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ORIGINAL RESEARCH

Use of Collagen Matrix for Augmentation of the Peri-implant Soft Tissue at the Time of Immediate Implant Placement

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ABSTRACT

Aim: The aim of this study was to determine the treatment outcome of the use of a porcine monolayer collagen matrix (mCM) to augment peri-implant soft tissue in conjunction with immediate implant placement as an alternative to patient's own connective tissue.

Materials and methods: A total of 27 implants were placed immediately in 27 patients (14 males and 13 females, with a mean age of 52.2 years) with simultaneous augmentation of the soft tissue by the use of a mCM. The patients were randomly divided into two groups: Group I: An envelope flap was created and mCM was left coronally uncovered, and group II: A coronally repositioned flap was created and the mCM was covered by the mucosa. Soft-tissue thickness (STTh) was measured at the time of surgery (T0) and 6 months postoperatively (T1) using a customized stent. Cone beam computed tomographies (CBCTs) were taken from 12 representative cases at T1. A stringent plaque control regimen was enforced in all the patients during the 6-month observation period.

Results: Mean STTh change was similar in both groups (0.7 ± 0.2 and 0.7 ± 0.1 mm in groups I and II respectively). The comparison of STTh between T0 and T1 showed a statistically significant increase of soft tissue in both groups I and II as well as in the total examined population ($p < 0.001$). The STTh change as well as matrix thickness loss were comparable in both groups ($p > 0.05$). The evaluation of the CBCTs did not show any signs of resorption of the buccal bone plate.

Conclusion: Within the limitations of this study, it could be concluded that the collagen matrix used in conjunction with immediate implant placement leads to an increased thickness of peri-implant soft tissue independent of the flap creation technique and could be an alternative to connective tissue graft.

Clinical significance: The collagen matrix used seems to be a good alternative to patient´s own connective tissue and could be used for the soft tissue augmentation around dental implants.

Keywords: Augmentation, Dental implants, Graft, Immediate placement, Soft tissue.

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INTRODUCTION

Connective tissue grafts (CTGs) are used successfully in periodontology for root coverage procedures in cases of gingival recession and to increase gingival thickness.[1] Soft-tissue (STi) augmentation procedures around dental implants are performed mainly to improve esthetic outcomes. After immediate implant placement and physiological STi remodeling, disturbances caused by healing or implant abutments, as well as immoderate labial or buccal positioning of dental implants, can lead to mucosal recession.[2] The peri-implant mucosa should be augmented to prevent or treat mucosal recession.[3-5] The enhancement of soft-tissue thickness (STTh) around dental implants may also be required to avoid shimmering through implant parts, especially those made of titanium.[6] Particularly, in the esthetic zone, CTGs have become the first-line therapy.[7] As part of therapy involving immediate implant placement and provisionalization, CTGs have also been shown to increase STTh and stabilize the peri-implant mucosa in thin biotypes.[8]

In a previous investigation, the use of a monolayer collagen matrix (mCM) for STi augmentation increased

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STTh in the context of submerged healing for 6 months after surgery.[9] The outcome of mCM use was comparable to that of treatment with CTGs. The aim of the present study was to investigate the possible use of the same mCM for peri-implant mucosal thickening at the time of immediate implant placement and loading.

MATERIALS AND METHODS

Patients

This was a prospective, nonrandomized, and private practice-based study. It included patients who presented for extraction of fractured or otherwise nonsalvageable teeth between September 2012 and April 2015. The inclusion criteria were: (a) Absence of pregnancy, diabetes mellitus, and history of medication or drug abuse; (b) smoking <10 cigarettes per day; (c) need to extract one maxillary anterior tooth (canine to canine) with adjacent dentition present; (d) presence of the buccal bone plate in the extraction socket (as determined during surgery); (e) good oral health; and (f) presence of an adequate amount of bone to accommodate a cylindrical screw-type implant with a minimum dimension of 3.5 × 11.5 mm. This study was conducted in accordance with the Helsinki Declaration of 1975, as revised in 2000. The patients were given a full description of the treatment procedures and then given at least 1 week to submit a signed informed consent form.

