**UNIVERSIDADE DE UBERABA**

**MESTRADO EM ODONTOLOGIA**

**JÚLIO CÉSAR DE CARVALHO ALVES**

# INFLUÊNCIA DO TIPO DE BRÁQUETE ORTODÔNTICO E PROTETOR BUCAL NA TENSÃO E DEFORMAÇÃO DE IMPACTO EM PACIENTES COM OVERJET POSITIVO ACENTUADO

UBERABA-MG
2017

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Dissertação apresentada como requisito para obtenção do título de Mestre em Odontologia, no Programa de Pós-Graduação em Odontologia da Universidade de Uberaba.

Área de concentração: Clínica Odontológica Integrada

Orientador: Prof. Dr. Crisnicaw Veríssimo

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**EPÍGRAFE**

A lei da mente é implacável.

O que você pensa, você cria.

O que você sente, você atrai.

O que você acredita

Torna-se realidade.

*Buda*

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À “ *DEUS* ”

Inteligência suprema, causa primária de todas as coisas!

Onisciente - Possui todo o conhecimento, toda a ciência.

Onipresente - Está em toda a parte.

Onipotente - Pode todas as coisas de forma completa e plena.

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Por serem meus pais é que dedico está obra a vocês!

“ Dirceu Alves e Maria Regina de Carvalho Alves ”

**RESUMO**

O objetivo deste estudo foi de analisar a influência da presença e composição do bráquete (metálico ou cerâmico), presença do protetor bucal na tensão e deformação em paciente com overjet acentuado positivo. Modelos bidimensionais plane strain dos incisivos centrais maxilares de um paciente com overjet acentuado positivo foram criados baseados em uma tomografia computadorizada, simulando o ligamento periodontal, suporte ósseo, tecido mole, bráquetes ortodônticos (metálico ou cerâmico) e o protetor bucal. Uma análise de elementos finitos não-linear de impacto foi realizada na qual uma esfera metálica atingiu a superfície a 1 $m.s^{-1}$. A distribuição de tensões (Von Mises e Von Mises Modificado), deformação e deslocamento do protetor bucal foram calculados. A distribuição de tensões foi afetada pela presença do bráquete e composição. Modelos com bráquete metálico e cerâmico tiveram maiores tensões sobre a área do esmalte vestibular que sofreu impacto. Modelos com bráquetes cerâmicos geraram maiores valores de tensão do que bráquetes metálicos. Protetores bucais reduziram os valores de tensão e deformação independentemente do tipo de bráquete. A capacidade de absorção de impacto foi de 88.37% e 89.27% para os bráquetes metálicos e cerâmicos, respectivamente. Não houve diferença de deslocamento do protetor bucal. A presença de bráquetes ortodônticos e a composição (metálico ou cerâmico) influenciaram a tensão e deformação gerada nos dentes durante um impacto. Bráquetes cerâmicos geraram maiores valores de tensão do que bráquetes metálicos. Protetores bucais reduziram substancialmente os picos de tensão e deformação independentemente do tipo de bráquete.

Palavras-chave: protetor bucal. biomecânica. análise por elementos finitos. má oclusão. Ortodontia

**ABSTRACT**

The aim of this study was to analyze the influence of orthodontic bracket presence and type (metallic or ceramic), and presence of a mouthguard on the stress and strain in a patient with increased positive overjet. Methods: Two-dimensional plane-strain models of a patient with increased positive overjet of the maxillary central incisor was created based on a CT scan, simulating the periodontal ligament, bone support, soft tissue, orthodontic brackets (metallic - MB or ceramic - CB) and mouthguard. A nonlinear dynamic impact finite element analysis was performed in which a steel object hit the model at 1 m.s-1. Stress distributions (Von Mises and Modified Von Mises), strain and displacement of the mouthguard were calculated. Stress distributions were affected by the bracket presence and type. Models with metallic and ceramic bracket had higher stresses over a larger buccal enamel impact area. Models with ceramic brackets generated higher stresses than the metallic brackets. Mouthguards reduced the stress and strain values regardless of bracket type. Mouthguard shock absorption were 88.37% and 89.27% for the metallic and ceramic bracket, respectively. There was no difference between the MB and CB for the mouthguard displacement. Orthodontic bracket presence and type (metallic or ceramic) influenced the stress and strain generated in the teeth during an impact. Ceramic brackets generated higher stresses than metallic brackets. Mouthguards substantially reduced impact stress and strain peaks, regardless of bracket type.

