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Comparative analysis of a conventional cantilever abutment and innovative double abutment in dental implant prosthesis: A finite element analysis study

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ABSTRACT

The innovative double paraboloid abutment (DA) in dental implant prosthesis is based on the new concept of Biodynamic Optimized Peri-implant Tissue (BOiT) and was introduced in a human case series report with follow-ups ranging from 3 to 12 years. This study aimed to evaluate the influence of two structural designs: the innovative DA and a distal conventional cantilever (CC) in fixed prostheses retained by a single dental implant. The evaluation focused on stress and strain distributions in bone tissue (cortical and medullary), as well as stress distribution in the abutments, UCLA, implants, and retaining screws under axial and oblique loading, using 3D finite element analysis. Each model consisted of a bone block representing the area from the right second premolar to the first molar, with one internal hexagon implant (4.0 × 10 mm) supporting a fixed dental prosthesis of two elements. Forces of 100 N were applied in both axial and oblique directions (at 30° in the Y direction). The von Mises criterion was used to assess maximum principal stress values and microstrain. Simulations were created using ANSYS mechanical software. After applying the loads and obtaining the stress results, using the same materials for each of the modeled parts, as well as bone and identical loads, it was observed that the DA design yielded more favorable results than the cantilever. The DA showed significantly lower stress levels and better strain distributions, indicating a more favorable biomechanical interaction between structures. These findings suggest that DA designs may reduce stress concentrations and potentially minimize the risk of clinical complications compared to traditional CC designs, leading to improved long-term implant stability and success rates in patients missing two adjacent dental elements, supported by a single osseointegrated implant.

Introduction

Currently, with increasing success rates, implant therapy has become a significant and effective tool for replacing lost teeth [1]. Despite this high rate of positive outcomes, there are biological and biomechanical factors that can influence the performance of dental implant therapy [2]. Another key issue is the pursuit of innovations that can make implant rehabilitations simpler and more accessible to the general population [3].

In this context of innovation, Colepícolo et al. [3]. reported a series of cases aimed at presenting the rationale and scientific evidence for a new abutment with a double (DA) elliptical paraboloid geometric design, based on the specific concept of Biodynamic Optimized Peri-implant Tissue (BOiT), which simultaneously involves the principles of bone mechanotransduction, biotensegrity, and mechanobiology. They presented 28 cases using DA to support two dental crowns on a single implant. Clinical and radiographic examinations were conducted at T1 (loading after 4 months) and T2 (final examination with an average follow-up time of 3 to 12 years). At T2, all periodontal clinical parameters were found to be adequate, reflecting healthy peri-implant

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conditions. All radiographic images showed insignificant annual marginal bone loss (0.022 ± 0.05 mm) compared to T1, indicating great bone stability. The authors concluded that DA represents an advantageous, simple, and non-invasive mechanism for the longevity and healthy regulation of peri-implant tissues

It is currently understood that biomechanical factors, such as the transmission of load forces through the implant and the distribution of stresses in the bone tissue, are significant in determining the success or failure of the implant [2,4–7]. These force distributions are dependent on the direction, frequency, and duration of the loads, which makes them more unpredictable when using a cantilever with two prosthetic crowns on an implant, particularly the distal ones [8].

In addition to force distribution, several studies through FEA have shown that some characteristics of the implant-prosthesis system, such as: greater implant inclination in fixed partial dentures [9], a higher number of implants in fixed bridges [10], shorter implant length [11, 12], implants with optimized geometry [13,14], and larger implant diameter [15], have a favorable effect on stress values in the supporting tissues.

However, the innovative DA primarily excels in force distribution, supporting two crowns on a single implant without adverse effects on the peri-implant tissues. Therefore, it was proposed to analyze the stress and strain distributions of the DA load through finite element analysis (FEA) compared to a conventional cantilever (CC) on a single implant. FEA was chosen because it is considered an appropriate method for investigating stresses and strains in a three-dimensional structure [16–19].

The main motivation and originality for this study stems from the gap in the existing scientific literature regarding biomechanical information on the real influence of an abutment in load reception and the redistribution of these forces throughout the entire system (implant-abutment-crown). Thus, due to the similarity between CC and DA for replacing two teeth with an implant, analyzing the biomechanical differences becomes a key issue.

The hypothesis developed in this experiment is that the new DA abutment system will yield better biomechanical results, with lower stress and strain outcomes, due to its innovative geometric shape designed for load redistribution, compared to the geometric design of the CC.

Therefore, the objective of this study was to verify and compare the stresses and strains under different loading conditions (axial and oblique) on the implant-abutment assembly and in the bone, between the CC system and the DA using FEA

Methods

In this in vitro experimental study, a bone model was acquired from images obtained from a dentate maxilla (representing the area from the right second premolar to the first molar) using computed tomography. This model consisted of a realistic geometric representation of the upper arch, measuring 18.0 mm in height, 19.0 mm in mesiodistal width, and 15.0 mm in vestibulolingual depth. It was classified as type three bone, characterized by a thin layer of cortical bone measuring 1.0 mm surrounding trabecular bone, in terms of density. The purpose of the tomography was to provide a bone-based model for implant positioning and the subsequent fabrication of the abutment models for simulation.

