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The Impact of Thread Length on Implant Stability - A Randomized Clinical Trial

Vanessa Rocha Rodrigues[1], Monica Amorim[2], Francisco Brandao de Brito[1], Susana Noronha[1], Helena Rebelo[1], Paulo Mascarenhas[1]

[1]Department of Periodontology, Faculty of Dental Medicine, University of Lisbon, Lisbon, Portugal

[2]Department of Orthodontic, Faculty of Dental Medicine, University of Lisbon, Lisbon, Portugal

Email address:

Vanessa_15_rodrigues@hotmail.com (V. R. Rodrigues)

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Abstract: Aim | Some studies show that different types of threads in tapered implants result in differences in primary stability. The aim of this study is to perform a prospective, controlled, randomized clinical trial comparing primary and secondary stability between long and standard thread implants for the treatment of partial edentulous patients. Methods | The study sample consists of 23 maxillary partial edentulous patients, in whom 32 implants were placed, with threads of 0.7 mm or 0.3 mm in the premolar and molar location. The comparison, in terms of the implant primary and secondary stability, was made by measuring the ISQ value (implant stability quotient), in four locations (buccal, palatal, mesial and distal). Statistical analysis was performed using the independent T-Test and the Mann-Whitney U test. Results | On the day of the implant placement, the 0.7mm thread implants presented greater primary stability in buccal, palatal, mesial and distal compared to implants with 0.3mm threads. The difference was statistically significant. After 3 months, there were no differences between both groups (secondary stability). Conclusion | Despite the limitations of the study, it is possible to verify that the implants with longer threads exhibit greater primary stability on the day of placement.

Keywords: Implant Stability, Thread, Length

1. Introduction

One of the basic factors in successful osteointegration, is the primary stability at the time of implant placement. Implant stability is an indirect indication of osteointegration and plays an essential role in long-term success of dental implants [1].

Implant stability can be categorized into two phases, primary stability, which is achieved during implant placement, and secondary stability, which is achieved after healing [2].

After placing an implant, primary stability, a mechanical phenomenon, is gradually replaced by secondary stability through the remodeling and regeneration of the surrounding bone through a process that involves new bone formation. The transition from primary to secondary stability is provided by the newly formed bone as osteointegration occurs [1].

Some studies suggest that primary stability decreases between weeks 2 to 8 after implant placement [1].

Other studies reported a severe loss of primary stability at week 3 to 4 [3].

The variety of these results may be related to variations in Implant designs [3].

When comparing the various methods for assessing implant stability, insertion torque and resonance frequency analysis are the most used ones [2].

Regarding the influence of implant macrogeometry on stability, implant threads can play a fundamental role. These threads aim to maximize the favorable distribution of forces and minimize stress forces at the bone-implant interface, as well as increase their contact surface [4].

Therefore, the identification of factors that can affect the implant primary and secondary stability is essential since it will clinicians to choose a particular type of implant that can reduce or eliminate the decrease in stability, allowing a greater number of cases for immediate or early loads.

This investigation consists in comparing primary stability in implants with long threads and standard threads, all of them from the same brand in the treatment of partial edentulous patients.

2. Materials and Methods

2.1. Sample Size and Study Design

A prospective, controlled and randomized clinical study was carried out at the Department of Periodontology, Faculty of Dental Medicine, University of Lisbon. The study sample size consisted of 23 patients with a total of 32 implants (16 MegaGen AnyRidge® (AR) and 16 MegaGen AnyOne® (AO). The measurement of primary stability was performed at the time of implant placement and the secondary stability 3 months after. The comparison was made of placement and secondary stability after 3 months was performed and a comparison was made between implants with long threads (0.7mm) and standard threads (0.3mm), all of the same brand. The implants were placed in partial edentulous in the upper premolar and molar area.

The study started after approval by the Ethics Committee of the Faculty of Dental Medicine of the University of Lisbon CE-FMDUL 19/4/2018 and is registered in ClinicalTrials.gov with the number NCT05141851. The reporting of this clinical trial was followed by the Consolidated Standards of Reporting (CONSORT) guidelines. Patients were recruited in Periodontology Specialization consultations, from the same institution.

2.2. Inclusion Criteria

1) Age equal to or greater than 18 years;
2) No systemic conditions that contraindicate Oral surgeries;
3) Periodontal health or controlled periodontal disease integrated into a periodontal support program and presenting a high level of plaque control (Plaque índex less than 30%- Ainamo and Bay 1975);
4) Partial edentulism in the upper jaw, specifically in the premolar and molar location.

