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RESEARCH ARTICLE

CHANGES IN THE WIDTH OF THE KERATINISED MUCOSA IN THE AREA OF ONE-STAGE DENTAL IMPLANTATION WHEN USING A SOFT TISSUE CUFF REINFORCED WITH BONE GRAFTING MATERIALYehven Niezhentsev,^{1*} Serhii Chertov, PhD²

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Abstract

Objectives: The aim of the paper is a follow-up comparison of the xenogenic collagen matrix and soft-tissue cuff reinforced with bone grafting material (STCRBGM) for an increase in the keratinized mucosa's width in the one-stage dental implantation area.

Materials and Methods: The main observation group consisted of 25 patients who, after tooth extraction, had the implant placed in a prepared bed where the socket was preliminarily filled with Sensobone xenograft, after which the STCRBGM was formed with subsequent fixation of a temporary crown. The comparison group included 26 patients in whom, after tooth extraction, the implant was placed in the prepared bed where the socket was preliminarily filled with Sensobone xenograft, after which the soft tissue area was filled with Sensobone xenograft, and the temporary crown was fixed. The width of the keratinized mucosa (KM) was determined from the free gingival margin to the mucogingival junction before implantation, then 3-month and one-year follow-up after implantation. The study results were processed using the statistical package of the licensed software "Statistica, version 13".

Results: Comparing the follow-up use of xenogenic collagen matrix and STCRBGM to increase the width of the KM in the field of one-stage dental implantation, it was found that the use of STCRBGM provided a significant increase in the width of the KM in 3-month follow-up after implantation by 0.87 mm, and in one-year follow-up by 0.94 mm, which is significantly 1.25 mm more than in the group where only xenogenic collagen matrix was used. Besides, a significant increase in the width of the KM was observed in one-year follow-up in the area of all teeth and in the group with xenogenic collagen matrix there was a significant decrease. The KM width does not depend on the age and gender of the patients, as well as on the type of teeth and jaws.

Conclusion: The effectiveness of one-stage dental implantation is facilitated by the adequate width of the KM provided by STCRBGM.

Keywords: One-moment dental implantation, Keratinized mucous membrane, Sensobone xenograft, Free connective tissue autograft.

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INTRODUCTION

One-stage dental implantation in patients with single anterior tooth loss can shorten the treatment period and provide better restorative and aesthetic effects.²⁶ After minimally invasive extraction, both one-stage and two-stage dental implantations can guarantee good clinical results, one-stage implantation, however, ensures more satisfaction, better aesthetic effect, and good prospects for clinical use.¹⁶

The mucous membrane around the implant is covered with keratinized epithelium, followed by a 1-1.5 mm thick barrier epithelium that fills the space up to the bone ridge. Studying the width of the keratinized mucosa (KM) around the implant is important. According to the literature, an increase in the width of the KM in the implant area is significantly associated with an improvement in the condition of soft tissues, and to avoid peri-implant inflammation, it should be at least 2 mm^{4,13,14} wide, since a width of less than 2 mm is associated with higher rates of gingival recession, gingival index, modified gingival index, and plaque index.

The mucous membrane around the implant is covered with keratinized epithelium, followed by modified plaque index, bleeding on probing, modified bleeding index, and bone loss.^{11,17,19,22} It has been established that the stability of soft tissues after implantation depends on the height of the keratinized tissue, periodontal phenotype, and papilla height.^{9,20} Covani U. et al.⁶ found that in one-stage dental implantation with a xenograft, in addition to positive final aesthetic results, during a one-year follow-up, early growth was maintained in the tissues around the implant, and a five-year follow-up revealed that the bone level had minimally changed.

Methods of preserving the volume of hard and soft tissues around the implant increasing the gingival KM and the thickness of soft tissues (creating gingival volume from the bone ridge to the edge of the mucous membrane).^{3,10} One of the key stages in dental implantation is using a connective tissue autograft.⁸ The use of individual anatomically designed immediate temporary restorations after the

extraction of one tooth and immediate implant placement minimises the loss of tissue volume, which optimises the final aesthetic result.²

Thus, ensuring an increase in the gingival KM in the implant area is an important task in dental implantology, as it is one of the factors affecting the long-term implantation result from both a functional and aesthetic point of view.