Key words: mouthguard. biomechanics. analysis by finite elements. malocclusions. orthodontics

## LISTA DE FIGURAS

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## LISTA DE ABREVIATURAS, SIGLAS E SÍMBOLOS

% - Porcentagem

FIG. – Figura

CT – Tomografia Computadorizada

mm – Unidade de Comprimento (milímetro)

m/s – Unidade de Velocidade (metro por segundo)

MPa – Força / Àrea (Mega Paschoal)

EVA – Etileno Vinil Acetato

MTG – Protetor Bucal

CB – Bráquete Cerâmico

MB – Bráquete Metálico

MEF – Método Elementos Finitos

# SUMÁRIO

# Introdução

# 1. INTRODUÇÃO E REFERENCIAL TEÓRICO

Os traumatismos dentários ocorrem com frequência durante a prática de esportes e atingem uma considerável parcela da população (Newsome *et al.*, 2001; Farrington *et al.*, 2012; Sepet *et al.*, 2014). Os traumatismos dentários podem ocasionar perdas dentárias ou danos irreparáveis, tanto no momento do trauma, como no decorrer do tratamento ou até mesmo anos após, devido às reabsorções radiculares (Newsome *et al.*, 2001; Andersson *et al.*, 2016; Diangelis *et al.*, 2016; Malmgren *et al.*, 2016). Os traumas ocasionados pela prática esportiva representam 14 a 39% das causas do traumatismo dentário e correspondem ao terceiro atendimento de traumas faciais (Sane & Ylipaavalniemi, 1988).Traumatismos dentários associados as estruturas adjacentes de suporte acometem indivíduos em todas as faixas etárias acarretando comprometimento crítico e danoso ao órgão dental e tecidos de suporte, desde trincas do esmalte dentário, avulsão e fratura do complexo dento-alveolar (Andreasen JO, *et al.*,2016). As protrusões maxilares e overjet proeminentes associadas à ausência de selamento labial passivo, com exposição dentária, são fatores de risco para traumatismos (Borzabadi-Farahani & Borzabadi-Farahani, 2011; Thiruvenkatachari *et al.*, 2015). A literatura fornece evidências de que um overjet acentuado de 6 ou 7 mm aumenta o risco de trauma dental, e quando o overjet é maior que 6 mm, frequentemente as consequências do trauma dental são mais severas (Borzabadi-Farahani & Borzabadi-Farahani, 2011; Thiruvenkatachari *et al.*, 2015). Pacientes com má-oclusões de Classe II com trespasse horizontal positivo são mais suscetíveis a sofrer lesões dentárias devido à protrusão dos incisivos superiores. Essas má-oclusões ou deformidades esqueléticas estão associadas, e podem ser classificadas em dois subgrupos clinicamente relevantes. A) Projeção anterior dos dentes maxilares (Overjet), B) Relação de discrepância entre as bases ósseas dos maxilares (maxila e mandíbula) (Thiruvenkatachari *et al.*, 2015).

A maioria dos pacientes com aumento do overjet positivo são submetidos a tratamento ortodôntico com aparelhos fixos durante a infância ou a adolescência (Owtad *et al.*, 2015) (Thiruvenkatachari *et al.*, 2015). Há indícios de que a composição dos bráquetes ortodônticos pode estar relacionada com dano da estrutura dentária frente a impactos e durante a remoção dos bráquetes (Yapel & Quick, 1994). Estudos afirmam que a aplicação de carga em altas velocidades em bráquetes metálicos ou cerâmicos estão associados a risco de danos ao esmalte dentário. Os bráquetes de cerâmica, quando submetidos ao impacto dissipam rapidamente as tensões podendo oferecer riscos de fraturas no esmalte dentário quando comparados com bráquetes metálicos (Yapel & Quick, 1994). Atualmente, existe preferência dos pacientes por aparelhos fixos estéticos confeccionados com materiais cerâmicos. No entanto não existem evidências da presença dos bráquetes e composição na geração de tensões durante um impacto.