2.3. Exclusion Criteria

1) Insufficient bone availability for implant placement without concomitant bone regeneration procedures;
2) Patients who were subjected to medication that could affect stability and osteointegration up to 3 months before the start of the study (cyclosporine and glucocorticoids);
3) Patients with untreated periodontal pathology or who are not following periodontal support treatment;
4) Smoking patients;
5) Pregnant or lactating.

2.4. Implant Design

The implants tested in this study were MegaGen AnyOne® and MegaGen AnyRidge® (MegaGen Implant Co., Ltd, Seoul, South Korea). Both implants are currently available in the market.

Both implants, AnyRidge® and AnyOne®, have a progressive threads system with a Knife Thread® design. According to the manufacturer, less insertion torque is required, implants have excellent primary stability, greater resistance to compressive strength, the shear forces generated are minimal and these implants have a high bone / implant contact (BIC).

Both implants are manufactured with the same material (commercially pure grade 4 titanium, standard ASTM F67-06) and have an RBM type surface treatment (Acid etched sandblasted surface (large grains).

Therefore, the only difference between the two implants is the length of the threads, which in AnyOne® implants is 0.3mm and in AnyRidge® implants is 0.7mm.

2.5. Preoperative Evaluation and Surgical Procedure

All patients who met the inclusion criteria underwent an initial evaluation. On the same day, the patient were sequentially allocated to the control group (AO) or test group (AR). In the initial evaluation, the following clinical parameters were observed:

Total plaque index (PI), expressed as a percentage, recorded by the presence / absence of bacterial plaque along the gingival margin, after the periodontal probe has been insinuated through the gingival sulcus, in four locations per tooth (mesial, distal, buccal and palatal);

Radiographic analysis through orthopantomography, periapical intraoral radiographs according to the parallelometric technique (using a silicone bite record so that the radiographs are parallelized and comparable to each other in different timepoints) and if necessary computed tomography (CT/ CBCT) of the upper jaw, in order to assess bone availability for implant placement. All participants read and signed the informed consent.

In the second appointment the surgical procedure for implant placement was performed. Surgical procedures were performed in the operating room of the Faculty of Dental Medicine of the University of Lisbon, by periodontology graduate students, between July 2019 and March 2020. The surgical protocol used in all participants was performed according to the manufacturer´s instructions.

In all implants, the evaluation of immediate post-surgical primary stability was performed, using the Mega ISQ®, the insertion torque as recorded (greater or lower than 35N) and a parallelized radiography was performed.

2.6. Study Variables

Immediately after implant placement, insertion torque was measured, and primary stability was assessed through resonance frequency analysis using the Mega ISQ®

To obtain the ISQ value, the SmartPeg was fitted in the implant and the ISQ® device was placed perpendicular to the Mega ISQ® and then four ISQ values were recorded (buccal, palatal, mesial and distal) and the average value was calculated.

Each result of the resonance frequency analysis was then framed on a quantitative scale and interpreted as follows, implant stability ratio <60, corresponds to low implant stability and the implant was at risk. An implant stability ratio between 60 and 65 corresponds to a implant stability. Values between 65 and 70, identified a medium high stability and lastly, values above 70, correspond to a high stability [5, 6].

2.7. Statistical Analysis

The data obtained were statistically analyzed using the SPSS program, to assess the differences between primary and secondary stability in the four locations (buccal, palatal, mesial and distal) in both groups.

The mean, median, minimum and maximum ISQ values were also evaluated. The statistical tests used were the T-independent test and the Mann-Whitney U test.

3. Results

The sample size consisted of 32 implants placed in 23 patients, however, one of the implants in the control group, two weeks after its placement, did not osseointegrate and had to be explanted. In the test group, one of the patients, dropped-out of the study. In total, 3 men and 12 women were included. The percentage of female patients (78%) was higher than the one of male patients (22%). The percentage of the plaque index assessed during the first appointment, in both groups (test and control) was 20.83%. The test group had a plaque index of 22.8% while the control group had a percentage of 19.58%, with no statistically significant differences between groups (Chart 1 and 2, attached).

It was possible to conclude that the implants with 0.7mm threads showed greater primary stability in the buccal, palatal, mesial and distal when compared to the 0.3mm thread implants., with a statistically significant difference (Chart 5, attached). However, after 3 months, there were no differences between the two groups, in the four locations (buccal, palatal, mesial and distal) (Chart 6, attached).