To allow for quantitative comparisons, two prosthetic models using DA and CC on a single implant[1] (internal hexagon, 4.0 × 10.0 mm) were modeled in three dimensions (3D) using Solid Edge software.[2] The models were categorized according to the placement of the abutments into two groups: the CC group (Fig. 1 ac) and the DA group (Fig. 1 bd).

For both groups, a titanium implant with the different structures was simulated using images obtained through micro-computed tomography. Evaluations through FEA were conducted for the following structures: (a) CC; (b) DA; (c) copym for cantiléver (metal-covered coping); (d) copym for DA (metal-covered coping); (e) internal hexagon implant; (f) UCLA [(University of California, Los Angeles) connection]; (g) cortical bone; (h) medullary bone; and (i) screw (Fig. 1).

The implants were positioned parallel to their long axis on the bone base from the tomography, and the implant platform was positioned at the height of the bone crest, standardizing the bone ridge. All implants were considered fully osseointegrated. The materials were assumed to be isotropic, homogeneous, and linearly elastic. The values for Young's modulus and Poisson's ratio are described in Table 1 and were based on the study by Van Oosterwyck et al. [20].

The models were transferred from ANSYS Mechanical to COMSOL Multiphysics[3] for the execution of static linear elastic simulations. The zero displacement boundary condition was defined for the flat faces of the maxillary segments. Two different loading scenarios were considered for each of the two proposed rehabilitation models: an axial load of 100 N applied in the Y direction and an oblique load at 30° in the Y direction (except for the fixation screws, which had a load of 20 N) [21]. The load points were directed towards the distal edge of the DA and CC structures. This value was chosen to represent an average biting force during mastication, based on previous studies that have reported bite forces in this range [9,11,12]. Additionally, this is corroborated by studies conducted in various clinical scenarios and with different functional loads on implant prostheses [10–12].

Fig. 2 shows these axial and oblique loading scenarios in the CC and DA groups, additionally showing a pre-load on the UCLA and the internal threaded part of the implant compressing at 20 N.

The selected FEA simulations are supported by several studies [9–17]. However, it is important to note that the boundary conditions for FEA simulations can affect various clinical scenarios, such as implant-abutment design, individual profile, and implant location. Additionally, multiple factors influence implant performance in clinical settings, including age, sex, degree of edentulism, bite location, and parafunctional habits. To reduce computational complexity, the bone surrounding the implant was modeled as a homogeneous, isotropic material [7,9,13]. While bone is naturally anisotropic, this simplification allowed the study to focus primarily on stress distribution within the implant system itself [9]. Shen

The results were evaluated qualitatively and quantitatively by the maximum principal stress (tensile) and minimum principal stress (compressive) in the implant, abutments, and bone tissue [22].

Analyses of the stresses (normal, bending, and torsion) acting on each element were performed for sizing purposes, using static methods and employing the Distortion Energy Theory, also known as Von Mises theory, within the finite element method.

Additionally, the maximum deformations of all groups were verified through FEA, and Mesh convergence graphs were created for both groups. The mesh convergence test was carried out by progressively refining the mesh for each component of the implant-abutment-prosthesis system. During this process, von Mises stresses, the number of generated elements, and the computational cost—balancing both efficiency and accuracy—were analyzed. Convergence graphs were created from this data, with convergence defined as the stabilization or reduction in the variation of the analyzed quantities, as shown in the presented graphs.

Results

Table 2 shows the stress and strain measurements of the two models

[1] Neodent® - Grupo Straumann, Curitiba, Paraná, Brazil.

[2] SolidWorks 2020 SP3; SolidWorks Corporation, Concord, Massachusetts, USA.

[3] ANSYS Mechanical with license ID: Ent-1055522-1-517497381 - ANSYS-1-517509577-11248064298) COMSOL, Inc., Burlington, Vermont, USA.