Treatment

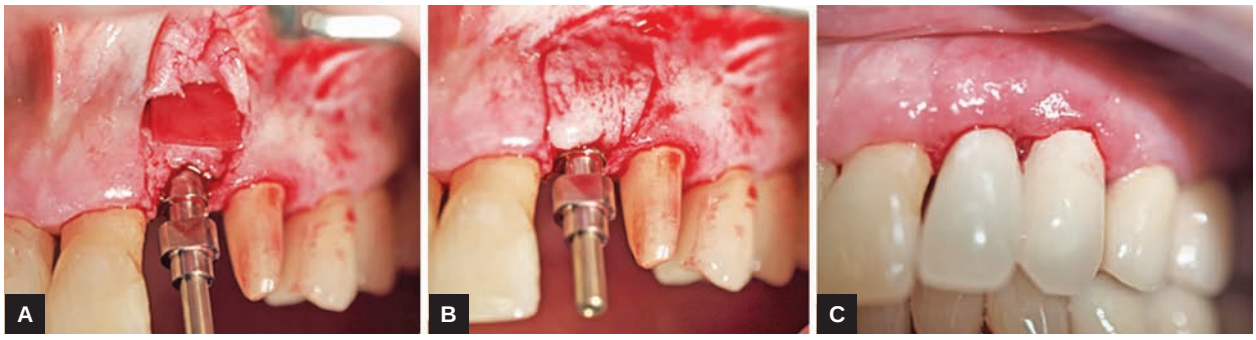
At least 6 weeks before surgery, oral hygiene instruction, tooth cleaning and polishing, and subgingival scaling were performed.[10] The same surgeon (Gregor-Georg Zafiropoulos) performed all surgeries. Target tooth extraction was performed atraumatically, and implants were placed manually at 875 rpm and 35 Ncm torque (Dentegris, Duisburg, Germany) using a one-stage surgical approach. The gaps were augmented with bovine xenograft (Cerabone, Botiss Biomaterials, Berlin, Germany; Fig. 1A).

Split-thickness flaps (STFs) were created on the buccal side, and porcine mCMs (Mucoderm, Botiss Biomaterials, Berlin, Germany; 1.7 mm thickness; approved for STi augmentation in Europe [CE 0483]) were used for augmentation. The mCMs were hydrated in sterile saline solution for 10 min, trimmed, and positioned on the periosteum.

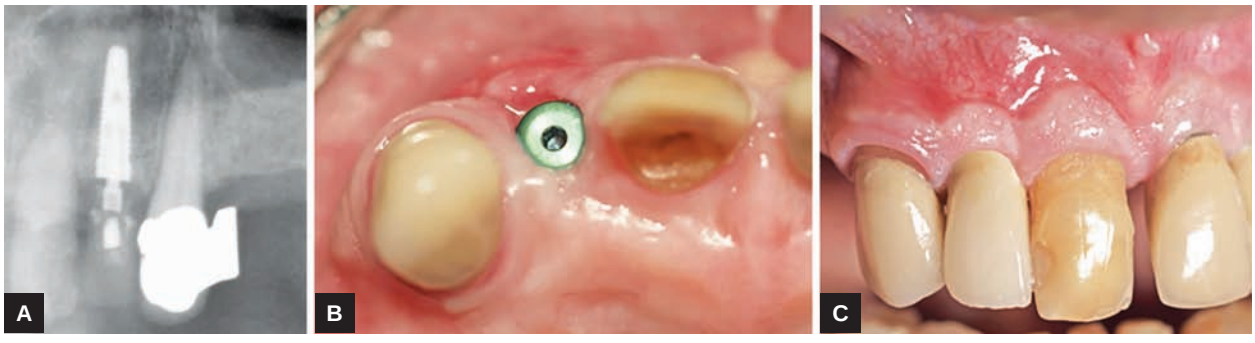
According to our surgical protocol, the patients received one of the two alternative flap designs. In group I, an envelope STF was created, the mCM was covered coronally, the flap was fixed with a horizontal mattress suture using nonresorbable suture, and subsequently, the mCM was fixed with the mucosal flap with simple loop suture (4-0 Ethibond Excel, Johnson & Johnson International, Neuss, Germany; Figs 1B and C). In cases of horizontal fracture in the middle or apical third of the root, vertical root fracture, deep subgingival root caries, lateral endodontic lesion, or deep vertical bone defect (group II), a coronally repositioned STF was created with a periosteal releasing incision, and the mCM was covered by the mucosa. The mCM was then fixated on the periosteum with interrupted simple-loop resorbable sutures (5-0 Monocryl; Johnson & Johnson International, Neuss, Germany; Figs 2A to C).