It was also evaluated the possible influence of the location and length of the placed implants, on primary and secondary stability.

The location of the implants, in the posterior area of the maxilla, varied from premolars and molars. In the control group, 9 implants were placed premolar location and 3 implants in the molar area, whilst in the test group, 8 implants were placed in the premolar area and 5 in the molar area (Chart 5 and 6, attached). In total, 17 implants were placed in the premolar area (68%) and 8 implants in the molar area (32%). In chart 2, it is possible to observe primary and secondary stability in the implants placed in the premolar area in both groups. Implants with longer threads (0.7mm), presented greater primary and secondary stability when compared to implants with standard threads (0.3mm) (p = 0.093 and 0.815, respectively).

Chart 3 evaluates the primary and secondary stability, in the implants placed in the molar location in both groups. It is possible to observe that the implants with longer threads (0.7mm), presented greater primary stability, when compared to implants with standard threads (0.3mm), with statistically significant differences ($p = 0.036$). However, when secondary stability is assessed, there is no statistically significant difference ($p = 0.143$).

Within the limitations of this study, it is possible to conclude that, regardless of the location of implant placement (premolars or molars), implants with longer threads, present greater primary stability.

It was also assessed whether the length of the placed implants (8.5mm; 10mm and 11.5mm), influenced primary and secondary stability (Chart 3 and 4, attached).

Nine implants, 8.5mm long, were placed, 5 in the control group and 4 in the test group (36%). Regarding 10mm length implants, a total of, a total of 8 implants (32%) were placed, 4 in each group. The 11.5mm long implants were placed 3 in the control group and 5 in the test group (32%).

When we evaluated the primary stability in implants with different lengths of threads (0.7mm versus 0.3mm), but with the same implant length (8.5mm), primary and delayed stability was higher in the test group. However, there were no statistically significant differences between boths groups (p = 0.286 and 1,000, respectively).

Similar to what happened with the 8.5mm length implants, implants with a length of 11.5 mm showed greater primary and secondary stability in the test group than in the control group. However, no statistically significant differences were observed between the two groups (p = 0.393 and 1,000, respectively).

With what concern to the 10mm length implants, it was showed a statistically significant difference in the primary stability, showed a statistically significant difference on the day of implant placement ($p = 0.029$). However, after 3 months there were no statistically significant differences ($p = 0.200$).

Therefore, considering the different results obtained, it was not possible to conclude that the length of the implants (8.5mm to 11.5mm) influenced the primary stability in implants with the two lengths of the studied threads. (Chart 4 to 6).

All implants were placed with an insertion torque of 35N, except for two, which were placed with a torque of 40N.

The variables of the present study were considered independent, in which the Mann-Whitney U test was used to compare the implant stability in the variables, location and length of the implants. And the T-independent test was used to assess the influence of the length of the threads on implant stability.

4. Discussion

The implant primary stability depends mainly on bone-implant contact. It is assumed that bone quality, surgical technique, and the length and diameter of the implant, can influence bone-implant contact and, consequently, the primary stability of the implant [7].

There are numerous factors that can potentially influence the extent and duration of bone remodeling in the postoperative period, many of which have not been adequately studied. One possible factor is the length of the implant threads.

Therefore, the identification of factors that can affect the primary and secondary stability of the implants is essential. It will allow clinicians to choose an implant, which reduces or eliminates the decreased implant stability during the initial period of bone remodeling, thus allowing a greater number of cases to be candidates for immediate or early loads.

Thus, some studies show that different types of threads in conical implants result in differences in primary stability [8]. The distribution of tensile forces in titanium implants with different lengths of threads has been analyzed and an improvement in the distribution of forces has been observed with the increase of the lengths of the implant threads [9]. Regarding the thread's length and width, the length makes a greater contribution to the distribution of forces in the alveolar bone [7]. Titanium implants with a longer spiral depth have a larger surface area, which is an advantage, low bone quality locations increasing primary stability [10].

The macroanatomy of the implants corresponds to their three-dimensional structure and includes the shape, characteristics of the neck and geometry of the threads. It plays an important role in primary stability, since it can influence the mechanical interconnection between the implant and the surrounding bone [4, 11].