AIM

A follow-up comparison of the xenogenic collagen matrix and soft-tissue cuff reinforced with bone grafting material (STCRBGM) for an increase in the keratinised mucosa's width in the one-stage dental implantation area.

MATERIALS AND METHODS

Clinical trials were housed by our private dental clinics (DNIPRO DENTAL HUB LLC and Dr. Niezhentsev's Clinic LLC) and the Department of Propaedeutic and Surgical Dentistry of Zaporizhzhia State Medical and Pharmaceutical University. The study included 51 patients who underwent one-stage dental implantation.

Depending on the implantation technique, all patients were divided into two groups. The main observation group consisted of 25 patients who, after tooth extraction, had the implant placed in a prepared bed where the socket was preliminarily filled with Sensobone xenograft, after which the STCRBGM was formed with subsequent fixation of a temporary crown. The comparison group included 26 patients in whom, after tooth extraction, the implant was placed in the prepared bed where the socket was preliminarily filled with Sensobone xenograft, after which the soft tissue area was filled with Sensobone xenograft, and the temporary crown was fixed. Patients of both groups were divided by age and gender (Table 1).

Patients of both groups had 35 dental implants installed (Table 2). There was no significant difference between the groups in the number of implants installed in the selected teeth.

Table 1. Division of patients by gender and age

Feature	Main observation group (n=25)	Comparison group (n=26)
Men	16 (64%)	15 (57.7%)
Women	9 (36%)	11 (42.3%)
Average age	48.2 (44.0; 54.0)	47.1 (39.0; 54.0)

Table 2: Number of dental implants installed in patients of the study groups

Implant placement	Main observation group (n=25)	Comparison group (n=26)
Central incisor (CI)	5 (14.3%)	5 (14.3%)
Lateral incisor (LI)	6 (17.1%)	7 (20%)
Canine (C)	3 (8.6%)	3 (8.6%)
1 premolar (1PM)	5 (14.3%)	5 (14.3%)
2 premolar (2PM)	6 (17.1%)	4 (11.4%)
1 molar (1M)	10 (28.6%)	11 (31.4%)
Total	35 (100%)	35 (100%)

The KM width around the implant was determined according to the method described by Nalbantoğlu A. M. et al.¹⁵ To indicate the mucogingival junction (the boundary between the mobile and fixed mucosa), the anterior part of the gingiva was stained with 5% Lugol’s iodine solution using a cotton swab and a brush with light pressure, and the solution was applied several times until a clear demarcation line was achieved. Once a clear line was obtained, a soft tissue retractor was placed to facilitate scanning and minimize mucosal displacement. The KM width was determined from the free edge of the gum to the mucogingival junction. The KM width around the implant was determined before implantation (before tooth extraction), and then during 3-month and a one-year follow-up.

3D scanning with obtaining optical impressions was performed using an intraoral scanner “Medit i500” (Manufacturer: Medit, Korea). Medit i500 is an open real-time CAD/CAM system that allows exporting .stl files that can be easily transferred and tracked throughout the entire technological process.

The results of the study were processed using the statistical package of the licensed software “Statistica, version 13” (Copyright 1984-2018 TIBCO Software Inc. All rights reserved. License No. JPZ8041382130ARCN10-J). The reliability of differences in the compared values was confirmed by Student's t-test. The normality of the distribution of quantitative traits was analyzed using the Shapiro-Wilk test. When the parameters had a distribution

that differed from the normal one, the descriptive statistics were presented as the median with interquartile range – Me (Q25; Q75). The significance of differences in the compared values for unrelated samples was determined by the Mann-Whitney test, and for related samples – by the Wilcoxon test. All tests were two-sided. The difference at $p < 0.05$ was considered statistically significant. Relationships between groups of studied parameters were identified with correlation analysis, by calculating Spearman's rank correlation coefficients between quantitative features (r).

RESULTS

Before implantation in patients of both groups, the KM width in the area of one-stage dental implantation was almost the same and had no significant difference (Table 3). In the patients of the main study group, a significant increase in the KM width relative to the index before implantation was determined by 0.87 mm after a 3-month ($p < 0.00001$) and by 0.94 mm ($p < 0.000004$) after a one-year follow-up. While in the comparison group, there was no significant difference in the follow-up dynamics of the index, there was only a tendency to a slight decrease in the KM width relative to the index before implantation: by 0.11 mm ($p = 0.548$) after a 3-month and by 0.2 mm ($p = 0.261$) after a one-year follow-up. Relative to the comparison group in the main study group, the KM width was significantly larger by 1.09 mm ($p < 0.0000001$) 3 months after implantation, and by 1.25 mm ($p < 0.0000001$) in a year.

