aesthetically oriented, periodontal mucogingival plastic surgery. Particularly with regard to coverage of gingival recessions, it has now become the treatment of choice alongside techniques that use periodontal membranes. Depending on the nature of the recession, various techniques are used; the common factors are fixation of the CTG onto the root surface to be covered and the complete or partial coverage of the CTG with a gingival flap displaced from apically or laterally (Figs 5 to 10).

However, the decision on whether a CTG or a barrier membrane is used for recession coverage should also be based on biological considerations: if a membrane is placed over a denuded root surface, the aim is not merely to cover the recession by means of the coronally displaced gingival flap positioned over it. The biological effect of the membrane is also intended to bring about periodontal regeneration on the formerly exposed root surface. New periodontal connective tissue attachment and, if possible, formation of new buccal alveolar bone are the intended goal of membrane application.

If a CTG is used to cover the recession and the gingival flap is positioned over it, this raises the question of how much the CTG fixed onto the cleaned root surface will bring about genuine periodontal regeneration and will not merely produce a long junctional epithelium. It is known from the literature that a long junctional epithelium forms on recessions that are covered with laterally or coronally displaced gingival flaps and that any periodontal regeneration remains confined to the apical and lateral defect borders (Wilderman and Wentz, 1965; Caffesse et al, 1984; Gotlow et al, 1986). Nevertheless, how does it behave if a connective tissue graft is placed under the gingival flap?

In a study on the beagle dog, Weng et al (1998) showed that, after a 9.6 mm long, surgically produced, chronic recession defect was treated with a connective tissue graft over a distance of 5.5 mm, new connective tissue attachment (equivalent to 57% of the defect length) was able to develop. In various case reports involving human histology analysis (Harris, 1999a; Goldstein et al, 2001), regenerated bone, cement and attachment developed under an autologous CTG. On the other hand, Harris (1999b) published a case study on a human biopsy after recession coverage with a CTG, in which no regeneration occurred on the root surface. Therefore the question arises of whether the presence of periosteum on the underside of a CTG may have an influence on the regenerative outcome.

While accepted opinion often describes the periosteum as 'the best membrane', studies from as early as the 1970s (Melcher, 1969, 1971; Melcher and Accursi, 1971) show that the periosteum has no regenerative potential after being de-

Fig 5 Harvested connective tissue graft.

Fig 6 Condition before recession coverage on teeth 12 and 13.

Fig 7 View of the recipient bed with periosteum and mucosal flap left in place.

Fig 8 Fixation of the connective tissue graft onto the surface to be covered.

Fig 9 Suturing and complete coverage of the connective tissue graft with a gingival flap displaced from apically.

Fig 10 Situation 3 months after recession coverage on teeth 12 and 13.

tached from the bone surface. The reason is that the regenerative potential of periosteum lies in what is known as the cambium layer. This layer becomes thinner with advancing age and in adults is made up of a single-cell layer of progenitor cells. The mechanical trauma of detaching the periosteum from the bone already destroys this cell layer, calling into question the membrane function of the periosteum. In an animal experiment (Weng et al, 2000) it was shown in the monkey model that the bone regeneration potential of periosteum-covered cavities is markedly lower than that of membrane-covered cavities. This suggests that, once it has been detached from the bone in adult patients, periosteum should be regarded as a simple connective tissue from the regenerative point of view. At most, there is likely to be greater regenerative potential in young patients where the cambium layer comprises several layers of progenitor cells lying on top of each other. In view of the literature quoted above, whether the periosteum layer should be left on the CTG or the periosteum should be directed towards the tooth or the gingival flap is no longer decisive and is rather secondary in relation to the regenerative outcome of recession coverage.

Bearing in mind the issue of regeneration, it is acceptable to use a connective tissue graft to cover a gingival recession (distinct from coronal or lateral displacement without a CTG). Despite contradictory case reports, this is acceptable provided it is at least clear that a pure displacement technique without CTG would only produce a long area of junctional epithelium on the side of the flap facing the root surface. If the main focus is turned away from the regenerative outcome to the aesthetic end-result in terms of the percentage coverage achieved, treatment with a CTG proves superior to the membrane technique, according to a recent systematic meta-analysis by Roccuzzo et al (2002).

The use of connective tissue grafts for soft tissue augmentation and contouring of alveolar ridge defects is indicated if build-up of the deficient area with hard tissue is not possible or undesirable. This mostly concerns ridge defects of smaller dimensions where the amount of surgical work involved, time spent and financial cost bear no relation to the required end-result (Langer and Calagna, 1980; Garber and Rosenberg, 1981; Breault et al, 1999; Gasparini, 2004). Prominent indications are soft tissue augmentation on the buccal side in order to compensate for a horizontal ridge defect and the creation of support in pontic areas. By means of undermining, sharp preparation of the soft tissue, a cavity or pocket is created into which the CTG is placed and fixed with sutures.