Implant threads goals are to maximize the favorable distribution of forces and and minimize stress forces at the bone-implant interface, as well as helping with the implant stability and increasing its contact surface. They may vary in design, shape, angle, distance and depth. These differences confer different behaviors during the osseointegration process [4, 12-14].

McCullough, J. Klokkevold, carried out a prospective, randomized, controlled study [15] with the goal of evaluating the role of spiral design in implant stability, at the implant placement day and 3 months after healing, through the analysis of resonance frequency. The thread design appears to have a role in the stability of the implant in the postoperative period, during healing.

In the present study, there are limitations related to the number of patients included, implants placed and the operator's experience. Furthermore, as mentioned above, implants with different lengths were included, which may have influenced the value of primary and secondary stability.

Although implants were placed only in the posterior area of the maxilla, the placement of implants varied from the region of the premolars to the molars.

The assessment of primary and secondary implant stability was always carried out by the same operator. Smokers or patients with illnesses were not included.

Systemic patients or taking medication that may affect implant stability and only subjects with a plaque index of less than 30% were included.

The results of these studies are in line with the results achieved in the present research work. Implants with longer threads (0.7mm) showed greater primary stability when compared to implants with smaller threads (0.3mm), with a statistically significant difference.

5. Conclusion

Taking into account the limitations of the study, it is possible to state that implants with longer threads have greater primary stability.

It is possible to conclude that, regardless of the place where the implants are placed (premolars or molars), implants with longer threads have greater stability on the day of their surgical placement. Which may indicate that implants with longer threads are useful, especially in locations with low bone and for immediate function protocols.

Regarding the different lengths of the implants, it is not possible to conclude that the length of the implants has influenced primary stability.

The authors do not face conflicts of interest in relation to the present study.

Author Contributions

VRR, HR and SN - Have made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data.

VRR, PM and FBB - Been involved in drafting the manuscript or revising it critically for important intellectual content.

PM - Given final approval of the version to be published. Each author should have participated sufficiently in the work to take public responsibility for appropriate portions of the content.

VRR, HR SN and PM- Agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

MA responsible for statistical analysis.

The study is registered in ClinicalTrials.gov with the number NCT05141851 and have be approved by the Ethics Committee of the Faculty of Dental Medicine of the University of Lisbon CE-FMDUL 19/4/2018.

Conflicts of Interest

The authors do not face conflicts of interest in relation to the present study.

All participants read and signed the informed consent.

Acknowledgements

MegaGen® Portugal.

