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Original Article

Primary Stability of 73 Implants with Novel Macrogeometry in Edentulous Maxilla Rehabilitation Using the All-on-Four Technique

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ABSTRACT

The capacity for immediate loading hinges on primary stability, which is influenced by bone quality and sufficiency, operative technique, and implant microgeometry. Implants featuring a conical architecture with decompression chambers (Implantes Maestro Implacil de Bortoli − São Paulo, SP, Brazil), designed to enlarge the bone–implant interface and diminish insertion resistance while safeguarding primary stability, were examined. This cross-sectional clinical study sought to quantify the primary stability of 73 implants under immediate loading and relate this measure to implant width and length. 21 individuals were enrolled based on clinical criteria and cone beam computed tomography scans. Implants were seated to a final torque ceiling of 35 N cm, with the value documented at the termination of fixture placement. Statistical treatment comprised Spearman's rank correlation and the Mann–Whitney U test, both at a 5% significance threshold. Mean torque reached 51.51 N cm for implants measuring 3.5 mm in diameter and 59.50 N cm for those of 4.0 mm. This difference reached statistical significance, favoring the wider implants (P = 0.03). Variation in primary stability as a function of implant length did not attain statistical significance (P = 0.373). Broader-diameter implants are inclined to deliver enhanced primary stability; when sub-instrumented, every implant exhibited mean primary stability adequate for immediate loading.

Keywords: All-on-four technique, Immediate loading, Primary stability, Implant diameter

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Introduction

Replacing a full edentulous maxillary arch with protocol prostheses placed in immediate function is a well-substantiated therapeutic modality, providing swift functional and aesthetic restoration that appeals to both recipients and practitioners by condensing treatment duration [1, 2]. The prerequisite for immediate loading is that implants must exhibit primary stability at placement, with the prosthetic phase initiated within the following week [3]. Among surgical designs to fulfill this aim, the all-on-four configuration stands out [4-6].

Whether to proceed with immediate loading or allow a latent osseointegration window pivots chiefly on primary stability [6]. A 2017 consensus [7] proposed 35 N cm as the advisable minimal insertion torque for all-on-four immediate loading, notwithstanding evidence that torques falling below 30 N cm may not imperil therapeutic success [8]. This stability arises from an interplay among bone quality and volume [9], surgical execution [9-12], and the microgeometry of the implant [13, 14].

The implant system evaluated (Implantes Maestro Implacil de Bortoli − São Paulo, SP, Brazil) employs a tapered body furnished with decompression chambers. This macrogeometry aims to amplify the bone-to-implant contact zone, facilitate bone compaction within the chambers, and moderate insertion torque

while preserving primary stability **(Figure 1)**. Bench investigations indicated that insertion torque can fall below the recommended immediate loading threshold [15], yet sub-instrumentation strategies yielded markedly elevated values in both laboratory settings and clinical cohorts [16, 17].

Figure 1. Maestro implant (Implacil de Bortoli).

The present work aims to gauge primary stability across a consecutive series of 73 Maestro implants (Implacil de Bortoli − São Paulo, SP, Brazil) inserted into edentulous maxillae via the all-on-four protocol and subjected to immediate loading, and to link these measurements to the implants' diameter and length.

Materials and Methods

Study design

The investigation consisted of a cross-sectional clinical evaluation of 21 subjects who required complete maxillary restorations with implants.

Ethical approval of studies and informed consent

Authorization was obtained from the Ethics and Research Committee of Pontifícia Universidade Católica do Paraná (PUCPR - number 5.338.876). All participants were verbally briefed on every stage of the study and its implications, after which they signed the Informed Consent Form specific to this research.

Patient selection

Individuals needing maxillary rehabilitation supported by dental implants, utilizing protocol-type prostheses via either the conventional all-on-four configuration or the hybrid all-on-four configuration when accompanied by posterior zygomatic implants, were chosen. Selection was based on both clinical assessment and cone beam computed tomography.

Inclusion criteria:

(1) Individuals exhibiting a totally edentulous maxilla, a partially edentulous maxilla, or for whom extraction of every remaining dental element in the arch was prescribed;

(2) Individuals with adequate bone thickness and height to host dental implants, as appraised through cone beam computed tomography;

(3) Individuals willing to undergo rehabilitation with protocol-type prostheses.