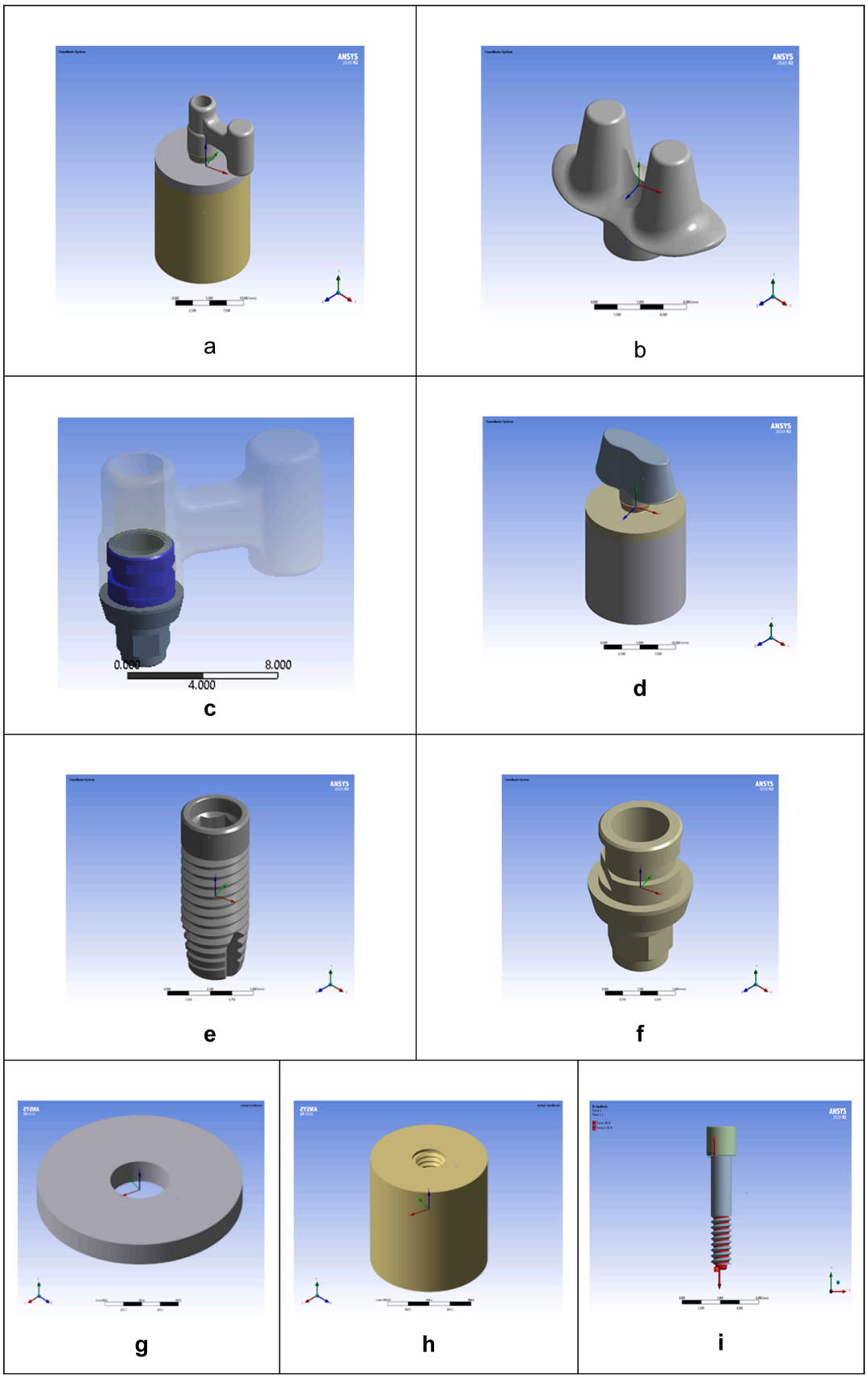

Fig. 1. Structures studied through FEA.
(a) Cantilever Abutment; (b) DA Abutment; (c) Coping for Cantilever; (d) Coping for DA; (e) Implant; (f) UCLA; (g) Cortical Bone; (h) Medullary Bone; (i) Screw.

Table 1
Material properties in FEA.

Materials	Elastic modulus (Young E)	Elastic limits	Poisson ratio
Cobalt chromium alloy (abutments and UCLA)	2,1e + 05 MPa	~200 - 230 GPa	0.30
Bone	1300 MPa	~0.1 – 20 GPa	0.30
Ti-6AI-4 V screw	1,12e + 05 MPa	~110–120 GPa	0.33
Titanium Grade 4 implant	1.15e + 05 MPa	~105–115 GPa	0.34

in the following structures: screw, UCLA, implant, abutment, cortical bone, and medullary bone. Regarding axial load stress, lower maximum stress values were generally observed in all structures with the DA compared to the CC (expressively CC > DA). In terms of strain, significantly lower values were reported for DA compared to CC.

Notably, the CC model experiences the highest stress under axial load; for example, CC exhibits approximately 8 times greater stress values than the DA model in the abutment structure (CC = 204.07 and DA = 25.577) and approximately 11 times greater in cortical bone (CC = 22.489 and DA = 2.8708).

In relation to oblique load, stress values were significantly lower in DA compared to CC for the UCLA (DA = 134.68; CC = 247.87), implant (DA = 155.04; CC = 245.56), and abutment (DA = 124.05; CC = 222.35). The differences in values for cortical bone (DA = 37.20 and CC = 47.66) and trabecular bone (DA = 3.98 and CC = 4.71) were more closely aligned. In terms of strain, lower values for DA were observed compared to CC across all structures, although the values were more convergent. The exception was the screw, where slightly higher strains values for DA (10.26) were noted compared to CC (8.74).