Table 3. Follow-up dynamics of KM width in the area of one-stage dental implantation, Me (Q25; Q75), mm

Stage of implantation	Main observation group (n=25)	Comparison group (n=26)	p
Before implantation	3.64 (2.94; 4.38)	3.53 (2.89; 4.06)	p = 0.545
3-month follow-up	4.51 (3.94; 5.16) *	3.42 (2.90; 4.04)	p < 0.0000001
One-year follow-up	4.58 (3.94; 5.11) *	3.33 (2.85; 3.84)	P < 0.0000001

Notes. * - a significant difference in the values at a 3-month and one-year follow-up after implantation compared to the value before implantation within the same observation group, p<0.05.

Having studied the KM width in the area of one-stage dental implantation depending on the jaw (Table 4), no significant difference was found in both observation groups before implantation and in the follow-up (3 months and one year after implantation). However, in both groups, there was a tendency for the KM to be wider in the upper jaw than in the lower jaw by an average of 0.5 mm: in the main study group this was by 0.59 mm before implantation, by 0.52 mm 3 months after implantation and 0.44 mm in a year, and in the comparison group this was by 0.59 mm, 0.54 mm and 0.52 mm, respectively. Before implantation, the KM width in the area of one-stage dental implantation in both the upper and lower jaw was almost the same in patients of both groups and did not differ significantly. In the patients of the main

study group, the KM width was significantly greater than in the comparison group 3 months after implantation on the upper jaw by 1.08 mm (p<0.0004) and on the lower jaw by 1.1 mm (p<0.000001), and in a year – on the upper jaw by 1.22 mm (p<0.00009) and on the lower jaw by 1.3 mm (p<0.000000). In the patients of the main study group, a significant increase in the KM width was determined relative to the value before implantation after 3 months on the upper jaw by 0.86 mm (p<0.00007) and after a year by 0.44 mm (p<0.0001). In the comparison group, there was no significant follow-up difference in the value, there was only a tendency to reduce the KM width relative to the value before implantation by 0.54 mm (p=0.635) after 3 months and by 0.52 mm (p=0.344) after a year.

Table 4. Follow-up CSR width in the area of one-stage dental implantation depending on the jaw, Me (Q25; Q75), mm

Stage of implantation	Main observation group (n=25)		Comparison group (n=26)		p
	Upper jaw	Lower jaw	Upper jaw	Lower jaw	
	1	2	3	4	
Before implantation	3.76 (3.11; 4.48)	3.17 (2.87; 3.87)	3.66 (3.12; 4.28)	3.07 (2.80; 3.27)	1-2=0.102 3-4=0.053 1-3=0.731 2-4=0.649
3-month follow-up	4.62 (3.99; 5.21) *	4.10 (3.66; 4.58) *	3.54 (3.06; 4.11)	3.00 (2.73; 3.15)	1-2=0.069 3-4=0.067 1-3<0.0004 2-4<0.000001
One-year follow-up	4.67 (4.21; 5.34) *	4.23 (3.78; 4.62) *	3.45 (3.00; 4.12)	2.93 (2.61; 3.13)	1-2=0.149 3-4=0.064 1-3<0.00009 2-4<0.000000

Notes. * - a significant difference in the values at a 3-month and one-year follow-up after implantation compared to the value before implantation within the same observation group, p<0.05.

Having analyzed the follow-up indicators of the KM width in the area of one-stage dental implantation by type of tooth (after 3 months and after a year) (Table 5), it was found that in the main observation group, there was a significant increase in the KM width in the area of all teeth. Thus, the index of the KM width relative to the index before implantation in the CI area increased by 0.96 mm ($p<0.02$) after 3 months and by 1.12 mm ($p<0.003$) after a year; in the LI area by 1.12 mm ($p<0.0009$)

and 0.97 mm ($p<0.0002$), respectively; in the area of CC by 0.8 mm ($p<0.009$) and 0.92 mm ($p<0.008$), respectively; in the area of 1PM by 1.21 mm ($p<0.0009$) and 1.15 mm ($p<0.0003$), respectively; in the 2PM area by 1.01 mm ($p<0.004$) and 1.05 mm ($p<0.001$), respectively; in the 1M area by 0.53 mm ($p<0.00005$) and 0.68 mm ($p<0.0007$), respectively. No significant difference was found between the values 3 months after implantation and one year later between all teeth.

