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PRIMARY STABILITY IN THE POSTERIOR MAXILLA ON AN IMPLANT WITH A NEW MACROGEOMETRY: TORQUE VS. RESONANCE FREQUENCY ANALYSIS – AN IN VIVO STUDY

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ABSTRACT

Implants with decompression chambers can acquire secondary stability more effectively, despite their lower primary stability assessed with insertion torque. The low compression of the bone tissue around the implant tends to favor bone healing and regeneration in the region. The aim of this study was to evaluate the difference between the primary stability measurements of implants with decompression threads installed in the maxilla and whether the length of the implants can influence the stability results. **Methods:** implants installed in the maxilla were evaluated (Maestro implants, Implacil de Bortoli - São Paulo, SP, Brazil), allocated into two groups according to their length (Group 1, implants shorter than 10 mm and Group 2, implants longer than 10 mm). Primary stability was assessed by Resonance Frequency Analysis (RFA) by the Implant Stability Quotient (ISQ) and the insertion torque value of each implant. **Results:** 26 implants were inserted in 9 patients. When evaluated by insertion torque, group 1 had an average value of 23.99 Ncm, while group 2 had an average value of 32.91 Ncm, with a significant difference between the groups (p=0.012). In the evaluation by Resonance Frequency Analysis, an average value of 58.78 ISQ was observed in group 1 and 61.81 ISQ in group 2, with no statistically significant difference (p=0.06). **Conclusion:** the length of Maestro implants influences the mechanical stability measured in torque of implants installed in the posterior region of the maxilla.

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INTRODUCTION

Primary stability of implants is essential for achieving osseointegration (Lioubavina-Hack, 200). Several factors influence primary stability, such as bone quality, implant macro and microgeometry, and surgical technique (Lioubavina-Hack, 2006; Li, 2017; Stanford, 2016; Manfro, 2021; Albrektsson, 1993; Buser, 2004; Dos Santos, 2011; Körmöczi, 2021 and Monje, 2019). With regard to bone quality, we can report greater primary stability in mandibular bone than in maxillary bone, due to the fact that the mandible is a more compact and less spongy bone, giving a higher insertion torque of the implant in relation to the maxillary bone (Stanford, 2016). On the subject of surgical technique, under-instrumented implants tend to have a higher insertion torque than implants of the same diameter instrumented with a longer sequence of cutters (Cohen *et al*., 2016 and De Carvalho Formiga, 2021). The thread design, as more aggressive threads end up providing greater primary stability, as well as the evolution of the surface treatment of implants has been giving an optimal micro-roughness to not only adhere osteoblasts on the implant surface but also increase the area of bone-implant contact with its roughness, thus providing a better primary stability that optimizes the clinical use of even shorter implants (Tolentino da Rosa de Souza *et al*., 2018). Two methods are most often used to measure the primary stability of implants. The first is through the torque obtained by the motor or by a graduated mechanical torque meter when inserting the implant into the bone. The second is through a Resonance Frequency Analysis (RFA) by the Implant Stability Quotient (ISQ) (Monje, 2019; Barewal *et al*., 2003; Balleri, 2002; Jeong, 2015; Kim, 2015; Rabel, 2007 and Chan, 2010). Osstell (Integration Diagnostics AB, Göteborg, Sweden) measures, by magnetic pulses, the rigidity of the connection between the lateral walls of the implant and the surrounding bone, giving a higher value the more stable it is at the time of evaluation [(7)]. Therefore, RFA is the most used test to assess the overall mechanical stability of the implant (Huang *et al*., 2020). The implant used in this study has a conical shape with decompression chambers to increase the implant and bone contact area, reducing bone compression during implant insertion without loss of primary stability (Gehrke *et al*., 2019 and Gehrke, 2020). An animal study with this implant system showed favorable bone accumulation in the decompression chambers and decreased implant insertion torque without loss of primary stability (Gehrke, 2019). *In vitro*, this implant showed low primary stability when evaluated by mechanical torque, but showed higher values in the Implant Stability Quotient (ISQ). Despite relatively low primary stability, it demonstrated faster secondary stability than implants with conventional macrogeometry (Gehrke, 2019). The aim of this study was to evaluate the difference between measurements of primary stability of implants containing decompression threads installed in the maxilla and whether the length of the implants can influence the stability results.