It can be concluded that since CC exhibits higher stresses in the modeling of the proposed structures compared to DA, it demonstrates worse biomechanical performance when considering the axial load hypothesis. Regarding the oblique load, CC showed higher stress values for

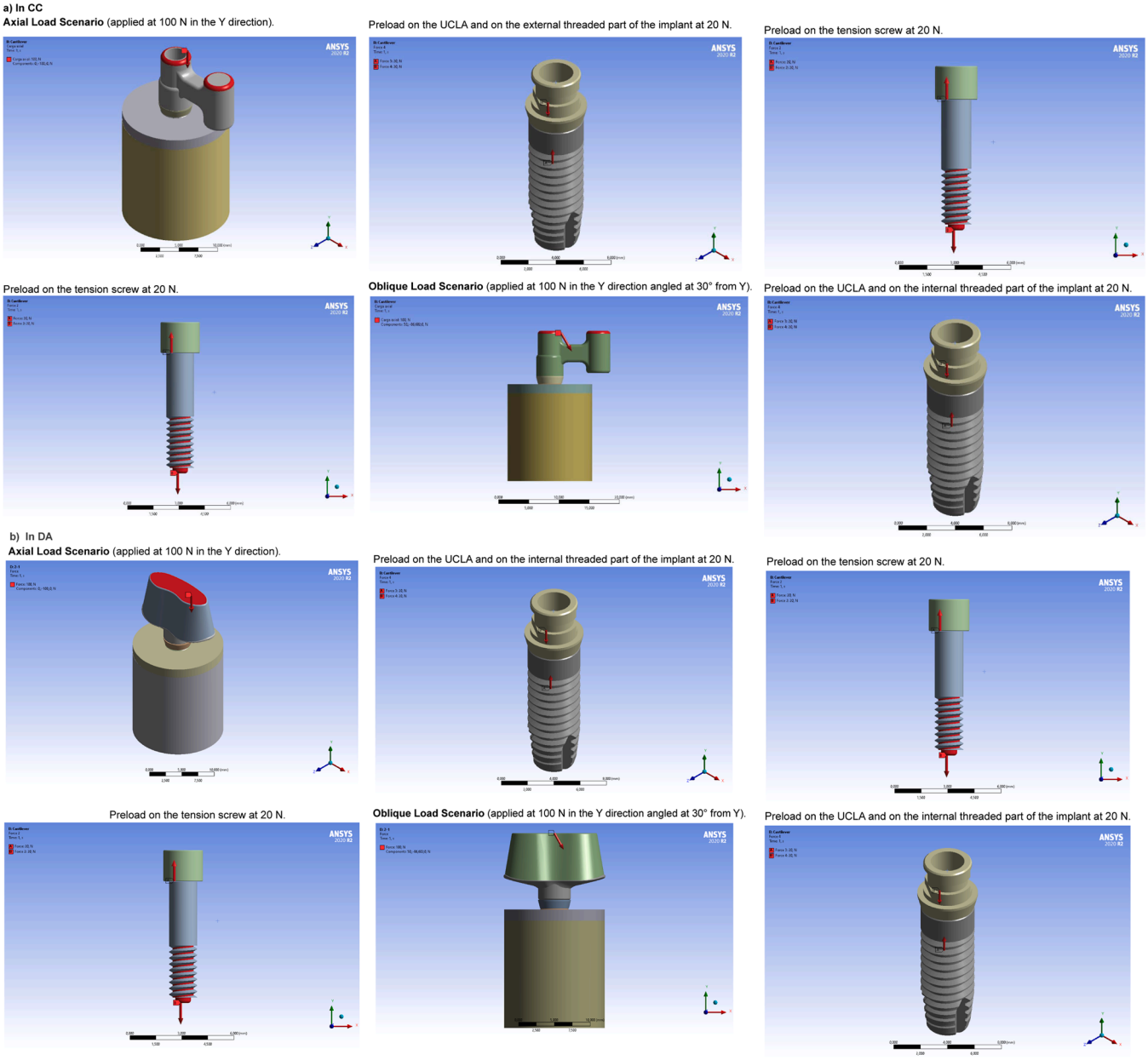

Fig. 2. Axial and oblique load scenarios in different structures in CC and DA.

Table 2
Maximum stresses and strains of the studied structures under axial and oblique loads.

AXIAL LOADS Von Mises Stresses (MPa)						
	Screw	UCLA	Implant	Abutment	Cortical Bone	Medullary bone
DA	26.772	33.623	64.416	25.577	2.8708	4.8178
CC	78.117	117.56	216.01	204.07	22.489	6.7073
Strains [μm]						
DA	2.7893	4.2996	3.8887	4.7019	1.2869	3.4042
CC	10.0100	15.3880	7.7738	52.0610	2.9762	5.6164
OBLIQUE LOADS Von Mises Stresses (MPa)						
DA	135.94	134.68	155.04	124.05	37.20	3.98
CC	55.48	247.87	245.56	222.35	47.66	4.71
Strains [μm]						
DA	10.26	16.26	6.66	33.69	5.93	4.51
CC	8.74	22.24	8.36	71.87	7.47	5.48

Axial load of 100 N applied in the Y direction and an oblique load at 30° in the Y direction (except for the fixation screws, which had a load of 20 N).

the studied structures; however, the values were closer for both cortical and trabecular bone.

Figs. 3 and 4 illustrate the comparative stress distribution fields around the CC and DA models concerning the abutment, implant, cortical bone, medullary bone, screw, and UCLA under axial (Fig. 3) and oblique (Fig. 4) loads.