Impressions were taken using a polyether material (Impregum; 3M ESPE, St. Paul, MN, USA) and the open-tray impression technique. Subsequently, healing abutments were positioned on the implants until the delivery of temporary fixed partial dentures (tFPDs) 2 days later (Fig. 3A). The tFPDs were fixed on customized milled titanium abutments (ZenoTi, grade V, Type IV; Wieland, Pforzheim, Germany) using provisional cement (TempBond; Kavo Kerr Group, Charlotte, NC, USA). 6 months after surgery (T1), tFPDs were replaced

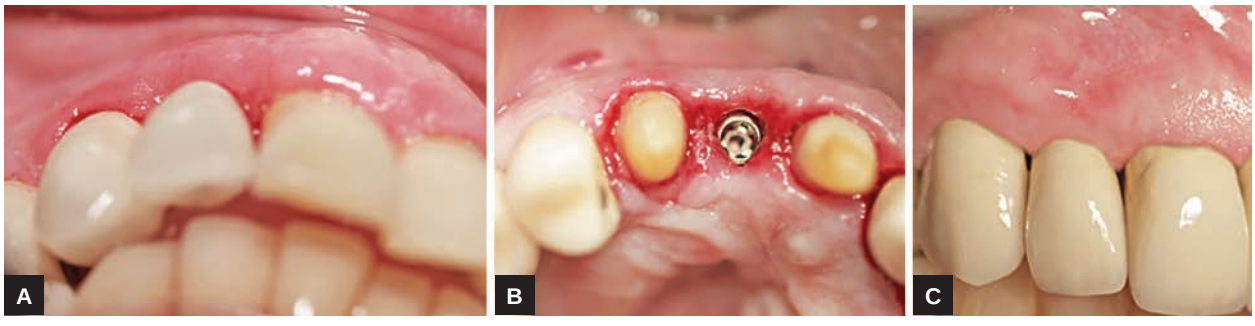
Figs 1A to C: (A) Schematic representation of implant placement and use of the measurement stent. R: Endodontic reamer; ST: Stent; and SI: Silicon stop; (B) implant placement in group I; and (C) matrix fixed to the mucosa with nonresorbable sutures in group I



Figs 2A to C: Treatment in group II: (A) Elevation of the split flap and fixation of the matrix on the periosteum; (B) repositioning of the flap; and (C) temporary restoration 10 days after surgery



Figs 3A to C: Treatment in group I: (A) X-ray: Immediately placed implant restored with temporarily fixed partial denture; (B) clinical control view 1 month after the surgery; and (C) clinical view 6 months after the surgery



Figs 4A to C: Clinical view 6 months after the surgery in group II: (A) Buccal/occlusal view; (B) occlusal view after removal of the temporary restoration; and (C) buccal view of the implant area after final restoration

by metal–ceramic fused FPDs, fixed using provisional cement (Improv; Alvelogro Inc., Snoqualmie, WA, USA; Figs 3B and C; and 4A to C).