Table 5. The follow-up KM width in the area of one-stage dental implantation by tooth type in the main observation group (n=25), Me (Q25; Q75), mm

Tooth type	Number of implants	Before implantation	3-month follow-up	One-year follow-up	p
		1	2	3	
CI	5	3.99 (3.99; 4.67)	4.95 (4.38; 5.64)	5.11 (4.93; 5.57)	1-2<0.02 1-3<0.003 2-3=0.244
LI	6	3.70 (3.14; 4.38)	4.79 (4.01; 5.31)	4.67 (4.27; 5.41)	1-2<0.0009 1-3<0.0002 2-3=0.295
CC	3	3.72 (3.12; 4.22)	4.52 (3.97; 5.11)	4.64 (4.16; 4.98)	1-2<0.009 1-3<0.008 2-3=0.446
1PM	5	2.64 (2.28; 2.87)	3.85 (3.62; 3.88)	3.79 (3.66; 3.84)	1-2<0.0009 1-3<0.0003 2-3=0.204
2PM	6	3.21 (2.87; 3.79)	4.22 (3.94; 4.72)	4.26 (3.94; 4.68)	1-2<0.004 1-3<0.001 2-3=0.699
1M	10	4.17 (3.87; 4.72)	4.75 (4.33; 5.21)	4.85 (4.46; 5.28)	1-2<0.00005 1-3<0.0007 2-3=0.502
Total	35	3.64 (2.94; 4.38)	4.51 (3.94; 5.16)	4.58 (3.94; 5.11)	1-2<0.00001 1-3<0.00001 2-3=0.135

It was also found that before implantation in patients of the main observation group, the smallest KM width was in the area of 1PM, which amounted to 2.64 (2.28; 2.87) mm and was significantly less compared with these indicators in the CI region by 1.35 mm ($p<0.02$), in the LI region by 1.06 mm ($p<0.03$), in the CC region by 1.08 mm ($p<0.01$), in the 2PM region by 0.57 mm ($p<0.01$) and in the 1M region by 1.53 mm ($p<0.0002$). Even though the KM index width in the area of absolutely all teeth after implantation significantly increased, it remained

significantly smaller in the area of 1PM compared to the same index: in the CI area by 1.1 mm after 3 months ($3p<0.02$) and by 1.32 mm after a year ($p<0.006$); in the LI area by 0.88 mm after a year ($p<0.03$); in the CC area by 0.85 mm after a year ($p<0.03$); in the 1M area by 0.9 mm after 3 months ($p<0.02$) and by 1.06 mm after a year ($p<0.03$) mm.

In the comparison group, the follow-up of the KM width indicators in the area of one-stage dental implantation by tooth type showed a completely

different picture (Table 6). Thus, in the CI area, no significant change in the KM width was found during the follow-up, but there was a tendency to reduce its width relative to the pre-implantation value by 0.16 mm after 3 months and by 0.2 mm after a year. In the areas of LI, CC and 2PM, a year after implantation, a significant decrease in the KM width was determined by 0.17 mm ($p<0.001$), 0.16 mm ($p<0.04$) and 0.29 mm ($p<0.001$). In the 1PM area, the KM width

decreased by 0.12 mm, and a significant difference was determined between the indicators after 3 months and a year by 0.1 mm ($p<0.01$). In the 1M area, a significant difference was determined both after 3 months by 0.12 mm ($p<0.00001$) and after a year - by 0.22 mm ($p<0.00001$), while the indicator after a year significantly differed from that after 3 months by 0.1 mm ($p<0.04$).