The cross-sections depicted (Figs. 3 and 4) were generated by selecting planes that align with the direction of the applied force, providing a comprehensive understanding of how CC and DA influence stress distribution in the bone. Initially, a reduction in the size of regions experiencing stress levels above or near physiological limits is observed in the DA followed by the CC. The distinction between minimum and maximum principal stress is crucial for identifying areas of potential overload due to compressive or tensile stress, respectively, in accordance with the established maximum normal stress criterion.

Fig. 5 shows the mesh convergence between the structures with CC and DA. The graphs represent the mesh convergences performed on each model, indicating that even with finer mesh refinement (increased mesh nodes), there were no significant changes in the results, ensuring the accuracy and reliability of those obtained through FEA.

Fig. 6 presents a diagrammatic representation and clinical application of the DA and CC.

Discussion

This study demonstrated through FEA that the DA exhibited lower stresses and strains in the modeling of the proposed structures compared to the CC, thereby revealing better biomechanical performance and supporting the affirmative hypothesis of this study. The use of DA was associated with lower stress and strain distributions in the implant, abutment, and surrounding bone, which, in turn, hypothetically supports the long-term clinical stability of the entire system.The difference in oblique load between DD and CC on the screw is not relevant from a biomechanical standpoint.

Chang et al. [23]., in a study on FEA model validation, state that an initial study using FEA should subsequently be validated through clinical studies. Thus, despite the reverse chronological order, our FEA results reinforce the validity of the clinical findings reported by Colepícolo et al. [3]., where excellent biomechanical performance of the DA was observed in peri-implant clinical and radiographic parameters across a series of cases with follow-up ranging from 3 to 12 years.

The DA was based on the BOiT concept, which simultaneously involves the principles of bone mechanotransduction, [24–28] biotensegrity [25,28,29], and mechanobiology [24–26,28]. Thus, the design of the DA (elliptical paraboloid) allows for high stiffness with reduced bending stresses, redirecting and equalizing forces. Its geometry is suitable for supporting shear forces in a plane on the hyperbolic shell and thus transmits uniform eccentric axial forces to the edge members of the system. Vectorial loads are minimized, preventing the traditional transverse coordinate axis that leads to early bone loss in the area of the implant connection to the abutment [3].

It should be noted that Colepícolo et al. [3]. also reported a series of cases (n = 16) with an innovative triple abutment called TA, which showed excellent clinical and radiographic results. However, this current study does not aim to present comparisons between TA and CC, as TA supporting three dental crowns on a single implant should be studied using FEA compared to a fixed implant-supported bridge with three dental elements.

The DA acts as a distributor and organizer of multiple mechanical loads and supports two crowns on each abutment, with its innovative geometric design, it exhibits total passivity (without the need for prosthetic soldering), resulting from coupled mathematical and physical conformations in biologically active vector models in its geometry [3].

When comparing DA and CC, the following clinical issues can be highlighted: (i) DA offers a better load distribution compared to CC, in addition to providing a precise and passive fit, without welding, which directly impacts the patient's osteoperception, offering greater comfort and security ; (ii) Since the distribution of axial and oblique forces in DA is more favorable, aesthetics are not compromised in the long term, preventing recessions, especially in the anterior areas, where the preservation of gingival tissue is a priority ; (iii) In CC, the structure of the prosthesis extends beyond the implant, making it more susceptible to fractures and loosening of screws, especially when exposed to intense masticatory forces, leading to insecurity in the patient. (iv) In terms of cost, both DA and CC are supported by a single implant, but DA provides a better distribution of forces, preventing overload on the implant platform area; (v) DA promotes faster rehabilitation in critical situations (such as the need for grafts) or high stress and maintains the longevity of the prosthesis, which helps reduce long-term costs ; (vi) DA on angled implants provides better biomechanical conditions compared to conventional angled abutments, due to the 3D angle compensation, directly on the cervical divergent sleeve ; (vii) DA retains its biomechanical advantages in multiple prostheses, supporting two crowns on a single implant in a passive way, without welding, and can be used to restore partial or complete areas of an arch [3], and (viii) Thus, the use of DA represents an innovative contribution to implant dentistry, particularly regarding its superior biomechanical performance compared to CC under varying load conditions.

It is known that an important factor for the predictability of implants is the design of prosthetic connections (abutments) and materials that promote stability under regular masticatory loads. A significant challenge in modern implant dentistry is preserving bone level around implants over an extended functional period [30].