As lesões orofaciais podem ser evitadas com protetores bucais (Newsome *et al.*, 2001; Owtad *et al.*, 2015). Os protetores bucais são dispositivos intra-orais usados para diminuir a tensão e deformação gerados durante um impacto e prevenir lesões dentárias (Verissimo *et al.*, 2017). Apesar das recomendações de que todos os pacientes ortodônticos que participam de esportes de contato devem utilizar um protetor bucal para proteger dentes e estruturas adjacentes de lesões faciais, muitos pacientes ignoram essa recomendação (Bussell & Barreto, 2014). Atenção especial deve ser destinada para pacientes em tratamento ortodôntico associado ao uso de protetor bucal (Borzabadi-Farahani & Borzabadi-Farahani, 2011; Bussell & Barreto, 2014). Os pacientes ortodônticos recebem um protetor bucal personalizado com alívio na superfície vestibular interna criado com diferentes materiais e técnicas, usando cera utilidade, materiais elastoméricos ou tubos de plástico (Croll & Castaldi, 2004; Maeda *et al.*, 2008). O espaço interno é projetado para manter a biomecânica ortodôntica durante a utilização do protetor bucal. Mesmo com este espaço interno, a estabilidade e o ajuste adequado de um protetor bucal na cavidade bucal devem ser sempre assegurados, sendo imprescindível para o seu bom funcionamento. Entretanto, são necessários mais estudos para a prática clínica baseada em evidências científicas, e sobre as recomendações sobre o uso de protetores bucais para pacientes em tratamento ortodôntico, bem como conhecimento sobre os mecanismos de fratura, tipos de materiais para confecção de protetor bucal e métodos confecção (Fields & Christensen, 2013) Para atletas que usam aparelhos ortodônticos fixos, um protetor bucal personalizado e adaptado intimamente aos dentes pode prevenir e minimizar lacerações intraorais e contusões (Pacheco *et al.*, 2010).

O método de elementos finitos foi desenvolvido na engenharia entre os anos de 1950 e 1960, desde então o método vem sendo extensamente utilizado em diversas áreas do conhecimento. Durante este período o enfoque principal era a indústria aeroespacial, porém a partir de 1960 surgiram os primeiros softwares comerciais, e após este período, novos softwares foram desenvolvidos. Este método é considerado como sendo o mais compreensível para calcular a complexa condição da distribuição das tensões em diversos materiais, inclusive nos odontológicos, proporcionando dados valiosos com custo operacional relativamente baixo e tempo reduzido (Versluis & Versluis-Tantbirojn, 2011). Na odontologia o potencial do MEF é comprovado em numerosos estudos com análises bidimensionais e tridimensionais. O método de elementos finitos, através da análise dinâmica de impacto, tem sido utilizado para avaliação da biomecânica de protetores bucais e capacidade de absorção de impacto de protetores bucais com validação experimental (Verissimo *et al.*, 2016a; Verissimo *et al.*, 2016b; Verissimo *et al.*, 2017).

Vários estudos avaliaram o comportamento biomecânico dos protetores bucais e do traumatismo dentário (Takeda *et al.*, 2004a; Takeda *et al.*, 2004b; Bhalla *et al.*, 2013; Ozawa *et al.*, 2014; Verissimo *et al.*, 2016a; Verissimo *et al.*, 2016b; Verissimo *et al.*, 2017) no entanto, poucos estudos avaliaram a biomecânica do trauma dental em pacientes ortodônticos com aumento do overjet positivo, bem como o uso de um protetor bucal. Portanto, os mecanismos de absorção de choque dos protetores bucais e as distribuições de tensão sobre as estruturas dentárias em usuários de aparelho ortodôntico ainda não estão claros. Diante do referencial teórico apresentado, o objetivo do presente estudo foi avaliar pelo método de elementos finitos a influência da presença de bráquetes ortodônticos, tipo e composição (metálico ou cerâmico) na distribuição de tensões, deformação e capacidade de absorção de choques do protetor bucal personalizado em um paciente com overjet positivo acentuado durante impacto horizontal.

# Objetivo

# 2. OBJETIVO

## 2.1. Objetivo geral

Utilizar uma análise dinâmica não-linear de impacto por elementos finitos para avaliar a influência da presença e composição de bráquetes ortodônticos e presença de protetor bucal na deformação, tensão, capacidade de absorção de impacto e deslocamento do protetor bucal em paciente com overjet positivo acentuado.