Appendix

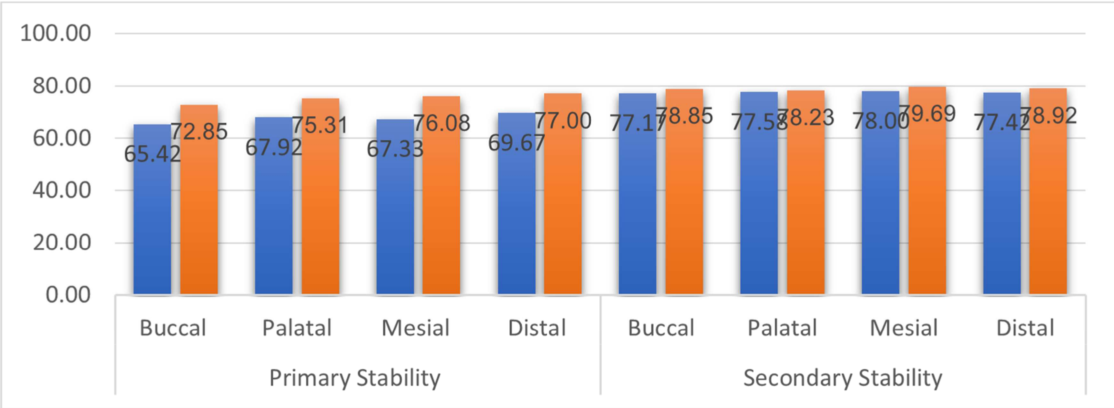

Figure 1. *Primary and Secondary stability in both groups.*

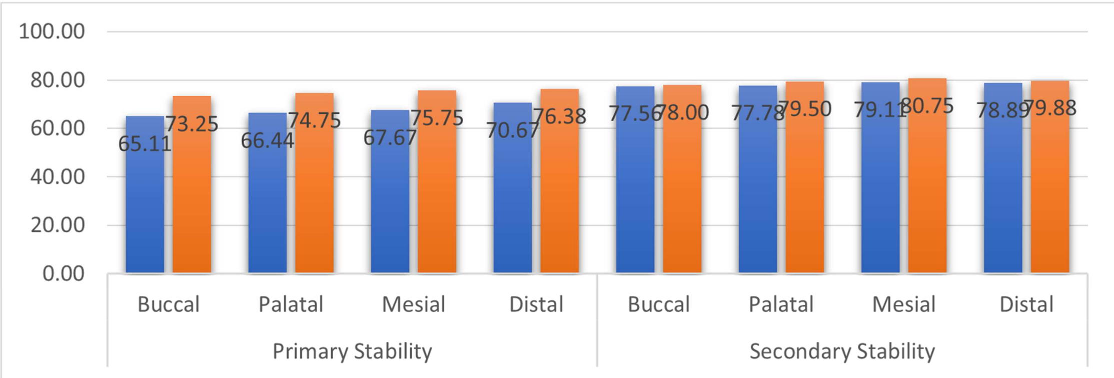

Figure 2. *Primary and Secondary Stability, in the same location (premolars) in both groups.*

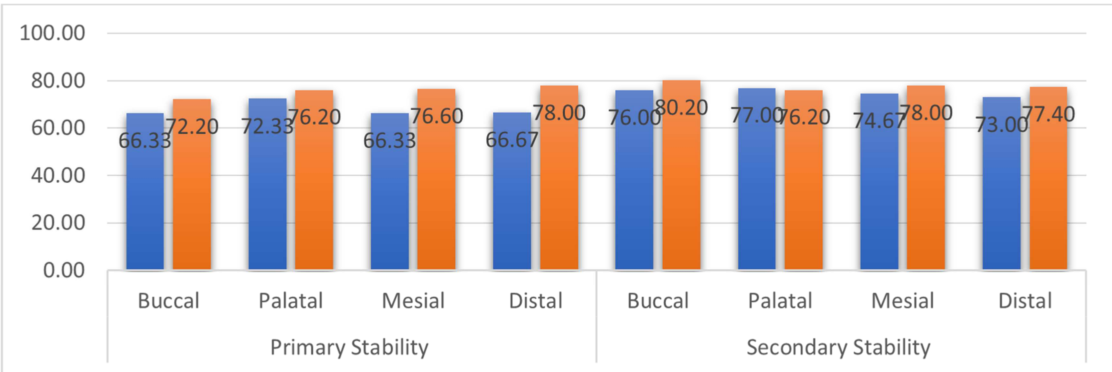

Figure 3. *Primary and Secondary Stability, in the same location (molars) in both groups.*

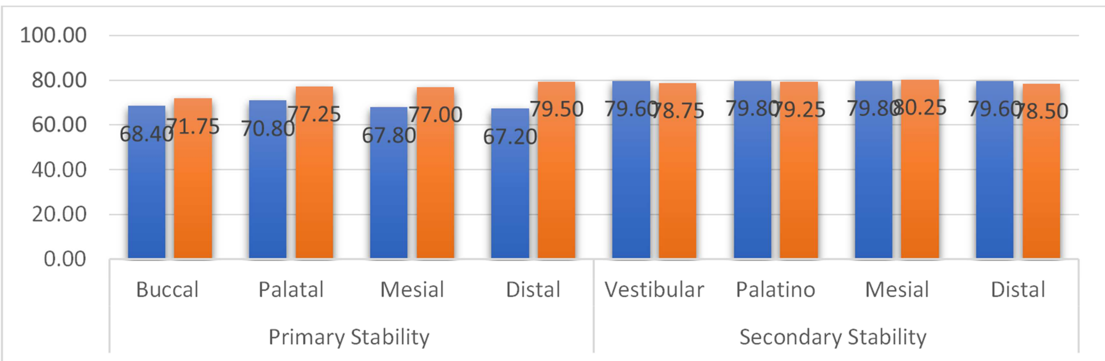

Figure 4. *Primary and Secondary stability, in implants of the same length (8.5mm) in both groups.*