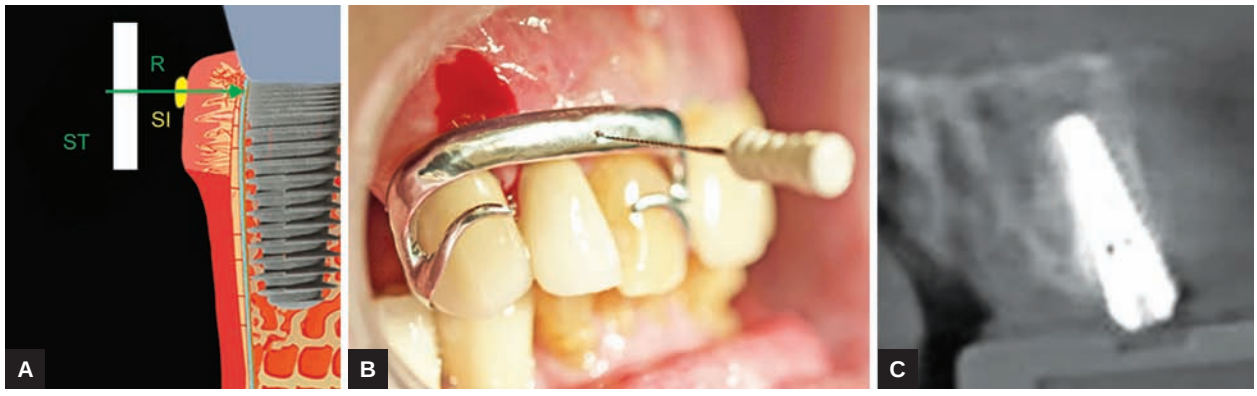
The patients were prescribed a chlorhexidine mouth rinse (0.1% Chlorhexamed Fluid; GlaxoSmithKline, Buehl, Germany) twice daily for 2 weeks, and sutures were removed at 2 weeks postoperatively. A soft diet was recommended for 4 weeks following surgery. Oral hygiene control and tooth polishing were performed for every 3 weeks from the time of suture removal until T1.

Measurement and Evaluation

Standardized STTh measurements were taken preoperatively (T0, immediately after extraction; Fig. 1A) and at T1 (Figs 5A and B) using a customized metal stent (CrCo alloy), which overlay the surgical area at a distance of 8 to 10 mm. The stent had one hole positioned 3 mm below the buccal crest of the extraction socket. Using light pressure, an endodontic reamer (#15; Dentsply DeTrey, Konstanz, Germany) with a silicone disk stop was inserted through the hole perpendicularly through the mucosal surface to the cortical bone. The stop was then placed in tight contact with the STi surface and fixated with cyanoacrylate. After careful removal of the stent with the reamer in place, penetration depth was measured to the nearest 0.1 mm using a gauge.

The implants were evaluated at T1 according to the success criteria of Smith and Zarb.[10] Peri-implant radiolucency, mobility, pain, discomfort, and/or neurosensory alteration were considered to indicate implant failure.

For the evaluation of hard-tissue and STi augmentation, cone beam computed tomography (CBCT) was



Figs 5A to C: Soft-tissue thickness measurement at T1 and implant uncovering: (A) Schematic drawing. R: Endodontic reamer; ST: Stent; and SI: Silicon stop; (B) clinical view of a patient from group I; and (C) CBCT image of a patient from group II, showing no sign of buccal bone plate resorption at T1

Table 1: Demographic characteristics of the study population

Characteristic	*Total*	*Group I*	*Group II*
Patients, n [all/female (%)]	27/13 (48.1)	14/8 (57.1)	13/5 (38.5)
Smokers, n (%) (all/female)	11 (40.7)/3 (0.1)	4 (28.6)/2 (14.3)	7 (53.8)/1 (0.1)
Age (years), mean (SD) (range)	52.2 (12.9) (25–72)	58.7 (10.5) (35–72)*	45.2 (11.8) (25–63)

*$p < 0.05$, group I *vs* group II (Mann–Whitney test); SD: Standard deviation

performed before final FPD loading at T1. Buccal plates at all target sites were examined and their presence or resorption was recorded.

Data Analysis

Statistical analyses were performed using commercial software (Statistical Package for the Social Sciences, version 23; Deutschland GmbH, Ehningen, Germany). Mean values, standard deviations (SDs), and median values of STTh at T0 and T1 were calculated. The normality of distributions was examined using Kolmogorov–Smirnov test. Matrix thickness loss (MThL) and changes in STTh were also determined. The MThL was calculated in the following manner: STTh T0 + mCM thickness – STTh T1. Differences between groups I and II in MThL and STTh at T0 and T1 were examined using Mann–Whitney U-test, with a statistically significance level of $p < 0.05$. Differences between STTh at T0 and STTh at T1 were examined in the same manner. Associations of STTh at T0 with the change in STTh and MThL were examined using Kendall's tau correlation analysis.