Exclusion criteria:

(1) A requirement for bone reconstruction or any advanced surgical measure to enable implant insertion;

(2) Individuals who did not consent to enroll in the study;

(3) Individuals with uncontrolled diabetes, indicated by glycated hemoglobin (HbA1c) readings above 7.5%;

(4) Individuals who were heavy smokers (>10 cigarettes/day);

(5) Current or prior use of bisphosphonates, whether oral or injectable;

(6) Immunodeficient individuals;

(7) Radiotherapy delivered to the head and neck region within a period shorter than 5 years before study initiation;

(8) Individuals presenting any further systemic condition representing a present contraindication to oral surgery or interfering with the osseointegration cascade.

Surgical protocol

Surgeries were conducted under local anesthesia with 4% articaine containing 1:100,000 Adrenalin (DFL − Rio de Janeiro, RJ, Brazil) alongside oral sedation (midazolam 7.5 mg), or under general anesthesia for cases incorporating the zygomatic technique in the posterior zone. Preoperative pharmacotherapy consisted of 1 g cefadroxil administered 1 hour before the surgery and 8 mg dexamethasone given 2 hours prior; the antibiotic coverage was sustained for 7 days. Analgesics were prescribed on an individualized basis reflecting the extent of surgical morbidity and the

patient's pain tolerance. Every patient used mouth rinses containing 0.12% chlorhexidine digluconate beginning the day before surgery and continuing for a full week.

The all-on-four protocol involved placing two anterior implants in the premaxillary region based on available bone. In comparison, two posterior implants were positioned tangentially to the mesial wall of the maxillary sinus, which was pinpointed via limited sinus access and clinical identification. When posterior implant placement proved unfeasible, zygomatic implants (Conexão Sistema de Próteses − Arujá, SP, Brazil) were placed instead. Ridge regularization via osteotomy was performed as circumstances demanded. The drilling sequence followed the guidance in **Figure 2**, and the optional dental milling drills were used when implants registered a stability greater than 60 N cm with less than half of their length inserted. In these cases, the implants were removed, and optional dental milling drills were used.

	Spear Milling Cutter 2-0	Sub 3-0 Reamer	Milling cutter 4.0x7.0
Implant 3.5	YES	OPTIONAL	
Implant 4.0	YES	YES	OPTIONAL

Figure 2. Drill scheme used to install the implants.

Implant type was determined at random, whereas the specific length and diameter were dictated by the bone available. An electric motor coupled to a surgical contra-angle drove the implants to a torque of 35 N cm, after which final positioning was accomplished with a manual surgical torque wrench (Implacil de Bortoli − São Paulo, SP, Brazil); the torque was recorded once fixture insertion was finalized. All implants were seated at the bone level **(Figure 3)**.

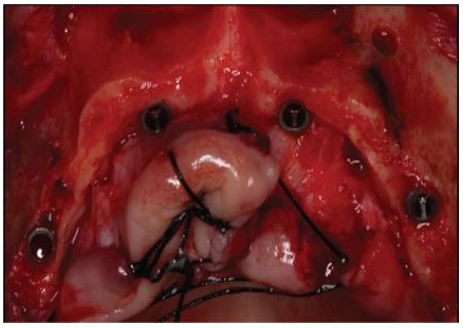

Figure 3. Implants are installed at the bone level. Outcomes were recorded in a table according to the installation sequence: 1) posterior right, 2) anterior right, 3) anterior left, and 4) posterior left.

Results and Discussion

The participant pool consisted of 21 individuals—8 male and 13 female—whose ages spanned from 36 to 75 years. A breakdown of their preoperative dental status reveals that 13 presented with a fully edentulous maxilla, 6 with residual dentition extracted during the same operative session, and 2 with previously placed, poorly positioned implants that were also removed during the procedure.

Fifteen subjects were managed via the standard all-on-four protocol, receiving four Maestro implants apiece (totaling 60 conventional fixtures). The remaining six underwent the hybrid all-on-four variant: one involved a single zygomatic implant combined with three conventional fixtures. At the same time, five patients had two conventional and two zygomatic implants each. The distribution of the 73 implants, sorted by quantity according to their respective lengths and diameters, is illustrated in **Figure 4**.