MATERIALS AND METHODS

Study design: This study is a controlled clinical trial with 09 patients who needed one or more implants in the posterior region of the maxilla and who underwent implant placement with the new macrogeometry containing decompression threads (Maestro implants, Implacil de Bortoli - São Paulo, SP, Brazil) with implants less than 10 mm long (group 1) and implants longer than 10 mm (group 2). The study followed the research guidelines and was submitted to the Research Ethics Committee and approved under number 5.291.753 (PUC/PR). The patients were verbally informed about all the stages of the study, as well as its outcomes, by accepting the Informed Consent Form (ICF) of this research.

Sample Selection : Nine patients were recruited by means of a cone beam computed tomography examination, with absence of dental elements in the maxilla. Patients who m*et al*l eligibility criteria were included in the sample of this research.

The following inclusion criteria were considered:

- Partially or totally edentulous patients in the maxilla requiring one or more implants in the arch;
- Having had a cone beam computed tomography exam prior to surgery;
- Provide sufficient prosthetic space for subsequent prosthetic rehabilitation.

The following exclusion criteria will be considered:

- Patients who did not accept to take part in the study;
- Need for some kind of bone reconstruction or advanced surgery to allow for implant installation;
- Patients who are heavy smokers (> 10 cigarettes/day);
- Patients with uncontrolled diabetes, considering glycated hemoglobin (HbA1c) above 7.5%;
- Immunodeficient patients;
- Use of both oral and injectable bisphosphonates;
- Radiotherapy in the head and neck region for a period of less than 5 years before the start of the research;
- Patients who have any other systemic condition that contraindicates oral surgery at this time or who have conditions that interfere with the osseointegration process.

Group Allocation : The groups were defined according to the length of the implant to be installed. This was defined by the bone availability of the implant site. All implants used were conical internal connection implants that were funded by the researchers. Each patient underwent surgery to place Maestro implants from the company Implacil de Bortoli (São Paulo, SP, Brazil). The choice of the group belonging to each patient was made according to the patient's needs. Group 01 included implants shorter than 10 mm, while group 02 included implants longer than 10 mm. The same patient could be evaluated in both groups if he or she had implants longer than 10 mm in one region, and shorter than 10 mm in another region.

Surgical protocol: The surgeries were performed by the same operator under local anesthesia of 4% Articaine with 1:100,000 adrenaline (DFL – Rio de Janeiro, RJ, Brazil) and oral sedation (Midazolan 7.5mg) or with general anesthesia when associated with the zygomatic technique in the posterior region. The patients were pre-medicated with 1 g of Cefadroxil one hour before the procedure and 8 mg of dexamethasone 2 hours before. The antibiotic was maintained for 7 days. Pain medication was given individually according to the morbidity of the treatment and the pain sensitivity of the patients. All patients were rinsed with 0.12% chlorhexidine digluconate starting one day before surgery and maintained for 7 days. A linear incision was made with a 15c scalpel blade at the bone crest. The flap detachment was performed with a Molt detacher and then the demarcation of the perforation site and milling was started as recommended by the manufacturer, with a 20:1 counter-angle mounted on an electric motor, up to an initial insertion torque of 35 Ncm. Irrigation was performed with saline solution, and the perforations were made with the corresponding 2-0 conical cutters and with the 3.0 conical cutter for the implants (figure 1). The Maestro implants (figure 2) were installed 2 mm below the crestal bone initially with the counter-angle mounted on a surgical motor and the primary stability was evaluated in two ways, through the torque that was measured by surgical mechanical torque meter when the torques were above 30 Ncm, and with the prosthetic torque meter at torques below 30 Ncm. Both torque wrenches used were from the manufacturer of the system. Once implant installation was completed, a SmartPeg type 49 sensor was installed in the implants and Resonance Frequency Testing (RFA) by Implant Stability Quotient (ISQ) was performed with an Ostell instrument. (Integration Diagnostics AB, Göteborg, Sweden). The measurement was performed according to the manufacturer's instructions on the buccal, distal, mesial and palatal surfaces and the average of these 4 measurements was considered.