## 2.2. Objetivo específico

Avaliar a influência da presença e composição de bráquetes ortodônticos e presença de protetor bucal na deformação, tensão, capacidade de absorção de impacto e deslocamento do protetor bucal em paciente com overjet positivo acentuado de acordo com os seguintes fatores em estudo:

a) Presença e composição de bráquetes ortodônticos em três níveis:

1- Sem bráquete.

2- Com bráquete ortodôntico metálico.

3- Com bráquete ortodôntico cerâmico.

a) Presença do protetor bucal em dois níveis:

1- Sem protetor bucal.

2- Com protetor bucal.

# Capítulo Único

# 3. Capítulo Único - INFLUENCE OF ORTHODONTIC BRACKET TYPE AND MOUTHGUARD ON THE IMPACT STRESS AND STRAIN IN PATIENTS WITH INCREASED POSITIVE OVERJET.

PREVENTION AND SPORTS DENTISTRY

Manuscript Type: Original Article

Title: Influence of orthodontic bracket type and mouthguard on the impact stress and strain in patients with increased positive overjet.

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**Abstract**

*Background/Aim*: The aim of this study was to analyze the influence of orthodontic bracket presence and type (metallic or ceramic), and presence of a mouthguard on the stress and strain in a patient with increased positive overjet. *Methods:* Two-dimensional plane-strain models of a patient with increased positive overjet of the maxillary central incisor was created based on a CT scan, simulating the periodontal ligament, bone support, soft tissue, orthodontic brackets (metallic - MB or ceramic - CB) and mouthguard. A nonlinear dynamic impact finite element analysis was performed in which a steel object hit the model at 1 $m.s^{-1}$. Stress distributions (Von Mises and Modified Von Mises), strain and displacement of the mouthguard were calculated. *Results:* Stress distributions were affected by the bracket presence and type. Models with metallic and ceramic bracket had higher stresses over a larger buccal enamel impact area. Models with ceramic brackets generated higher stresses than the metallic brackets. Mouthguards reduced the stress and strain values regardless of bracket type. Mouthguard shock absorption were 88.37% and 89.27% for the metallic and ceramic bracket, respectively. There was no difference between the MB and CB for the mouthguard displacement. *Conclusion:* Orthodontic bracket presence and type (metallic or ceramic) influenced the stress and strain generated in the teeth during an impact. Ceramic brackets generated higher stresses than metallic brackets. Mouthguards substantially reduced impact stress and strain peaks, regardless of bracket type.

**Key words:** mouthguard; biomechanics; finite element analysis; orthodontics; impact absorption ability.

## 1. Introduction

Dental and oral facial injuries are common during sports practice (1-3). Some studies showed that there is a higher risk for dental traumas in patients with malocclusions that are undergoing orthodontic treatment (4). Class II malocclusions with positive overjet are more susceptible to sustain dental injuries because of the maxillary incisor protrusion. These malocclusions or skeletal deformities are associated and can be classified into two clinically relevant subgroups. A) Anterior projection of the maxillary teeth (Overjet); and B) Relationship of discrepancy between the maxillary bones (maxilla and jaw) (5). Maxillary protrusions are also associated with inadequate or poor lip coverage that also increases the risk for anterior dental trauma. It is reported that an overjet larger than 6 or 7 mm increases the risk for dental trauma, and when the overjet is more than 6 mm, frequently the consequences of the dental trauma are more severe (5).

Most of the patients with increased positive overjet are subjected to orthodontic treatment with fixed appliances during the childhood or adolescence (5, 6). There is some indication that the composition of orthodontic brackets could be related to tooth structure damage in front of a high speed blow (7). Orofacial injuries can be prevented by wearing mouthguards (1, 6). Mouthguards are intraoral devices used to decrease the stress and strain generated during an impact and prevent dental injuries (8-10). Despite the recommendations that all orthodontics patients participating in contact sports should wear a mouthguard to protect teeth and adjacent structures of oral-facial injuries, many patients disregard this important advice (11).