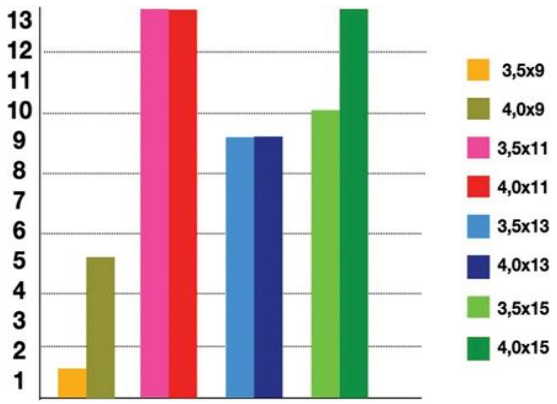

Figure 4. Number of fixtures installed according to implant diameter and length.

Table 1 presents descriptive data for all 73 implants, grouped by placement position, along with the lengths, diameters, and insertion torques. Averaged across the full set, primary stability was 55.89 N cm.

Table 1. Description of the 73 installed implants according to position, length, and diameter, and their respective primary stability in N cm

Case	Implant 4		Implant 3		Implant 2		Implant 1	
	Size (mm)	Torque (N cm)	Size (mm)	Torque (N cm)	Size (mm)	Torque (N cm)	Size (mm)	Torque (N cm)
1	3.5 × 15	50	3.5 × 11	60	3.5 × 11	40	3.5 × 15	40
2	3.5 × 13	45	3.5 × 13	80	3.5 × 13	80	4.0 × 15	80
3	4.0 × 13	80	4.0 × 13	70	4.0 × 11	80	4.0 × 11	80
4	4.0 × 15	60	4.0 × 13	70	4.0 × 13	70	4.0 × 15	80
5	4.0 × 15	70	3.5 × 11	60	4.0 × 11	80	3.5 × 15	60
6	Zygoma	#	3.5 × 11	60	3.5 × 11	50	Zygoma	#
7	4.0 × 15	70	4.0 × 13	80	4.0 × 13	60	4.0 × 15	80
8	Zygoma	#	4.0 × 9	30	4.0 × 11	25	Zygoma	#
9	4.0 × 15	25	4.0 × 11	60	4.0 × 11	60	Zygoma	#
10	Zygoma	#	4.0 × 9	50	4.0 × 11	45	Zygoma	#
11	Zygoma	#	4.0 × 9	60	3.5 × 9	40	Zygoma	#
12	4.0 × 15	60	4.0 × 11	60	4.0 × 11	60	4.0 × 15	70
13	3.5 × 13	30	3.5 × 11	60	3.5 × 11	40	3.5 × 13	35
14	4.0 × 15	25	4.0 × 13	80	4.0 × 11	70	4.0 × 15	35
15	Zygoma	#	3.5 × 11	30	3.5 × 13	70	Zygoma	#
16	3.5 × 13	45	3.5 × 11	30	3.5 × 11	40	3.5 × 15	35
17	3.5 × 15	55	4.0 × 11	60	3.5 × 11	55	3.5 × 15	45
18	3,5 × 15	25	3.5 × 13	80	3.5 × 15	80	3.5 × 15	60
19	4.0 × 11	40	4.0 × 9	60	4.0 × 9	60	4.0 × 11	45
20	3.5 × 15	60	3.5 × 11	60	3.5 × 13	60	3.5 × 11	40
21	4.0 × 15	50	4.0 × 13	50	4.0 × 13	50	4.0 × 15	40

#: no torque

Breaking down the outcomes by implant width, the 3.5 mm fixtures yielded a mean primary stability of 51.51 N cm, whereas the 4.0 mm fixtures attained 59.50 N cm. This disparity reached statistical significance, favoring the broader implants (P = 0.03). It is worth emphasizing that, despite the statistical distinction, both cohorts comfortably exceeded the torque threshold for immediate loading by this technique.

Turning to the implant length variable, no statistically significant difference in primary stability was observed (P = 0.373). One may also note that the entire sample of implants, without exception, met the primary stability requirement for immediate loading per the described protocol.

