ORIGINAL ARTICLE

CONTENTS

Soft tissues around the dental implants folowing mandibular segmental defect replacement: quantity and quality comparison assessment

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ABSTRACT

Aim: To compare the quantity and quality of surrounding soft tissues in patients after segmental mandibular defect reconstruction (SMDR) with bone grafts, before and after placement of implant-supported dental prostheses (ISDPs).

Materials and Methods: A total of 74 patients were included and divided into main (MG) and control (CG) groups. The MG consisted of patients after SMDR. The CG comprised 49 patients with a Kennedy Class II dental arch defect following tooth extraction. The width and area of attached gingiva (AG) were assessed before and after ISDP placement using intraoral scanning.

Results: After ISDP placement, the mean buccal width of AG at the medial implant was 0.94±0.90 mm in the MG and 2.18±0.95 mm in the CG ($p<0.01$). In the distal buccal region, the median values were 0 (IQR: 0–1) mm and 1.7 (IQR: 1–6) mm, respectively ($p<0.001$). The mean lingual width at the medial implant was 1.11±0.99 mm in the MG and 2.24±0.97 mm in the CG, whereas at the distal implant the median values were 0 (IQR: 0–0.6) mm and 2.1 (IQR: 1.5–2.75) mm, respectively ($p<0.001$). The median area of AG was 63.3 (IQR: 38.9–100.45) mm^2 in the MG and 233.9 (IQR: 186.75–295.75) mm^2 in the CG ($p<0.001$).

Conclusions: Patients after SMDR and placement of ISDP are characterized by lower quality and reduced volume of AG compared to conventionally rehabilitated patients with ISDP. To improve the long-term prognosis of treatment, soft tissue augmentation may be recommended.

KEY WORDS: mandibular reconstruction, dental implants, scanning, gingiva

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INTRODUCTION

Reconstruction of mandibular defects remains one of the most challenging problems in maxillofacial surgery, particularly in cases of segmental mandibular defects (SMDR) caused by tumours, osteonecrosis, or high-energy trauma [1–3]. Such defects result in the loss of bone, teeth, and adjacent soft tissues, leading to impaired mastication, speech, swallowing, and social adaptation, with a marked negative impact on quality of life [4, 5]. Comprehensive rehabilitation is therefore required.

The main goal of treatment is the restoration of function and anatomical form, which depends on accurate reconstructive planning and the possibility of implant-supported dental prosthesis (ISDP) placement. SMDR are commonly reconstructed with vascularised bone grafts, particularly the fibular free flap (FFF), which also allows replacement of associated soft tissue loss [6, 7]. Dental implants placed in transplanted fibular bone have demonstrated integration rates of up to 98% [8, 9]. However, the condition of the surrounding soft tissues remains a major challenge, as peri-implant soft tissue quality and quantity are critical for long-term treatment success [10, 11].

AIM

The aim of this study was to compare the quantity and quality of the surrounding soft tissues in patients after reconstruction of SMDR with FFF, before and after placement of ISDP.

MATERIALS AND METHODS

A prospective, controlled, non-randomised study included 74 patients who underwent prosthetic rehabilitation at the Head and Neck Pathology Centre of Kyiv Regional Clinical Hospital, which is the clinical base of the Department of Maxillofacial Surgery, Bogomolets National Medical University. The study was conducted from October 2023 to December 2025. The inclusion criteria for the study were as follows:

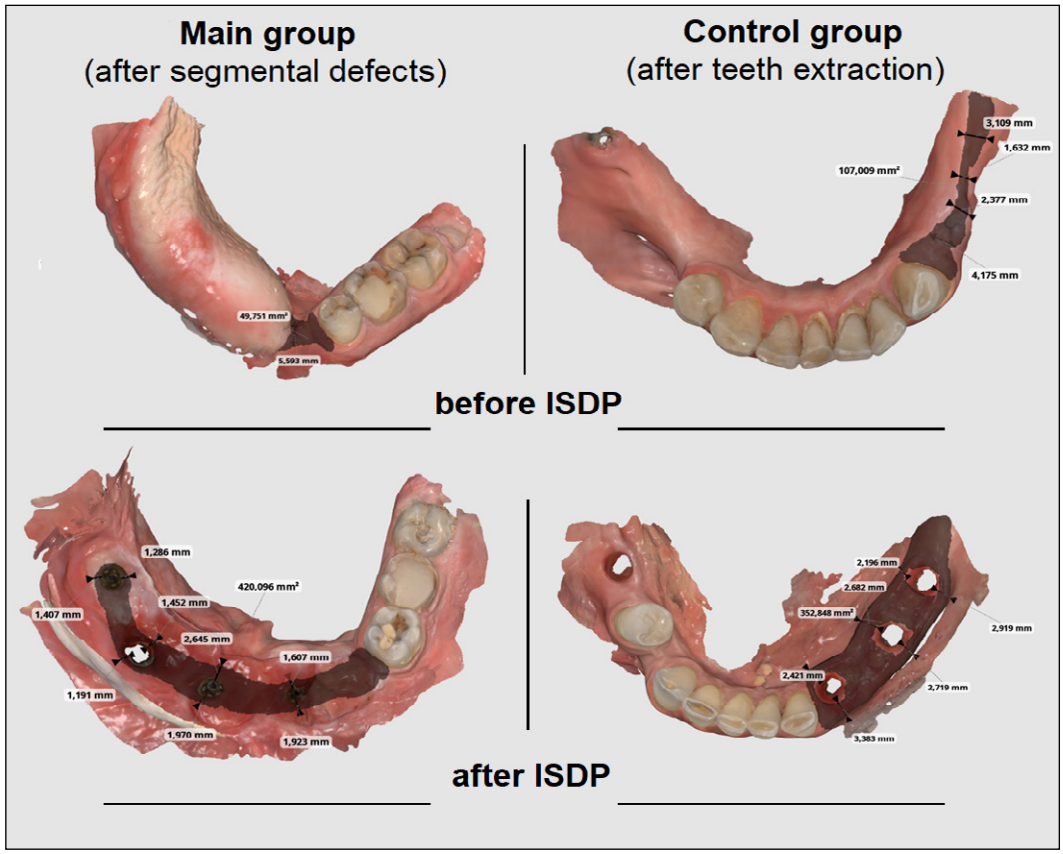

Fig. 1. Differences in the representation of intraoral scans between the two groups
Picture taken by the authors

1. Patients with SMDR (Brown Class I and II) who underwent surgical reconstruction using FFF [12];
2. CT-confirmed consolidation of the FFF bony component and the mandible (main group) or delayed dental implant placement after tooth extraction (control group);
3. Presence of a Kennedy Class II dental arch defect [13] corresponding to the reconstructed mandibular segment;
4. Placement of implant-supported dental prostheses in the area of mandibular reconstruction.

Twenty-five patients met the eligibility criteria and formed the main group after reconstruction of SMDR. The control group comprised 49 patients with a Kennedy Class II dental arch defect after tooth extraction for conventional reasons and no history of mandibular bone defects or discontinuity.

In both groups, the assessment of quantitative and qualitative characteristics was performed before and after placement of implant-supported dental prostheses (ISDP) (Fig. 1).

In both the main and control groups, the width and area of the attached gingiva were assessed before and after placement of ISDP. To this end, intraoral scanning of the prosthetic site was performed using a Medit i600 scanner (Medit Link) according to the manufacturer's recommended scanning protocol. The obtained scans were imported into Medit Link v3.4.7 (Korea) (Medit Design module), where the specified measurements were performed.

The intraoral scanning protocol was as follows:

1. The maxillary and mandibular arches were scanned, including the adjacent soft tissues.
2. The scan files were opened in Medit Design.
3. Measurement Mode was selected.
4. The width of the attached gingiva was determined based on the color differentiation provided by the software (lighter shade) and measured using the "Measure Distance by Two Points" tool.
5. The area of the attached gingiva was measured using the "Calculate Area by Selection" tool.