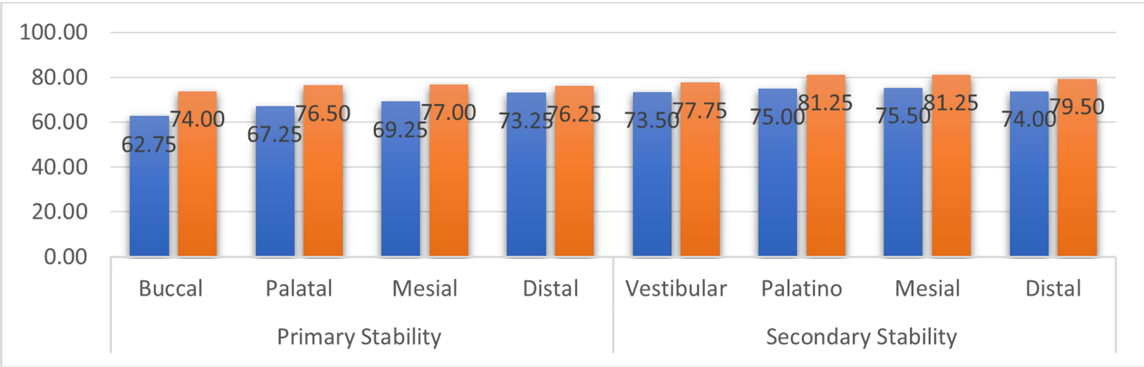

Figure 5. *Primary and Secondary stability, in implants of the same length (10mm) in both groups.*

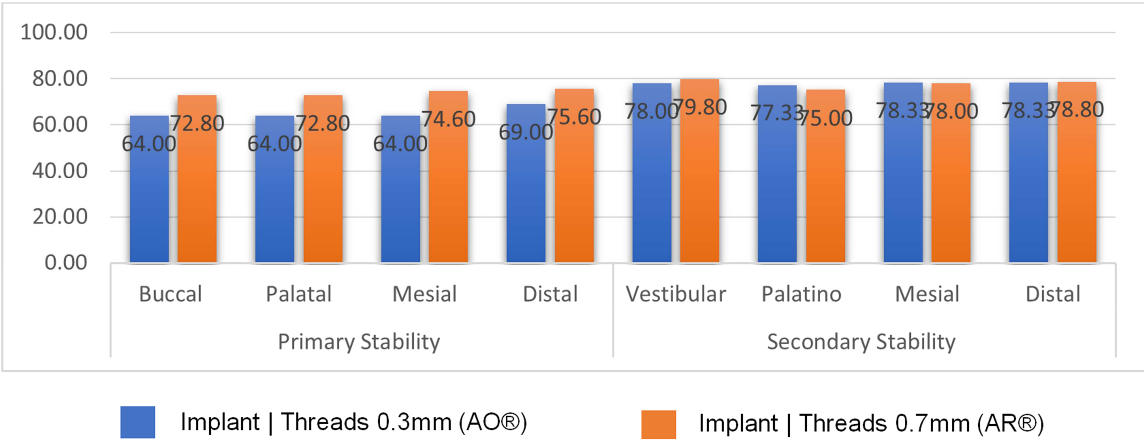

Figure 6. *Primary and Secondary stability, in implants of the same length (11.5mm) in both groups.*

Table 1. *Plaque Index Controlo Group.*

Patient	A	C	D	F	G1	I	L	M1	O	P1	P3	R	S	V	Y	X
PI (CG)	17%	21%	27%	23%	17,5%	17,9%	20,9%	23,9%	16%	19,6%	19,6%	24%	18%	21,5%	23,8%	25%

Table 2. *Plaque Index Test Group.*

Patient	B	C1	E	G	H	J	M	N	P	P2	Q	R1	T	U	W	Z
PI (TG)	10%	21%	26,5%	17,5%	25,4%	20,9%	23,9%	25,3%	19,6%	19,6%	25,7%	24%	28,5%	27%	20,9%	21,5%

Table 3. *Length of the implants Control Group.*

Patient	Length of the implants (mm)
A	8,5
C	10
D	11,5
F	11,5
G_1	8,5
I	11,5
L	8,5
M_1	10
O	11,5*
P_1	10
P3	10
R	8,5
S	8,5
V	11,5
Y	8.5
X	10

Table 4. *Length of the implants Test Group.*

Patient	Length of the implants (mm)
B	10
C_1	11,5
E	11,5
G	10
H	11,5
J	8,5
M	11,5
N	11,5
P	8,5
P_2	8,5
Q	10
R1	8,5
T	10
U	10
W	8,5
Z	8,5*

Table 5. *Analysis of resonance frequency in primary and secondary stability in the control group.*