Rehabilitating the maxillary arch through immediate loading constitutes a well-founded treatment pathway for the fully edentulous, requiring a minimum of 4 fixtures [1-6]. The all-on-four framework has cemented its standing as the predominant approach for attaining this end today [5, 6, 18-20]. The primary stability provided by the four placed implants enables the delivery of a protocol-type prosthesis within a one-week window, providing immediate function. Such a workflow yields benefits for both the dental surgeon and the recipient, resulting in appreciable patient satisfaction with the masticatory restoration and an abbreviated care timeline [21]. Immediate loading employing protocol prostheses draws upon substantial scientific validation, with implant survival rates circling 97%, a figure on par with that observed for six-implant protocol rehabilitations [22]. The approach's viability hinges on the implant providing adequate primary stability. Even though scattered reports in the literature document favorable outcomes with insertion torques below 30 N cm, the most recent consensus positions 35 N cm as the recommended minimum. The determinants of primary stability include bone quality and volume, the protocol of osteotomy preparation, and the microgeometry of the implant surface [11-14].

In pursuit of enhanced primary stability, a majority of practitioners gravitate toward implants with more aggressive thread profiles engineered for compaction, often dismissing variables that contribute to secondary stability—such as spaces for clot retention and surface modifications [11, 14]. Though such implants sometimes yield lower torque readings at insertion, they exhibit a lower threshold for mechanical failure during osseointegration, thereby diminishing the likelihood of breakdown in a prosthesis-supporting fixture [15]. The contribution of the present work is to illustrate that even implants whose macrogeometry is primarily tailored to foster secondary stability can

deliver primary stability adequate for immediate loading when a sub-instrumentation strategy is applied. The implant system evaluated here integrates a decompression chamber alongside bone-compacting threading. This novel macrogeometry, featuring decompression chambers, was designed to achieve greater bone-to-implant contact. It reduces insertion torque without sacrificing primary stability, thereby creating a more favorable environment for local bone regeneration through diminished tissue stress [15]. An additional objective of the decompression chambers is to accelerate early secondary stability—an outcome validated in non-human models when such implants are compared with counterparts with purely compacting geometries, even though the former may exhibit lower initial primary stability values [20].

A reliable way to secure primary stability with this macrogeometry is to practice under-milling. In vitro experimentation documents higher insertion torque and higher Implant Stability Quotient scores when under-milling protocols are compared with conventional drilling sequences [23]. In a human subject investigation, under-milling effectively reinforced primary stability during maxillary all-on-four treatment [17]. A systematic review similarly corroborates the gains in primary stability afforded by under-milling, additionally noting an inclination toward less marginal bone resorption attributable to diminished drilling and the consequent attenuation of trauma to the alveolar crest [24].

A sizeable contingent of clinicians advocates the use of extra-long implants, aiming invariably to achieve cortical anchorage at the nasal floor or within the canine pillar to achieve amplified insertion torque. The findings gathered here indicate that neither the addition of implant length nor the specific insertion site affects primary stability. Conversely, studies comparing extra-short with standard-length implants do report a statistically significant difference, with standard-length fixtures exhibiting greater primary stability due to higher insertion torque [25].

The data gathered in this investigation indicate that implant length has no meaningful effect on primary stability. A statistically significant difference has been identified in research comparing extra-short fixtures with standard-length fixtures, in which standard-length implants yielded greater primary stability due to higher insertion torque [25]. The findings of the present study align with previously reported outcomes for the same implant when used in the rehabilitation of the edentulous maxilla [17]. This observation aligns with long-term implant survival data, which likewise fail to demonstrate any effect of implant length when using the all-on-four technique in the maxillary arch [26], rendering the pursuit of extra-long implants unjustified.

Mean values recorded for implants with a 4.0 mm diameter were markedly superior to those obtained with 3.5 mm implants. These findings are in harmony with results from an earlier investigation published in 2021 [17]. Although lower in magnitude, the mean values associated with 3.5 mm implants remain sufficient to fulfill the requirements for immediate loading within the all-on-four protocol [7] and, when examined from a long-term perspective, no disparity in implant survival has been observed, lending support to the utilization of narrow-diameter implants for immediate loading in the maxilla [27]. Certain studies report no significant correlation between implant diameter and primary stability [28, 29]. The employment of shallower threads owing to the presence of clot chambers is the principal factor underlying the divergence in implant diameters, given that 4.0 mm implants have greater thread depth, thereby expanding the contact surface area.