Statistical Analysis: The data obtained were analyzed in statistical software (SPSS 25.0, IBM Statistics, New York, NY) to verify normality of data distribution, homogeneity of variance and significant differences between variables related to outcomes and patients. The results were evaluated and compared between the groups regarding the length of the implants using the Student's t-test with a significance level of 5%.

RESULTS

Nine patients, 2 male and 7 female, underwent placement of 26 implants in the posterior region of the maxilla according to their respective needs.

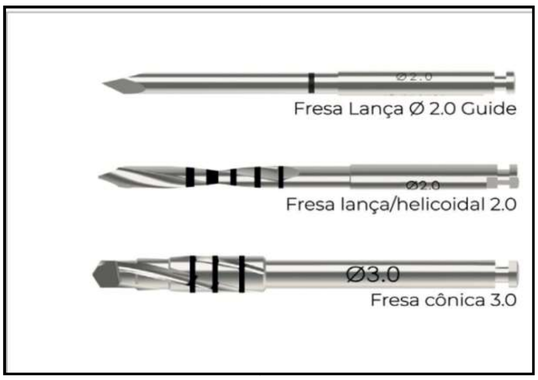

Figure 1. Cutters used for inserting the implants (Maestro, Implacil de Bortoli)

Figure 3 shows the distribution chart of implants installed according to size and number in group 1 (implants smaller than 10 mm) and

Figure 4 shows the distribution of implants installed according to size and number in group 2 (implants larger than 10mm).

Figure 2. Maestro implant, Implacil de Bortoli. Observe the shape of the decompression chambers

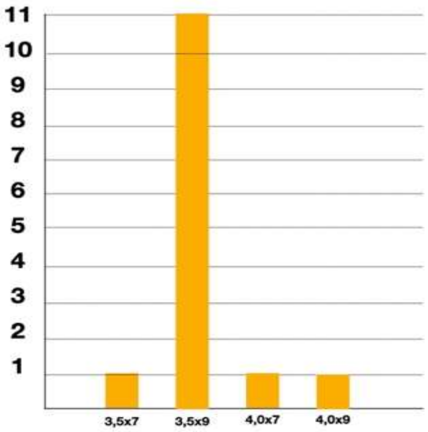

Figure 3. Distribution graph of the installed implants according to size and number in group 1

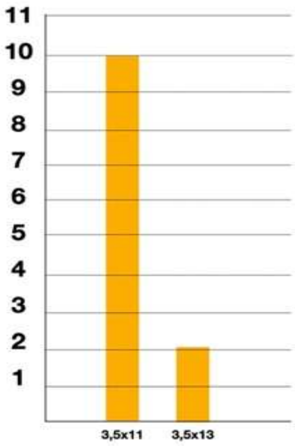

Figure 4. Distribution graph of the installed implants according to size and number in group 2

When evaluated by the insertion torque, obtained with a mechanical torque meter (Figure 5), group 1 presented an average of 23.99 Ncm, while group 2 presented an average of 32.91 Ncm. This difference was statistically significant, favorable to group 2, for implants longer than 10 mm in length (p=0.012). In the measurements of the magnetic resonance frequency by the Implant Stability Quotient (ISQ), shown in Figure 6, an average value of 58.78 ISQ was observed in group 1 and 61.81 ISQ in group 2. These values showed no significant statistical difference (p=0.06).