Patient	Primary Stability (ISQ)				Secondary Stability (ISQ)				Local
	Buccal	Palatal	Mesial	Distal	Buccal	Palatal	Mesial	Distal	
A	62	61	65	62	85	84	84	84	PM
C	66	66	74	66	79	80	80	79	PM
D	56	56	56	55	77	75	75	75	PM
F	60	60	60	76	70	70	73	73	PM
G_1	71	71	53	53	75	75	75	75	M
I	76	76	76	76	87	87	87	87	PM
L	58	61	61	61	73	74	74	73	PM
M_1	70	70	71	71	80	77	71	69	M
O	70	70	57	70	-	-	-	-	PM
P_1	57	57	57	80	62	64	73	73	PM
P_3	58	76	75	76	73	79	78	75	M
R	81	81	80	80	84	85	84	84	PM
S	70	80	80	80	81	81	82	82	PM
V	83	84	84	85	84	84	84	84	PM
Y	74	74	83	83	83	81	85	85	PM
X	65	70	69	70	85	87	87	88	M
Mean	65,42	67,92	67,33	69,67	77,17	77,58	78,0	77,42	

Table 6. *Analysis of resonance frequency in primary and secondary stability in the test group.*

Patient	Primary Stability (ISQ)				Secondary Stability (ISQ)				Local
	Buccal	Palatal	Mesial	Distal	Buccal	Palatal	Mesial	Distal	
B	70	73	71	71	67	73	73	67	PM
C_1	71	70	75	70	82	81	85	85	PM
E	75	75	75	75	82	81	81	81	PM
G	73	73	75	75	81	82	81	82	PM
H	69	69	69	82	67	67	73	73	PM
J	74	75	74	74	78	73	78	73	M
M	75	75	79	76	79	78	80	80	M
N	74	75	75	75	89	68	71	75	M
P	80	80	80	89	82	83	83	84	M
P_2	58	76	75	76	73	79	78	75	M
Q	78	80	83	80	80	85	85	84	PM
R_1	75	78	79	79	82	82	82	82	PM
T	75	80	79	79	83	85	86	85	PM
U	76	75	78	84	80	80	82	84	PM
W	74	74	73	73	82	82	84	82	M
Z*	74	73	78	70	-	-	-	-	M
Mean	72,85	75,31	76,08	77,00	78,85	78,23	79,69	78,92	

Table 7. *Statistical analysis of primary stability.*

		Primary Stability			
		Threads 0,3 mm n= 16 (50%)	Threads 0,7mm n=16 (50%)	Difference	*p*
		$\bar{x}(s)$	$\bar{x}(s)$	$\bar{x}(s)$	
General		69.3 (8.12)	75.28 (3.29)	-5.98 (2.19)	0.013
Local	PM, n=21 (65,6%)	69.71 (9.18)	75.39 (3.35)	-5.68 (2.88)	0.219[a]
	M, n=11 (34,4%)	68.06 (4.21)	75.14 (3.48)	-7.08 (2.34)	0.006[a]
Length of the implant	8,5mm, n=12 (37,5%)	70.21 (9.53)	75.46 (3.93)	-5.25 (4.21)	0.589[a]
	10mm, n=10 (31,3%)	68.2 (3.33)	76.4 (3.67)	-8.2 (2.22)	0.008[a]
	11,5mm, n=10 (31,3%)	69.3 (10.95)	73.95 (2)	-4.65 (4.98)	0.548[a]

Table 8. *Statistical analysis of secondary stability.*

		Secondary Stability			
		Threads 0,3 mm n= 15 (50%)	Threads 0,7mm n=15 (50%)	Difference	*p*
		$\bar{x}(s)$	$\bar{x}(s)$	$\bar{x}(s)$	
General		77,54 (5,77)	78,92 (5,00)	-1,38 (2,15)	0,528
Local	PM, n=20 (66%)	78,33 (6,53)	79,53 (5,99)	-1,20 (3,05)	0,815[a]
	M, n=10 (33%)	75,17 (1,01)	77,95 (3,2)	-2,78 (1,95)	0,143[a]
Length of the implant	8,5mm, n=11 (36,6%)	79,70 (5,13)	79,19 (3,86)	0,51 (3,10)	1,000[a]
	10mm, n=10 (33.3%)	74,50 (4,84)	79,94 (6,76)	5,44 (4,16)	0,200[a]
	11,5mm, n=9 (30%)	78,00 (8,05)	77,90 (5,21)	0,10 (4,60)	1,000[a]

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