Conclusion

Acknowledging the inherent constraints of this study, it was nonetheless possible to deduce that implants with macrogeometry and decompression chambers—designed with an emphasis on secondary stability rather than insertion torque—can be safely applied for immediate loading in edentulous arches, particularly with regular-diameter fixtures. The application of sub-instrumentation is necessary to ensure that torque values remain within the parameters advised in the literature for this technique [6, 8, 30].

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Ethics Statement: None

References

1. Gallucci GO, Hamilton A, Zhou W, Buser D, Chan S. Implant placement and loading protocols in partially edentulous patients: a systematic review. Clin Oral Implants Res. 2018;29(Suppl 16):106-34.
2. Kern JS, Kern T, Wolfort S, Heussen N. A systematic review and meta-analysis of removable and fixed implant-support prostheses in

edentulous jaws: post-loading implant loss. Clin Oral Implants Res. 2016;27(2):174-95.
3. Gallucci GO, Benic GI, Eckert SE, Papaspyridakos P, Schimmel M, Schrott A, et al. Consensus statements and clinical recommendations for implant loading protocols. Int J Oral Maxillofac Implants. 2014;29(Suppl):287-90.
4. Scala R, Cucchi A, Ghensi P, Vartolo F. Clinical evaluation of satisfaction in patients rehabilitated with an immediately loaded implant-supported prosthesis: a controlled prospective study. Int J Oral Maxillofac Implants. 2012;27(4):911-9.
5. Agliardi EL, Pozzi A, Stappert CF, Benzi R, Romeo D, Gherlone E. Immediate fixed rehabilitation of the edentulous maxilla: a prospective clinical and radiological study after 3 years of loading. Clin Implant Dent Relat Res. 2014;16(2):292-302.
6. Maló P, Rangert B, Nobre M. All-on-4 immediate-function concept with Brånemark system implants for completely edentulous maxillae: a 1-year retrospective clinical study. Clin Implant Dent Relat Res. 2005;7(Suppl 1):S88-94.
7. Javed F, Ahmed HB, Crespi R, Romanos GE. Role of primary stability for successful osseointegration of dental implants: factors of influence and evaluation. Interv Med Appl Sci. 2013;5(4):162-7.
8. Rizkallah N, Fischer S, Kraut RA. Correlation between insertion torque and survival rates in immediately loaded implants in the maxilla: a retrospective study. Implant Dent. 2013;22(3):250-4.
9. Eskan MA, Uzel G, Yilmaz S. A fixed reconstruction of fully edentulous patients with immediate function using an apically tapered implant design: a retrospective clinical study. Int J Implant Dent. 2020;6(1):77.
10. Greenstein G, Cavallaro J. Implant insertion torque: its role in achieving primary stability of restorable dental implants. Compend Contin Educ Dent. 2017;38(2):88-95; quiz 96.
11. Anil S, Aldosari AA. Impact of bone quality and implant type on the primary stability: an experimental study using bovine bone. J Oral Implantol. 2015;41(2):144-8.
12. Tabassum A, Meijer GJ, Wolke JG, Jansen JA. Influence of the surgical technique and surface roughness on the primary stability of an implant in artificial bone with a density equivalent to maxillary bone: a laboratory study. Clin Oral Implants Res. 2009;20(4):327-32.
13. Tabassum A, Meijer GJ, Walboomers XF, Jansen JA. Evaluation of primary and secondary stability of titanium implants using different surgical techniques. Clin Oral Implants Res. 2014;25(4):487-92.
14. Campos FE, Gomes JB, Marin C, Bonfante EA, Suzuki M, Coelho PG. Effect of drilling dimension on implant placement torque and early osseointegration stages: an experimental study in dogs. J Oral Maxillofac Surg. 2012;70(1):e43-50.
15. Gehrke SA, Aramburú J Jr, Perez-Dias L, Treichel TLE, Dedavid BA, Mazon P, et al. New implant macrogeometry to improve and accelerate the osseointegration: an in vivo experimental study. Appl Sci. 2019;9(15):3181.
16. De Carvalho Formiga M, Gehrke AF, De Bortoli JP, Gehrke SA. Can the design of the instruments used for undersized osteotomies influence the initial stability of implants installed in low-density bone? An in vitro pilot study. PLoS One. 2021;16(10):e02579985.
17. Manfro R, Garcia GFF, Bortoluzzi MC, Broilo JR, da Silva VD, Cararo JC, et al. Avaliação da estabilidade primária dos implantes Due Cone e Maestro no tratamento da maxila edêntula pela técnica All on 4-estudo in vivo. ImplantNews. 2021;6(5):686-90.
18. Ahmadi A, Dörsam I, Stark H, Hersey S, Bourauel C, Keilig L. The all-on-4 concept in the maxilla – a biomechanical analysis involving high performance polymers. J Biomed Mater Res B Appl Biomater. 2021;109(11):1698-705.
19. Bhering CLB, Mesquita MF, Kemmoku DT, Noritomi PY, Consani RLX, Barão VAR. Comparison between all-on-four and all-on-six treatment concepts and framework material on stress distribution in atrophic maxilla: a prototyping guided 3D-FEA study. Mater Sci Eng C Mater Biol Appl. 2016;69:715-25.
20. Gehrke SA, Aramburú J Jr, Dedavid BA, de Azevedo BC, Corrêa AWR, Neves FCC. Nova macrogeometria dos implante maestro visando acelerar e aumentar a osseointegração: uma análise experimental in vivo. InPerio. 2020;5(2):117-25.
21. Gonçalves GSY, de Magalhães KMF, Rocha EP, Dos Santos PH, Assunção WG. Oral health-related quality of life and satisfaction in edentulous patients rehabilitated with implant-supported full dentures all-on-four concept: a systematic review. Clin Oral Investig. 2022;26(1):83-94.
22. Niedermaier R, Stelzle F, Riemann M, Bolz W, Schuh P, Wachtel H. Implant-supported