A specific issue in implant dentistry is that bone resorption after tooth loss can interfere with the ideal positioning of the implant, and in some cases, resorption may prevent the placement of an adequate

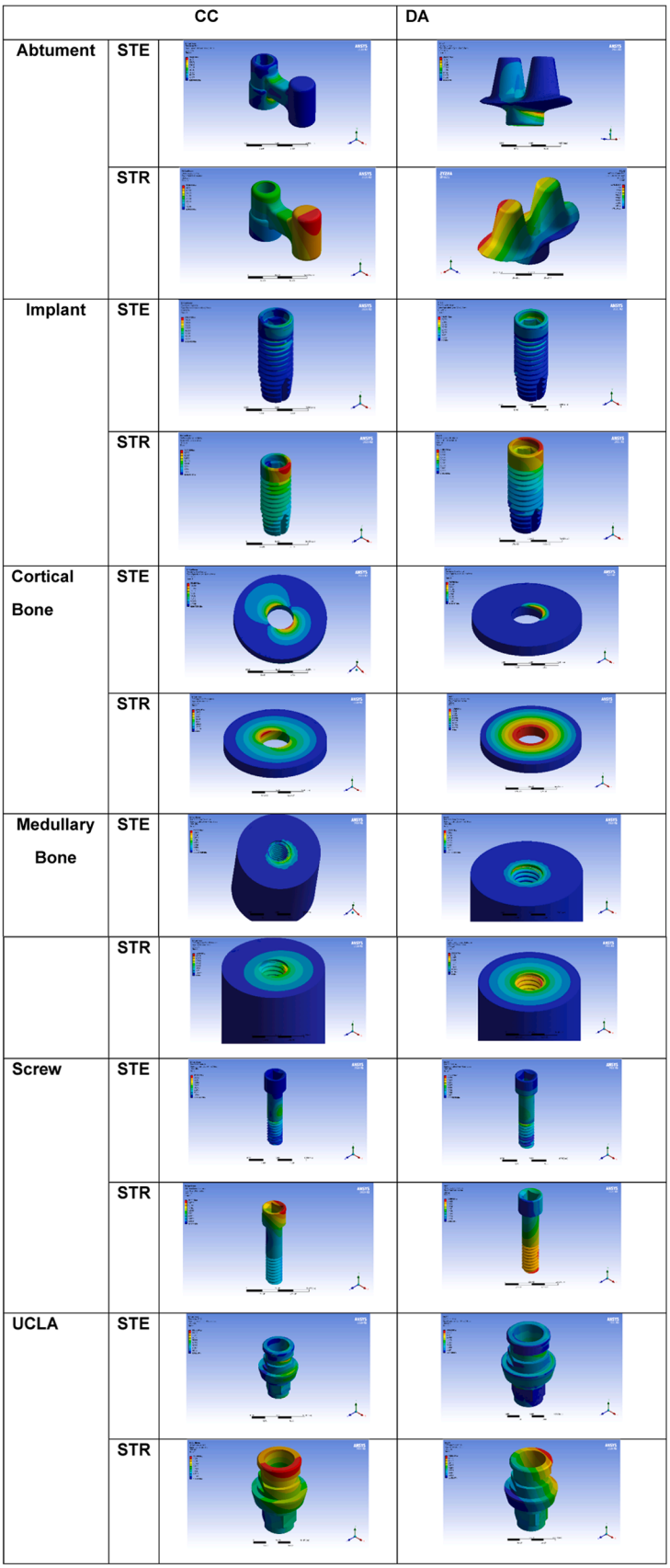

Fig. 3. Static linear elastic simulations with maximum and minimum stress and strain values in the studied structures under axial load.
Axial Load Scenario (applied at 100 N in the Y direction). Screws (20 N). values Mpa, STE= Stresses (Mega Pascal); STR=Strains (μm – micrômetros).

