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Rehabilitation of the atrophic mandible with short implants in different positions: A finite elements study

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ABSTRACT

Objective: The aim of this study was to analyze whether the use of inclined short implants without lower transcortical involvement (test model - SI), thus preserving the mandibular lower cortical bone, could optimize stress distribution.
Materials and methods: Six identical atrophic mandible models were created featuring 8 mm of height at the symphysis. Two study factors were evaluated: implant length and angulation. Implant length was represented either by short implants (7 mm) with preservation of the mandibular lower cortical bone or standard implants (9 mm) with a bicortical approach and 3 possible implant positioning configurations: 4 distally-inclined implants at 45° (experimental model), all-on-four, 4 vertical implants. All tridimensional (3D) models were analyzed using the Finite Element Method (FEM) and the Ansys Workbench software.
Results: The maximum stress on the bone at the cervical region of the implants in the experimental model was 132 MPa and transcortical involvement with implant inclination yielded higher values (171 MPa). Regarding von Mises stress on the retaining screw of the prosthesis, 61 MPa was recorded for the experimental model while upright implants had the highest values (223 MPa). At the acrylic base, 4 MPa was recorded for the experimental model whereas models with upright implants showed the highest stress values (11 MPa).
Conclusion: Rehabilitation of severely resorbed mandibles with 4 short implants placed distally at 45°, without lower transcortical involvement, were biomechanically more favorable, generating lower stress peaks, than the models with short implants on an all-on-four, or on an upright configuration, with or without lower transcortical involvement.

1. Introduction

The increase in life expectancy in recent decades described by the World Health Organization has increased the number of people wearing lower dentures for many years [1]. As alveolar ridge volume is dictated by the presence of natural teeth, a lack thereof inevitably triggers bone resorption. In the case of complete teeth loss, replacement of natural teeth using soft tissue supported dentures generates unfavorable forces that may accelerate this process, exacerbating the instability of full dentures as well as the degree of patient dissatisfaction. Patients often report pain, difficulty chewing and speech impairment, which compromise their quality of life [2–6].

The use of osseointegrated titanium implants is considered an effective method for functional and esthetic replacement of lost teeth. Treatment success has always been related to variables such as volume and anatomy of the remaining bone, the longer the implant the more favorable the prognosis [2,7,8]. However, in many situations, placement of long implants is hindered by severely resorbed alveolar ridges, anatomical limitations such as the mental foramen or inferior alveolar nerve and mandibular canal and shape of the mandible [1,9–14].

Placement of short implants (≤8 mm long) may be considered an effective option to rehabilitate edentulous patients whenever conventional implants cannot be placed without prior bone augmentation procedures [3,4,9–18], such as autologous bone graft, osteogenic

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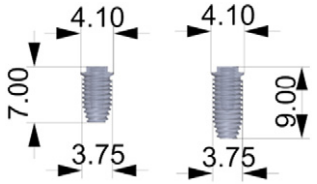

Fig. 1. Illustration of the 6 models generated: SI - short inclined implants; IT – inclined transcortical implants; SA - short implants positioned as all-on-four; TA – transcortical short implants positioned as all-on-four; SU - short upright implants; UT - upright transcortical implants.

distraction or mental foramen transposition, which increase surgical morbidity and treatment time [1,3,4,9–12,14–16,19].

A survey on the occurrence of mandibular fractures associated with dental implants concluded that mandibles with <10 mm of bone height at the region of the symphysis are at risk of fracture and associated complications [20]. One factor that may favor the occurrence of a mandibular fracture is the penetration of the lower mandibular cortical ridge, by the implant, *i.e.* bicortication. Thus, the installation of shorter implants, keeping the integrity of the lower mandibular cortex, might reduce the risk of mandibular fragilization [21,22].

One way to improve the distribution of functional forces on the prosthesis, implants and peri-implant tissues in patients with little bone is the use of angled implants. Biomechanical justification for distal inclination of implants is based on decreased distal extension of the prosthesis and favorable anteroposterior distribution of implants. Furthermore, the use of tilted implants can increase its primary cortical anchoring and stability, allowing the use of longer implants [1,23–26].