immediately loaded fixed full-arch dentures: evaluation of implant survival rates in a case cohort of up to 7 years. Clin Implant Dent Relat Res. 2017;19(1):4-19.

23. Lemos BF, Lopez-Jarana P, Falcao C, Ríos-Carrasco B, Gil J, Ríos-Santos JV, et al. Effects of different undersizing site preparations on implant stability. Int J Environ Res Public Health. 2020;17(23):8965.
24. Antonacci D, Bollero P, Stocchero M, Jinno Y, Canullo L. Clinical effects of conventional and underprepared drilling preparation of the implant site based on bone density: a systematic review and meta-regression. J Prosthodont Res. 2023;67(1):23-34.
25. Gašperšič R, Dard M, Linder S, Oblak Č. The use of 4-mm implants splinted to 10-mm implants for replacement of multiple missing teeth in the posterior maxilla region with expanded maxillary sinus. an observational cases series: patient characteristics and preliminary results. Int J Periodontics Restorative Dent. 2021;41(4):561-8.
26. Malo P, Nobre MAA, Lopes AV, Rodrigues R. Immediate loading short implants inserted on low bone quantity for the rehabilitation of the edentulous maxilla using an All-on-4 design. J Oral Rehabil. 2015;42(8):615-23.
27. Babbush CA, Kanawati A, Brokloff J. A new approach to the All-on-Four treatment concept using narrow platform NobelActive implants. J Oral Implantol. 2013;39(3):314-25.
28. Farronato D, Manfredini M, Stocchero M, Caccia M, Azzi L, Farronato M. Influence of bone quality, drilling protocol, implant diameter/length on primary stability: an in vitro comparative study on insertion torque and resonance frequency analysis. J Oral Implantol. 2020;46(3):182-9.
29. Ivanova V, Chenchev I, Zlatev S, Mijiritsky E. Correlation between primary, secondary stability, bone density, percentage of vital bone formation and implant size. Int J Environ Res Public Health. 2021;18(13):6994.
30. Javed F, Romanos GE. The role of primary stability for successful immediate loading of dental implants. A literature review. J Dent. 2010;38(8):612-20.