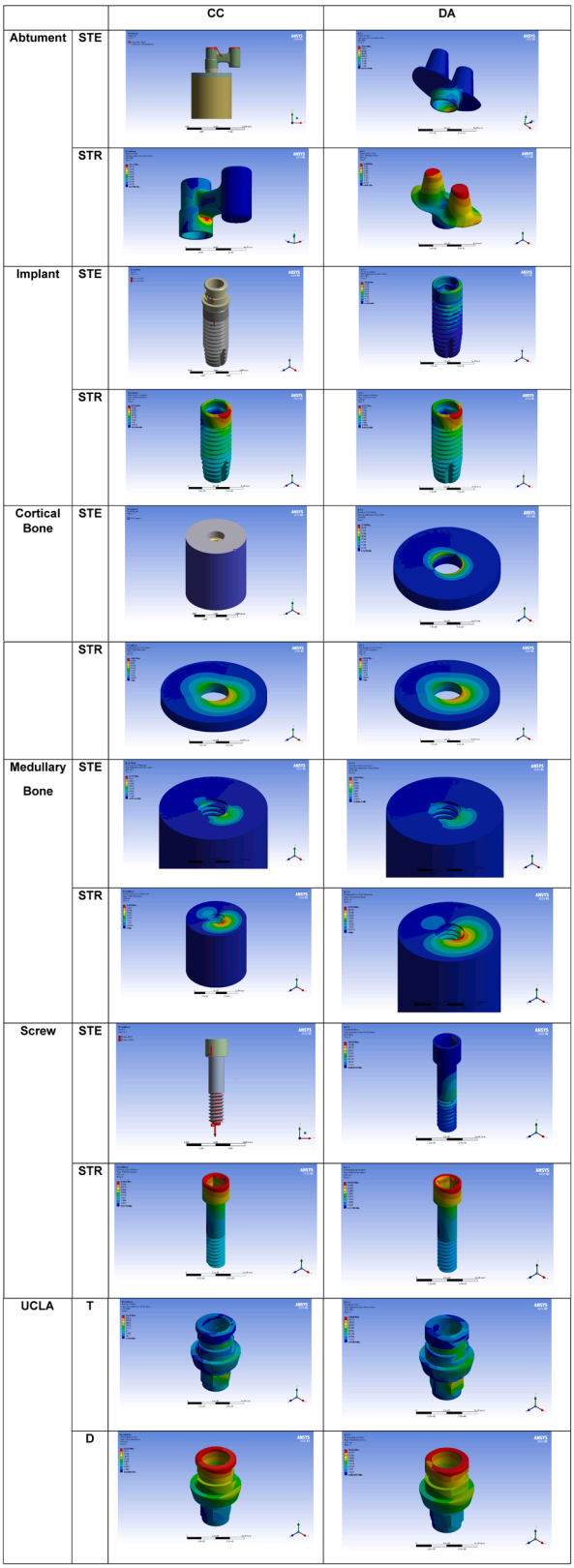

Fig. 4. Static linear elastic simulations with maximum and minimum stress and strain values in the studied structures under oblique load.
Oblique Load Scenario ((applied at 100 N in the Y direction angled at 30° from Y). Screws (20 N). values Mpa. STE= Stresses (Mega Pascal); STR=Strains (μm – micrômetros).

number of implants [31]. In such situations, the use of bridges or cantilevers (mesial or distal) is suggested as an alternative to avoid surgical procedures that prolong treatment, increase costs, and elevate surgical morbidity [32]. However, the longevity of these treatments is still not fully understood. Additionally, some clinicians unfortunately tend to reduce the number of implants based solely on cost considerations, without grounding their decisions in biomechanical concepts, as there is insufficient scientific evidence to guide professionals on how many dental implants are necessary for successful rehabilitation [8].

De Souza Batista et al. [8]. present a study using FEA comparing three-element bridge models with two cantilevers (mesial and distal). The results demonstrated that the distal cantilever exhibited worse biomechanical behavior than the mesial one. This fact is explained by the occlusal table size of the first molar, which is larger than that of the first premolar, and by the number of cusps on the molar, which receives four load applications compared to two on the first premolar. These results corroborate the findings of Kreissl et al. [33]., who reported that the use of implant-supported partial dentures with cantilevers had a higher incidence of complications in a 5-year prospective study.

In addition, the study by de Souza Batista et al. [8]. showed a higher stress concentration, particularly on the screw of the models with two implants under oblique load, even when this load was applied with half the axial force. The concentration of stress in this area could lead to screw loosening, requiring additional visits to address the discomfort, either to retighten or replace the screw. Thus, the use of treatments with distal cantilevers should be avoided. In such situations, the use of bone grafts and the placement of an additional implant is suggested to achieve a longer-lasting treatment. However, it is known that grafts increase the morbidity and costs of treatment [8].

In this context, the use of DA offers the following advantages: (i) reduction of stress concentration at the implant seating platform and on the screw; (ii) rehabilitation of areas with two dental elements using a single implant; (iii) rehabilitation in the presence of tilted implants or with minimal parallelism; (iv) elimination of the undesirable effects of cantilever-type prostheses; (v) total passivity and ease of hygiene (the parabolic prophylactic emerging profile of the DA allows for normal use of dental floss due to the segmented arrangements supported by a single implant [3]. Expanding into clinical practice, DA offers several potential benefits for long-term implant stability. These include a reduction in bone resorption, a decreased risk of implant fracture, enhanced screw joint stability, minimized micromotion, and improved patient comfort.

Furthermore, the DA maximizes the use of atrophic or irregularly thick bone areas and preserves anatomically risky regions (such as the maxillary sinus and the mandibular nerve) by allowing for different angles of implant insertion that are biomechanically compensated in a multidimensional manner. Specifically, the increased stress from the inclination is offset by the geometric design of the abutment [3].

According to Hämmerle et al. [34]., for reconstructions with a single implant and cantilevers, the available data, although promising, are so scarce that the procedure cannot be recommended for routine clinical use. In this context, the use of DA may represent a significant advancement compared to traditional cantilevers.

A recent systematic review including nine studies revealed that the implant survival rate tends to be lower in the cantilever group, and marginal bone loss tended to be higher in the cantilever group; however, there was no significant difference. There was no significant difference in patient satisfaction based on the presence or absence of a cantilever. Moreover, the incidence of mechanical complications was significantly higher in the cantilever group. According to the analysis of anterior and posterior regions, implant survival rate tended to be lower in the cantilever group of the posterior region, and marginal bone loss around the implants tended to be higher in the cantilever group of the anterior region. Additionally, there is a lack of clinical evidence regarding the effects of the number of implants, cantilever length, and the differences between mesial and distal cantilevers. Therefore, further research is needed [35].

Fig. 5. Mesh convergence between CC and DA (Stress vs. Mesh Nodes).
The graphs represent the mesh convergences performed on each prosthesis with DA and CC, indicating that even with greater mesh refinement (increased mesh nodes), there are no significant changes in the results.