RESULTS

A total of 27 patients (14 males and 13 females; mean age, 52.2 ± 12.9 [range: 25–72] years) were included in this study and they underwent ST augmentation (Table 1). All patients demonstrated good oral hygiene and compliance (probing pocket depth: 4.2 ± 0.7 mm; clinical attachment level: 6 ± 0.2 mm; bleeding on probing: 6%; and plaque index: 8%). The indications for extraction and distribution of teeth extracted and implants placed are shown in Tables 2 and 3 respectively.

Patients' age, but not sex or smoking habit, differed statistically significantly between treatment groups ($p = 0.007$; Table 1). All healing periods were uneventful. The augmented areas showed no sign of inflammation or other indication of wound healing disturbance, and no implant was lost.

No statistically significant difference in STTh change or MThL was observed between groups I and II ($p > 0.05$, Table 4). The STTh at T0 and T1 differed statistically significantly in the whole population and in both groups (all $p < 0.001$). In the total population, the mean MThL was detected at 1.0 ± 0.2 mm (median: 1.1 mm; Table 4).

The CBCT showed no sign of buccal bone plate resorption (Fig. 5C). Kendall's tau values for the correlation of STTh with STTh change and MThL at T0 were –0.392 and 0.434 respectively (Graphs 1A and B).

Table 2: Reasons for tooth extraction

Group	*Endodontic failure (%)*	*Caries (%)*	*Periodontal failure (%)*	*Tooth fracture (%)*
I	4 (28.6)	4 (28.6)	2 (14.2)	4 (28.6)
II	3 (23.0)	2 (15.4)	4 (30.8)	4 (30.8)
Total	7 (26.0)	6 (22.2)	6 (22.2)	8 (29.6)

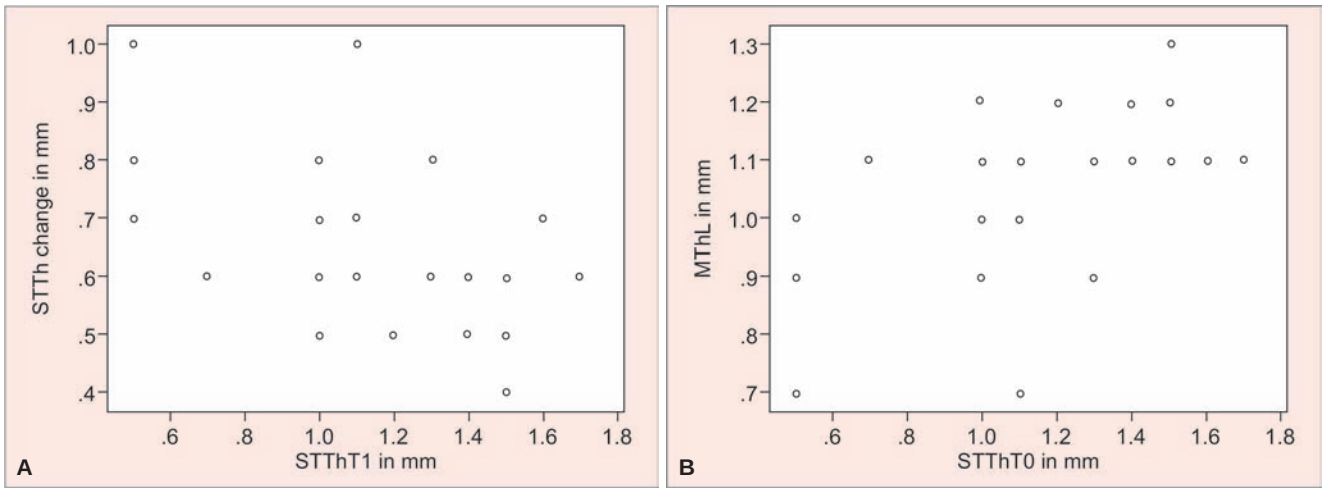
Table 3: Implant positions

Group	*Central incisors (%)*	*Lateral incisors (%)*	*Incisors (%)*	*Canines (%)*
I	0 (0.0)	8 (57.1)	8 (57.1)	6 (42.9)
II	3 (23.0)	5 (38.5)	8 (61.5)	5 (38.5)
Total	3 (11.1)	13 (48.1)	16 (49.2)	11 (40.8)