The all-on-four concept consists of a relatively less invasive treatment option with a high success rate [27–29]. Distally inclined implants at 45° decrease the concentration of stresses on the peri-implant bone [23] and compressive forces on the distal bone/implant interface compared to the configuration with four upright implants [1,13,24,25,30–33].

Based on the aforementioned arguments, the aim of this study was to evaluate stress distribution on severely resorbed mandibles, with 8 mm of remaining bone height at the symphysis, restored with implants at varying angulations and length (bicorticated and non-bicorticated) using the tridimensional Finite Element Method (FEM) [33–35]. The null-hypothesis tested was that different implant angulations and length would not affect biomechanical behavior.

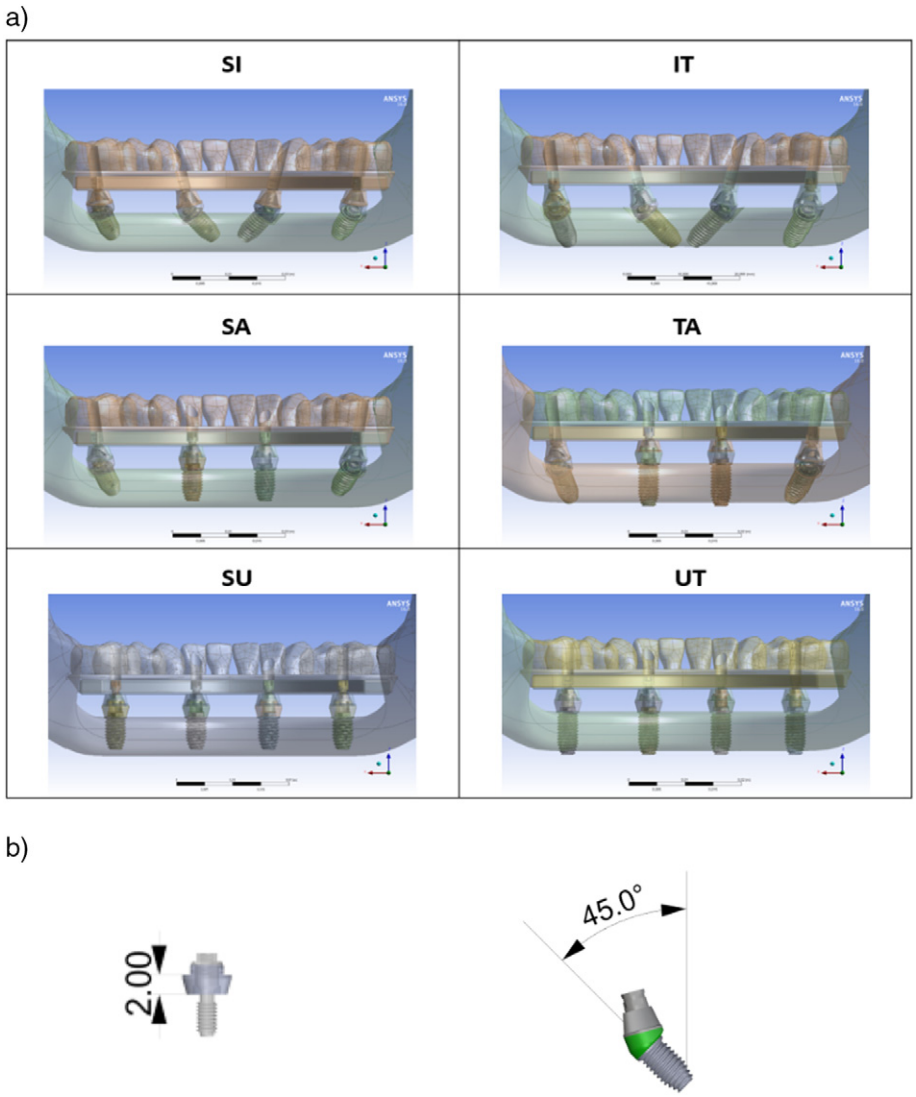

Fig. 2. Implant dimensions. An implant with an external hexagonal interface Titamax TI Cortical (Neodent®, Curitiba, Brasil) was used.