The boundary between the attached gingiva and the movable mucosa was identified using software-generated colour differentiation: a lighter shade for keratinised (attached) gingiva and a brighter shade for movable mucosa. In patients before placement of ISDP, the width of the attached gingiva was measured from the vestibular mucogingival junction (movable mucosa) to the lingual one. The area of the attached gingiva was measured along the crest of the alveolar ridge, including its buccal and lingual surfaces, from the gingival margin to the mucogingival junction. In patients after placement of ISDP, the width of the attached gingiva was measured

Table 1. Width and area of attached gingiva in distal extension defects before implant placement

Parameters	Main group (n = 16)	Control group (n = 24)	p*
Width of attached gingiva in the area of the medial aspect, mm	Me = 1.7 (IQR: 0.35-3.35)	Me = 3.9 (IQR: 2.65 - 6.1)	<0.01
Width of attached gingiva in the distal aspect mm	Me = 0.7 (IQR: 0-1.7)	Me = 3.9 (IQR: 2.05-5.4)	<0.001
Area of attached gingiva, mm^2	Me = 49.5 (IQR: 41.4-92.3)	Me = 185.3 (IQR: 94.6-207.85)	<0.001

Note: * — U-Mann-Whitney test
Source: compiled by the authors of this study

Table 2. Width and area of attached gingiva in distal extension defects after implant placement

Parameters	Main group (n = 9)	Control group (n - 25)	p
Buccal width at the medial implant, mm	M = 0.94±90	M = 2.18 ± 0.95	<0.01**
Buccal width at the distal implant, mm	Me = 0 (IQR: 0-1)	Me = 1.7 (IQR: 1-6)	<0.001*
Lingual width at the medial implant, mm	M = 1.11±0.99	M = 2.24±0.97	<0.001**
Lingual width at the distal implant, mm	Me = 0 (IQR: 0 - 0.6)	Me = 2 (IQR: 1.5 - 2.75)	<0.001*
Area of attached gingiva, mm^2	Me = 63.3 (IQR: 38.9 - 100.45)	Me = 233.9 (IQR: 186.75-295.75)	<0.001*

Notes: * — U-Mann-Whitney test; ** — T-test
Source: compiled by the authors of this study

Table 3. Comparison of the width and area of attached gingiva based on the location of the skin paddle in FFF after implant placement

Parameters	Extraoral skin paddle inset (n = 6)	Intraoral skin paddle inset (n = 4)	p*
Buccal width at the medial implant, mm	M = 0.82 ± 1.0	M = 1.01 ± 0.87	0.91
Buccal width at the distal implant, mm,	M = 0.87 ± 0.82	M = 0 ± 0	0.02
Lingual width at the medial implant, mm	M= 0.98 ± 1.10	M= 1.12 ± 0.83	0.83
Lingual width at the distal implant, mm	Me = 0 (IQR: 0 - 0.5)	Me = 0.35 (IQR: 0 - 0.95)	0.40
Area of attached gingiva, mm^2	M = 19.84 ± 57.27	M= 176.14 ± 161.47	0.17

Note: * — U-Mann-Whitney test
Source: compiled by the authors of this study

from the gingival margin to the mucogingival junction. All clinical stages of prosthetic treatment and all measurements were performed by a single prosthodontist.

For patients with distal extension edentulous defects prior to dental implant placement, the following parameters were assessed:

1. The width of the attached gingiva was measured at two points: in the distal part of the defect, 5 mm anterior to the retromolar triangle, and in the medial part, 5 mm distal to the tooth adjacent to (limiting) the defect.
2. The area of the attached gingiva was measured from the midpoint of the tooth adjacent to (limiting) the defect to the retromolar triangle.