FEA is a powerful numerical technique aimed at solving complex models by dividing a continuous medium into elements that retain the characteristics and properties of the body from which they originated. This allows for the evaluation and understanding of the biomechanical behavior of stresses, even in complex geometric structures of various implant and prosthetic designs, as well as in clinical scenarios, at significantly reduced logistical cost and time [17,18,32]. It is noteworthy that, despite the existence of other criteria for evaluating stress distribution, such as the maximum stress value, the von Mises stress criterion was chosen. This is because it is widely accepted, particularly relevant to the ductile materials involved, and effectively addresses complex stress states, such as those encountered in implant prostheses [13,19].

However, studies conducted using FEA also have several limitations: the results depend on the accuracy of the models, including the geometric representation and material properties; inadequate models can lead to erroneous conclusions; simplifications in modeling (e.g., bone material properties and loading conditions) may affect the generalization of results; and FEA is less effective at fully capturing the complexity of biological interactions between implants, tissues, and fluids, which could impact the accuracy of predictions [36–38] Thus, quantitatively, an accurate translation of the findings of this study to the clinical setting should not be expected.

Titanium, alumina and zirconia are the materials most used in the manufacture of abutments. A recent study [11] comparing these materials using FEA was conducted revealing no differences in stress under bone tissue. However, ceramic materials can reduce the gray color associated with metallic components that interferes with aesthetics. Therefore, studies using DA made with ceramic materials are necessary and this is a goal of our research group.

It is important to highlight that the presentation of these results through FEA provides a convenient and comfortable preliminary clinical

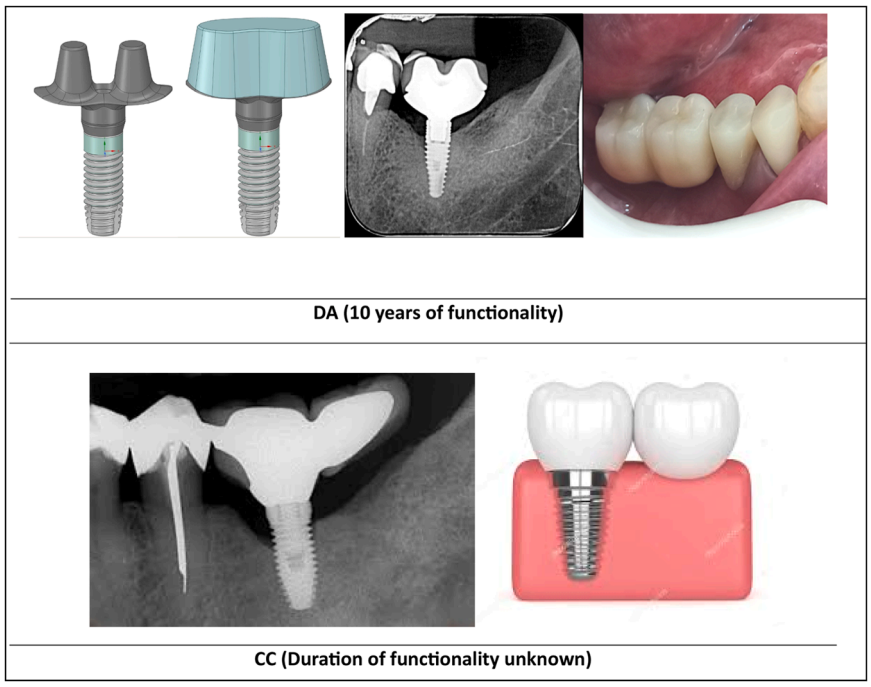

Fig. 6. Diagrammatic and clinical presentation of the use of DA and CC.

assessment, revealing excellent long-term clinical and radiographic performance of the DA. However, it is essential to consider the limitations of case series studies and FEA studies. Therefore, an integrated approach that combines simulation with experimental validation through prolonged randomized controlled clinical trials is necessary to obtain reliable and applicable conclusions for clinical practice. Furthermore, encourage future biomechanical studies that could validate the results with FEA, and also include the limitations of this study by incorporating patient-specific bone characteristics and different implant geometries.

Conclusion

The modeling conducted through FEA revealed significantly lower stress and strain distributions under both axial and oblique loads in the structures proposed for DA indicating a more favorable biomechanical behavior for DA compared to CC. These findings suggest that DA designs may reduce stress concentrations and potentially minimize the risk of clinical complications compared to traditional CC designs, thereby improving long-term implant stability and success rates in patients missing two adjacent dental elements, supported by a single osseointegrated implant.

Ethics approval statement

Not Aplicable

Patient consent statement

Not Aplicable

CRediT authorship contribution statement

Luciana Silva Colepícolo: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Paulo Henrique Vieira Magalhães:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. **Maria Auxiliadora Mourão Martinez:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Conceptualization. **Luís Otávio Miranda Cota:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation. **Rafael Paschoal Esteves Lima:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation. **Lucas Fernandes Sousa Pessoa:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation. **Guilherme Augusto Oliveira:** Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation. **Fernando Oliveira Costa:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data supporting the findings of this study are available upon reasonable request to the corresponding author.

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