Table 4: STTh and MThL at T0 and T1

	Total		Group I		Group II	
Parameter	*Mean ± SD*	*Median*	*Mean ± SD*	*Median*	*Mean ± SD*	*Median*
STTh T0	1.1 ± 0.3*	1.1	1.1 ± 0.4*	1.1	1.1 ± 0.3*	1.0
STTh T1	1.8 ± 0.3	1.7	1.8 ± 0.4	1.8	1.7 ± 0.2	1.7
STTh change	0.7 ± 0.2	0.6	0.7 ± 0.2	0.6	0.7 ± 0.1	0.7
MThL	1.0 ± 0.2	1.1	1.1 ± 0.2	1.1	1.0 ± 0.1	1.0

*p < 0.001, T0 *vs* T1 (Mann–Whitney test). Values are given in millimeters. SD: Standard deviation



Graphs 1A and B: Scatterplots showing the lack of correlation between STTh and STTh change (A) as well as STTh and MThL at T0 (B)

DISCUSSION

In the current study, mCM was used as grafting material for STi augmentation at the time of immediate implant placement. Two different surgical techniques were used for mucosal flap elevation. To the best of our knowledge, the present report is the first to describe mCM use for this purpose.

The postoperative healing period and 6-month follow-up period were uneventful, with no complication, implant loss, or inflammation. 6 months after the surgery, STTh had increased, independent of flap procedure. These results are comparable to the outcomes of previous study in which mCM was used with submerged healing; Zafiropoulos et al[9] observed mean STTh increases of 1.06 mm at 1 mm below the gingival margin and 0.89 mm at 3 mm below the gingival margin. The latter value is mostly comparable to the results of the current study, in which STTh was measured 3 mm below the buccal crest. The outcomes of the current study were inferior to those of peri-implant STi augmentation using CTGs in other studies, which resulted in STi gains of 0.83 mm[11,12] at 9 months postoperatively, and 0.97[13] and 1.3 mm[14] at 12 months postoperatively.

Given the similarity of findings in both treatment groups and the small number of cases in each group, correlation analysis was applied to the total population in this study. STTh at T0 was not correlated with STTh change or MThL. Although this study was not designed to investigate the influence of biotype on STTh, initial STTh seems to have no influence on the clinical outcome. In this study, a membrane with a standardized thickness of 1.7 mm was used. In further studies, the use of different mCM thicknesses for different tissue biotypes might be advantageous, improving the technique and clarifying the indications.

In this study, mean MThL was comparable in both groups. The mean STTh change in both groups was 0.7 mm, which corresponds to the remaining thickness of the native membrane. This thickness is slightly greater than that observed in previous studies of STi augmentation with CTGs around teeth (0.5 mm). The thickness of harvested CTGs is typically 1 to 1.5 mm.[14-17] Thus, loss of nearly 50 to 70% of the initial CTG thickness occurs during the healing period due to remodeling.[16-19] In this study, the proportions of STTh loss in groups I and II were 64.7% and 58.8% respectively, in accordance with the results observed with CTG use.[15,16,18,20] Over an observation period of 6 months, mCM use thus seems to yield results equivalent to CTG use. In STi augmentation using CTGs, the most STTh loss occurs within the first 6 months; after this period of integration and remodeling, STTh remains constant for up to 30 months.[16] Further research is needed to determine whether long-term results are similar for mCM use.

Preclinical studies have documented the beneficial properties of porous collagen regarding engraftment of blood vessels, tissue integration, and biodegradation.[21-25] Clinical studies have proven that tissue integration is satisfactory and unproblematic, with complete CM remodeling and biodegradation.[8,9] These promising results can be confirmed by the functional and esthetic outcomes observed in this study.

Within the limitations of the current study, mCM appears to be an alternative to CTGs for STi augmentation around dental implants. Additional and more extensive clinical studies are needed to examine the long-term results of treatment with mCM, including the possible development of recession.

CONCLUSION AND CLINICAL SIGNIFICANCE

The mCM seems to be an alternative to CTGs for STi augmentation around dental implants.

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