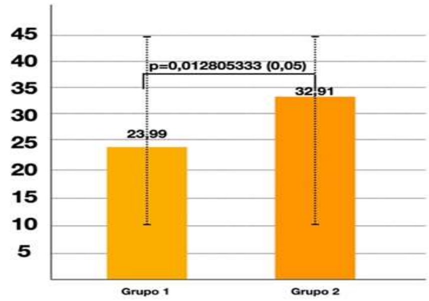

Figure 5. Graph of average insertion torque of the implants in each evaluated group

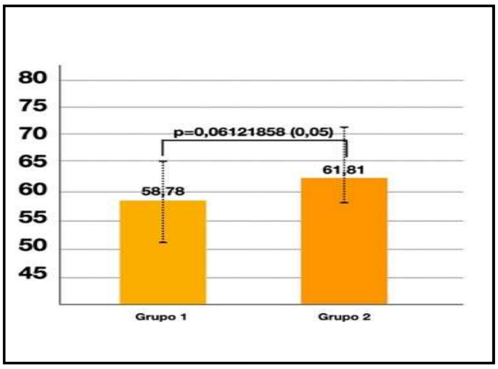

Figure 6. Graph of average resonance frequency by Implant Stability Quotient (ISQ) in each evaluated group

DISCUSSION

Primary (mechanical) stability is advised to successfully achieve secondary (biological) stability. For this, it is recommended to adapt the implant macro-design and drilling protocol according to the bone characteristics [9]. Implants with a less aggressive macrogeometry and with insertion in type III and IV bone, or even with insertion in immediate cases in which the implant placement is performed in the same session as the extraction, can have their primary stability increased by modifying the insertion protocol with under-milling. Studies indicate that under-milling can help improve primary stability both in cases where bone quality and availability in the site is poor, and in cases where the macrogeometry of the implant is less compressive [22,23]. Besides having this option to increase implant stability, studies also point out that an improvement in the roughness and surface treatment of the implant can lead to good secondary stability, even without high primary stability, due to less compression of the bone tissue around the implant with rapid bone formation and tissue recovery [24,25]. The magnetic Resonance Frequency Analysis (RFA) has proven useful in monitoring the dynamic transition (time course) from mechanical to biological stability [9,13-15,18]. Therefore, it is advisable to use the RFA as a reference tool in monitoring to assess short-term changes since the baseline [9,16,17]. The stability measured by the torque meter measures only the mechanical stability of the implant [9,17,26]. Despite being essential factors for osseointegration, neither measure has a direct link to long-term implant survival [9,26-30]. The length of the implants showed a statistical difference in primary stability. This fact is due to an increase in the implant surface area and may also be due to better quality bone when bi-cortical stability is used, especially in a region where there is a predominance of quality III or IV bone, which are those found in this study [1, 4, 31]. Some studies corroborate our findings, showing significantly lower primary stability values in shorter implants [32,33]. Other studies show no difference in insertion torque between different implant lengths [34,35]. However, all these studies present the relationship of ISQ of insertion with the insertion torque, and the higher the ISQ value the higher the insertion torque value [32-34]. However, the subsequent ISQ according to the evaluation times is not affected by the insertion torque, showing a successful osseointegration and primary stability. The literature shows that stability measured in insertion torque and insertion ISQ have a direct relationship [9,13-16]. In the evaluation performed in this study, the mechanical torque showed a significant difference in relation to the implant length, while the RFA did not show a significant difference in the values obtained. This fact is corroborated by tests in rabbits with the implant used here when compared to implants with normal geometry. In these studies, the mechanical torque showed a statistical difference while no difference was observed in the resonance frequency [20,21]. The values obtained in this work showed that despite a lower torque in the mechanical tests, the resonance frequency analysis guarantees that the primary stability of the Maestro implants can be sufficient for safe and early osseointegration, as well as other implants used in the clinic with the same mechanical characteristics [24-25].

CONCLUSION

Despite the limitations of the study, it is possible to conclude that the length of Maestro implants influences the mechanical stability measured in torque of implants installed in the posterior region of the maxilla. It is also possible to conclude that when the Implant Stability Quotient was evaluated by the Resonance Frequency Analysis there was no statistically significant difference.

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