For patients with a distal extension dental arch defect after implant placement, the following parameters were assessed:

1. The width of the attached gingiva on the buccal (vestibular) and lingual aspects along the midline of the mesial and distal implants.
2. The area of the attached gingiva from the midpoint of the tooth adjacent to (limiting) the defect to the retromolar triangle.

Statistical analysis was performed by a blinded investigator using EZR software (version 1.61) based on R version 4.2.2. Normality was assessed with the Shapiro–Wilk test. Normally distributed data were presented as mean ± SD and compared using the independent-samples t-test, whereas non-normally distributed data were presented as median and interquartile range (IQR) and compared using the Mann–Whitney U test. Statistical significance was set at $p<0.05$.

ETHICS

The study was approved by the Bioethics and Research Ethics Committee of Bogomolets National Medical University, which approves open publication of the study results. All procedures were conducted in accordance

with the Declaration of Helsinki [14]. Written informed consent was obtained from all participants.

FRAMEWORK

The study is a part of the research project of the Department of Maxillofacial Surgery at Bogomolets National Medical University titled "Clinical and experimental substantiation of new methods for rehabilitation of patients with maxillofacial defects and deformities using digital technologies and patient-specific solutions" (No. 0125U000004).

RESULTS

In 12 patients, the skin paddle was positioned intraorally, and in 13 patients extraorally. Before implant placement, the median width of attached gingiva in the main group was 1.7 (IQR: 0.35–3.35) mm medially and 0.7 (IQR: 0–1.7) mm distally, compared with 3.9 (IQR: 2.65–6.1) mm and 3.9 (IQR: 2.05–5.4) mm, respectively, in the control group ($p<0.01$). The median area of attached gingiva was 49.5 (IQR: 41.4–92.3) mm^2 in the main group and 185.3 (IQR: 94.6–207.85) mm^2 in the control group ($p<0.001$) (Table 1).

After implant placement, all attached gingiva measurements were lower in the main group than in the control group. Buccal width at the medial implant was 0.94±0.90 mm versus 2.18±0.95 mm ($p<0.01$). Buccal width at the distal implant was 0 (IQR: 0–1) mm versus 1.7 (IQR: 1–6) mm ($p<0.001$), lingual medial width was 1.11±0.99 mm versus 2.24±0.97 mm ($p<0.001$), and lingual distal width was 0 (IQR: 0–0.6) mm versus 2.1 (IQR: 1.5–2.75) mm ($p < 0.001$), respectively. The median area of attached gingiva was 63.3 (IQR: 38.9–100.45) mm^2 in the main group and 233.9 (IQR: 186.75–295.75) mm^2 in the control group ($p<0.001$) (Table 2).

After implant placement in the FFF group with an intraoral skin paddle, buccal medial width was 1.01±0.87 mm versus 0.82±1.00 mm in the group with an extraoral skin paddle ($p=0.91$), buccal distal width was 0±0 mm versus 0.87±0.82 mm ($p=0.02$), lingual medial width was 0.98±1.10 mm versus 0.98±1.10 mm ($p=0.83$), and lingual distal width was 0 (IQR: 0–0.5) mm versus 0.35 (IQR: 0–0.95) mm, respectively ($p=0.40$). The median area of attached gingiva was 19.84±57.27 mm^2 in the FFF group with an extraoral skin paddle and 176.14±161.47 mm^2 in the control group ($p=0.17$) (Table 3).

DISSCUSION

The importance of attached gingiva has long been recognised. Lang and Löe showed that a keratinized gingival width of <2 mm may predispose to inflammation [15], and recent studies confirm its role in peri-implant health [16, 17]. Patients after reconstruction of SMDR differ from those with intact jaws in both the quantity and quality of peri-implant soft tissues. In reconstructed areas, native mucosa may be replaced by skin tissue; therefore, although full restoration of natural gingiva is not possible, the formation of a stable band of keratinised soft tissue remains essential for long-term treatment success.