Table 6. The follow-up KM width in the area of one-stage dental implantation by tooth type in the comparison group (n=26), Me (Q25; Q75), mm

Tooth type	Number of implants	Before implantation	3-month follow-up	One-year follow-up	p
		1	2	3	
CI	5	3.19 (2.79; 3.46)	3.03 (2.58; 3.25)	2.99 (2.51; 3.22)	1-2=0.719 1-3=0.646 2-3=0.924
LI	7	3.56 (2.89; 4.31)	3.46 (2.90; 4.22)	3.39 (2.85; 4.16)	1-2=0.252 1-3<0.001 2-3=0.078
CC	3	3.39 (2.81; 3.69)	3.33 (2.89; 3.58)	3.23 (2.72; 3.50)	1-2=0.477 1-3<0.04 2-3=0.128
1PM	5	2.76 (2.46; 3.11)	2.74 (2.38; 3.06)	2.64 (2.33; 2.97)	1-2=0.649 1-3=0.084 2-3<0.01
2PM	4	3.64 (3.59; 3.70)	3.49 (3.40; 3.58)	3.35 (3.24; 3.46)	1-2=0.165 1-3<0.003 2-3=0.167
1M	11	4.00 (3.27; 4.67)	3.88 (3.15; 4.36)	3.78 (3.11; 4.36)	1-2<0.003 1-3<0.0002 2-3<0.04
Total	35	3.53 (2.89; 4.06)	3.42 (2.90; 4.04)	3.33 (2.85; 3.84)	1-2<0.00001 1-3<0.00001 2-3=0.803

We compared the follow-up values of KM width by tooth type between the groups (Table 5, Table 6). It was found that in the area of all teeth in patients of the main observation group, a significant increase in the value was determined relative to the comparison group. Thus, the KM width in the CI area after 3 months was increased by 1.92 mm ($p<0.003$), and after a year by 2.12 mm ($p<0.001$); in the LI area by 1.33 mm ($p<0.01$) and 1.28 mm ($p<0.006$), respectively; in the CC area by 1.19 mm ($p<0.03$) and 1.41 mm ($p<0.01$), respectively; in the 1PM

region by 1.11 mm ($p<0.0009$) and 1.15 mm ($p<0.0007$), respectively; in the 2PM region by 0.73 mm ($p<0.04$) and 0.91 mm ($p<0.01$), respectively; in the 1M region by 0.87 mm ($p<0.01$) and 1.07 mm ($p<0.002$), respectively.

Similar to patients of the main observation group, the patients in the comparison group before implantation demonstrated the smallest KM width in the 1PM area, which was 2.76 (2.46; 3.11) mm and was significantly less than in the LI area by 0.8 mm ($p<0.03$), in the 2PM area by 0.88 mm ($p<0.003$) and

the 1M area by 1.24 mm ($p < 0.01$). Following up after implantation, the index of KM width in the area of all teeth decreased, in the area of 1PM it remained significantly lower compared to the same index: in the LI area by 0.72 mm in 3 months ($p < 0.004$) and by 0.75 mm in a year ($p < 0.03$); in the 2PM area by 0.75 mm ($p < 0.004$) and by 0.71 mm ($p < 0.03$), respectively; in the 1M area by 1.14 mm ($p < 0.004$) and ($p < 0.03$), respectively.

The correlation analysis revealed no dependence of the KM width on the age and gender of patients and the type of teeth and jaws.

During the year of follow-up, there were no dental implant failures in both groups, and the survival rate of implants one year after their installation was 100%.

DISCUSSION

As obvious from the presented research results in patients who used STCRBGM for one-time dental implantation, there was a significant follow-up increase in the KM width (after 3 months of implantation and after surgery). Thus, before implantation, the KM width was 3.64 (2.94; 4.38) mm, and after a 3-month follow-up it significantly increased to 0.87 mm (4.51 (3.94; 5.16) mm), and after a one-year follow-up it increased by 0.94 mm (4.58 (3.94; 5.11) mm), which was significantly larger at 1.25 mm, than in the group where only xenogeneic collagen matrix was used (3.33 (2.85; 3.84) mm). In the group with the xenogenic collagen matrix, there was a tendency to a slight decrease in the KM width to 0.11 mm after a 3-month, and to 0.2 mm after a one-year follow-up.

According to Temmerman A. et al.²³, using a connective tissue graft increases the KM width around the implants by 1.3 ± 0.9 mm, more than in the presented study. Perhaps this is related to the age of the patients, since the younger the patient, the greater the initial value of the KM. In our other study, the average age of the patients was 48.2 (44.0, 54.0) and 47.1 (39.0, 54.0) years, which was the reason for the initial smaller value of the KM width.