Whereas in the past a CTG would have been inserted after blunt preparation of a mucoperiosteal flap between bone and periosteum, nowadays a split-flap preparation in the recipient area is increasingly preferred because the augmented area is more likely to be covered as a result of the greater flap mobility. With both techniques, however, the CTG can be covered either entirely or partly by the overlying flap. Early contouring of the grafted connective tissue is advisable in order to achieve improvements at the periodontal-restorative interface (Figs 11 to 15). The question of the long-term stability of this kind of purely soft-tissue augmentation is not entirely resolved in the literature. As the newly created soft tissue structures are often supported by prosthetic elements, reference should be made to two publications which show that soft tissue supports under pontics can be kept inflammation-free and volume-stable in the long term (Studer et al, 2000; Zitzmann, 2002).

Another application for connective tissue grafts is soft tissue thickening on the buccal side of teeth and implants (Azzi et al, 2002). Where the gingiva is thin or in the case of peri-implant mucosa, avital roots and titanium implants in the marginal area can be seen through the mucosal covering and impair the aesthetic end-result around the periodontal-restorative interface. As a simple corrective measure, a micro-scalpel is used to prepare a subepithelial pocket on the buccal side affected. The CTG harvested from the palate is then drawn into the prepared pocket with the aid of a guide stitch and fixed in the desired final position (Figs 16 to 18). With this technique, part of the connective tissue graft can be left outside the pocket, if required.

ALTERNATIVES/FUTURE PROSPECTS: TISSUE ENGINEERING

The harvesting area, as a secondary operation site, is still the greatest disadvantage of connective tissue grafting. As the harvesting site is usually more painful than the recipient site postoperative-

Fig 11 Horizontal ridge defect in the pontic area with concave profile.

Fig 12 Connective tissue graft harvested from the palate.

Fig 13 The connective tissue graft is placed under the split-skin flap.

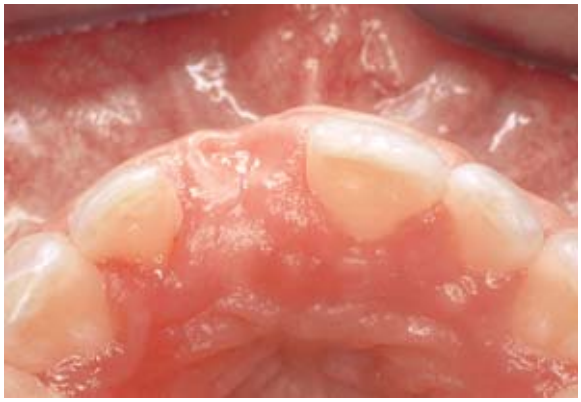

Fig 14 Occlusal view of the convex pontic area reshaped by the connective tissue graft, 3 months after grafting.

ly, a replacement material for a CTG that could do without a second operation site would also be desirable from the psychological point of view of the patient.

One approach moving in this direction is the culturing and in vitro growing of autologous epithelial cells (BioSeed-S) (Lauer, 1994; Lauer and Schimming, 2002; Lauer et al, 2003). After minimal tissue removal, this involves growing epithelial cells over a period of two to three weeks, which can then be inserted into the wound/recipient area. As the growing of cells has so far concentrated on the epithelial area, such cell cultures are in fact suitable as a replacement for a free mucosal graft, but not as a volume-producing replacement for dense connective tissue from the palatal region. However, these approaches are basically very promising and may be transferable to other types of soft tissue in the future.

Another replacement for connective tissue is known from the USA, which is obtained from allogeneic skin material (AlloDerm) in a similar way to demineralised, freeze-dried bone. The skin product originating from burns medicine can be used as a direct volume replacement for connective tissue grafts. The laboratory preparation of the product guarantees the removal of any cell remnants, in other words all that remains of the part of skin

Fig 15 Situation 3 months after soft tissue augmentation with all-ceramic bonded bridge inserted.

Fig 16 The thin buccal mucosa in the area of the emergence profile allows the neck of the implant to show through as a dark area.

Fig 17 A connective tissue graft is inserted and fixed into the sharply prepared pocket. Part of the CTG protrudes beyond the mucosal margin.

Fig 18 Situation 6 months after placement of the connective tissue graft and after final all-ceramic restoration of the single-tooth implant in region 23.

originally incorporating epithelium and dermis are the basement membrane and all the non-cellular elements of the dermis. As a result, the antigenic component of the material is removed, so that it can be biologically tolerated. The use of this product extends to all the indication areas covered by connective tissue grafting (recession coverage, soft tissue augmentation) but also to classic uses for a free mucosal graft (widening the keratinised gingiva/mucosa, vestibuloplasty). Initial case studies and comparative studies are extremely promising as far as the aesthetic and functional end-result is concerned (Callan and Silverstein, 1998; Harris, 1998; Silverstein and Duarte, 1998; Peacock et al, 1999; Silverstein et al, 1999; Tal, 1999; Harris, 2000; Wei et al, 2000; Mahn, 2003).

CONCLUSIONS

Connective tissue grafts are a versatile treatment method in periodontal plastic surgery and peri-implant soft tissue plastic surgery. Their strengths are ease of handling and good prospects of success. Harvesting techniques that are minimally traumatic but aimed at maximising tissue volume ensure multi-purpose usability of connective tissue grafts. Taking underlying wound healing mechanisms into consideration, this is a predictable treatment method. A long-term goal would be to avoid the need for a harvesting site by the use of methods derived from tissue engineering.

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