The absence of attached soft tissues complicates oral hygiene and may increase the risk of peri-implantitis. The incidence of peri-implant inflammation in reconstructed jaws ranges from 20.3% to 32.3% [18, 19]. Consequently, additional surgical procedures are often required to improve peri-implant soft tissue conditions. Hakim et al. reported that 62.2% of patients required additional surgical interventions to optimise soft tissue quality around implants [20]. Similarly, Shan et al. demonstrated that keratinised mucosa augmentation using an apically displaced flap with a free gingival graft can significantly increase keratinised tissue width after reconstructive surgery [21].

Our findings confirm that patients after mandibular reconstruction have significantly reduced levels of attached soft tissue compared with patients with secondary edentulism. Adequate keratinised tissue plays a crucial role in facilitating oral hygiene and reducing mechanical irritation from prosthetic constructions. In the present study, implant placement was associated with an increase in the amount of attached tissue; however, the overall volume of immobile tissue remained limited in reconstructed areas.

An important observation of this study is the evaluation of the area of attached tissue in addition to linear measurements. In reconstructed mandibles, the mucosa related to prosthetic construction often has a complex three-dimensional configuration, and linear width alone may not adequately reflect the soft-tissue support available for prosthetic rehabilitation. Therefore, assessing the area of attached tissue may provide a more comprehensive evaluation of peri-implant soft-tissue conditions.

Our results also showed no significant differences in the width and area of attached gingiva depending on whether the skin paddle of the fibular free flap was positioned intraorally or extraorally. At the same time, significant differences were observed between reconstructed patients and controls with conventional tooth loss.

Therefore, once the autotransplant has successfully integrated and postoperative healing has been completed without complications, optimal conditions must be established for prosthetic rehabilitation. Restoration of masticatory and speech function remains the ultimate goal of treatment, and adequate dental rehabilitation is necessary to prevent occlusal disorders and other functional disturbances [22].

It is evident that the condition of the soft tissues surrounding implants after mandibular reconstruction may depend on multiple factors. The choice of osseous flap for reconstruction (e.g., fibula free flap (FFF), scapula free flap, etc.) influences the characteristics of soft tissue formation around the bone graft, as well as the covering tissues within the oral cavity. At the same time, mucosal attachment may also depend on the positioning of the FFF, which can be either bone-driven or occlusion-driven fibular flap positioning [23].

Depending on the etiology of the defect, soft tissues may be subjected to various multifactorial influences. Patients who have undergone oncological treatment typically receive radiotherapy, followed by soft tissue atrophy and fibrosis [24]. Defects caused by combat trauma are associated with wound contamination, delayed primary surgical care, poorly defined wound boundaries, and extensive defects caused by high-energy weapons [25, 26]. Furthermore, multidrug-resistant infections have been reported in up to 84.6% of wounded patients [27].

In the present study, we did not investigate the impact of the aforementioned factors on the condition of the soft tissues surrounding implants, which can be considered a limitation of this study. At the same time, the cohort of patients included in the main group was heterogeneous with respect to these parameters, which may be considered an averaged sample in relation to the factors described above.

The present study has several strengths, including its prospective controlled design, the use of digital intraoral scanning for standardised soft-tissue assessment, and the performance of all measurements by a single prosthodontist. However, several limitations should be acknowledged, including the non-randomised design, the relatively small sample size, and the short follow-up period after implant placement. Further studies with larger cohorts and longer observation periods are required to clarify the influence of soft-tissue quantity and area on long-term peri-implant outcomes in reconstructed mandibles.

CONCLUSIONS

The obtained results revealed that patients after segmental mandibular reconstruction and placement of implant-supported dental prostheses are characterized by lower quality and a reduced volume of attached keratinised gingiva compared with conventionally rehabilitated patients with implant-supported prostheses. Management of such patients remains complex and often unpredictable. Therefore, optimal conditions for long-term treatment success should be established, including additional surgical procedures to augment attached soft tissues in the dental implant area after reconstructive surgery.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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