It was established that the KM width in the area of one-moment dental implantation in both groups, before implantation and in the follow-up, did not depend on the jaw. However, it was found that in both groups, the KM width was on average 0.5 mm

larger on the upper jaw than on the lower.

The study revealed that depending on the type of teeth, the follow-up values of KM width in the area of one-moment dental implantation in the group with the use of STCRBGM reliably increased, and a year after implantation, a reliable increase in the KM width in the area of all teeth was determined (CI by 1.12 mm, LI by 0.97 mm, CC by 0.92 mm, 1PM by 1.15 mm, 2PM by 1.05 mm, and 1M by 0.68 mm), and in the group with xenogenic collagen matrix there was a significant decrease (LI by 0.17 mm, CC by 0.16 mm, 2PM by 0.29 mm, 1PM by 0.12 mm, 1M by 0.22 mm). Simultaneously, in the group with the use of STCRBGM, compared to the group with xenogenic collagen matrix, after a one-year follow-up, the KM width in the CI region was larger by 2.12 mm, in the LI region – by 1.28 mm, in the CC region – by 1.41 mm, in the 1PM region – by 1.15 mm, in the 2PM region – by 0.91 mm, and in the 1M region – by 1.07 mm.

It was also established that before implantation in patients of both groups, the smallest KM width value was in the area of 1 PM, which was 2.64 (2.28; 2.87) mm in the group with the use of STCRBGM and 2.76 (2.46; 3.11) mm in the group with xenogenic collagen matrix.

In our study, we did not find any correlation between the KM width and the age and gender of the patients. Similar results were obtained by Nalbantoğlu A.M. & Yanık D.,¹⁵ although there are contrary data in the literature.²¹

Literature data demonstrate that soft tissue augmentation methods reliably improve the quantity and quality of soft tissue around the implant. Among augmentation procedures, connective tissue graft is associated with better changes in keratinized tissue thickness compared to xenogenic collagen matrix,^{5, 7,12,25} which is confirmed in the presented study.

Qiu X. et al. found that a xenogenic collagen matrix in combination with an apically located flap has the same clinical effectiveness in increasing the KM width as a free connective tissue graft in combination with an apically located flap but with higher shrinkage.¹⁸ Comparing the effect of different autogenous grafts on the soft tissue thickness and the KM width, Tommasato G. et al. found that it was the connective tissue graft that showed the best performance in all comparisons, increasing the KM width of the KSO,²⁴ which is confirmed in our study.

CONCLUSION

Comparing the follow-up data of the use of xenogeneic collagen matrix and STCRBGM to increase the KM width in the area of one-time dental implantation, it was established that the use of STCRBGM provided: a reliable increase in the KM width 3 months after implantation by 0.87 mm, and after a year – by 0.94 mm, which is significantly larger by 1.25 mm than in the group where only the xenogenic collagen matrix was used; a significant increase in the width of KSO after a year in the area of all teeth (CI by 1.12 mm, LI by 0.97 mm, CC by 0.92 mm, 1PM by 1.15 mm, 2PM by 1.05 mm, 1M by 0.68 mm), and in the group with xenogenic collagen matrix there was a significant reduction (LI by 0.17 mm, CC by 0.16 mm, 2PM by 0.29 mm, 1PM by 0.12 mm, 1M by 0.22 mm). Simultaneously the KM width in the area of one-moment dental implantation in both groups, before implantation and during the follow-up, did not depend on the jaw and was on average 0.5 mm larger on the upper jaw than on the lower jaw. Before implantation in patients of both groups, the smallest KM width value was in the area of 1PM. The KM width does not depend on the age and gender of patients, as well as on the type of teeth and jaws. During a one-year follow-up period, there was no dental implant failure in both groups,

and the survival rate of the implants one year after their installation was 100%.

Thus, the effectiveness of one-stage dental implantation is facilitated by the adequate KM width, ensured by STCRBGM.

DECLARATIONS

Conflicts of interest and financial disclosures

The author declares that he has no conflict percent and there was no external source of funding for the research in question.

Ethical approval

The study was approved by the Institutional Ethics Committee and was conducted in accordance with the Declaration of the World Medical Association.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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