Special attention has been given to mouthguards for patients undergoing active orthodontic treatment (4, 11). Orthodontic patients will receive a custom-fitted mouthguard with an internal space for the brackets created with different materials and techniques, using wax, elastomeric materials or tube materials (12-15). The internal space is designed to maintain orthodontic biomechanics while wearing the mouthguard. Even with this internal space, stability and proper fit of a mouthguard in the oral cavity must be always be ensured because it is crucial for their proper functioning. Recommendations regarding mouthguard use for active orthodontics patients, biomechanical knowledge about fracture mechanisms, types of mouthguard materials, and methods of construction are necessary for more evidence-based practice (16).

Several studies evaluated the biomechanical behavior of mouthguards and dental trauma (10, 17, 18), however few studies evaluated the biomechanics of the dental trauma in orthodontics patients with increased positive overjet as well as the use of a mouthguard. Therefore, shock absorption mechanisms of mouthguards and stress distributions over tooth structures with bonded brackets are still unclear. The aim of this study was to use finite element impact analysis to analyze the influence of orthodontic bracket presence, type (metallic or ceramic), and mouthguard presence on stresses, strains, mouthguard shock absorption ability, and mouthguard displacement in patients with increased positive overjet during a horizontal (frontal) impact.

## 2. Material and Methods

*Two-dimensional patient specific dynamic finite element impact analysis*

One patient was selected for this study at the orthodontics residence of the University of Uberaba – UNIUBE (Fig. 1) with approval of the Ethics Committee (Protocol Number 58913316.7.0000.5145). The patient went through clinical examination in order to confirm the positive overjet and poor lip coverage (Fig 1A, 1B and 1C). Cephalometric analysis was carried out to confirm the 6mm overjet. After the orthodontic appliance bonding procedure (Fig. 1D, 1E and 1F) the patient was immediately submitted to a Computed Tomography (CT) scan. After that, the patient also received a custom-fitted mouthguard (Fig. 1G, 1H and 1I). Using the CT scan, a two-dimensional image was created of the selected patient, showing in cross-section the with increased overjet maxillary central incisor, periodontal ligament, bone support (cortical and trabecular bone), soft tissue, orthodontic bracket and mouthguard (MTG) (Fig. 2A).

The image was exported to image processing and analysis software (Image J, public domain, National Institute of Health, Bethesda, MD, USA) for tracing coordinates of the tissue outlines in the maxillary structures (Fig. 2B). The coordinates obtained were imported into a finite element analysis program (Marc/Mentat, MSC software, Santa Ana, CA, USA). Cubic-spline curves were drawn through these coordinates to recreate the tissue outlines (Fig. 2C). Five models were created for this study: Model without bracket/MTG (Fig. 2D); Models with metallic bracket - MB (Fig. 2E and 2F); with ceramic bracket - CB (Fig. 2F); Models with metallic bracket and mouthguard (MB-MTG) (Fig. 2G) and Models with ceramic bracket and mouthguard (CB-MTG) (Fig. 2H), following the methodology described by Veríssimo et al. (9). Metallic and ceramic brackets had the same geometrical form but different mechanical properties as shown in the Table 1. The mouthguard was created with 3 mm thickness. The element mesh was manually created using four-node isoparametric arbitrary quadrilateral plane strain elements with reduced integration (Fig 1I). This type of element has a single integration point. Frictionless contact was prescribed between the mouthguard and the model interface. Separation of the mouthguard was allowed during the impact. All other interfaces were bonded. The Single-Step Houbolt method was used for the dynamic impact analysis. This method is recommended for implicit dynamic contact analyses. Impact with a steel object (10 mm radius) moving at 1.0 m/s initial velocity in horizontal direction was simulated (Fig. 1J). The impact object was unrestrained after the initial velocity was applied. Gravitational forces were not modeled. Nodes on the base of the bone structure were rigidly fixed in the X and Y directions (Fig. 1J). All materials were considered linear-elastic, isotropic and homogeneous. The mechanical properties (elastic modulus, Poisson's ratio and material density) are shown in Table 1.

Each model was solved in Marc. The results were recorded until the impact object lost contact with the enamel, bracket or mouthguard. A custom-made software subroutine collected the strain values in the Y direction for one node on the palatal side. Mouthguard shock absorption ability (%) was calculated defined as the percentage of strain compared to the peak strain value of the model without mouthguard and brackets (MB and CB). This subroutine also recorded the 10% highest stresses in the enamel and dentin during the impact. Stress distributions were analyzed for Von Mises equivalent stresses, which integrate all stress components into one stress equivalent value. To take into account that some materials are stronger in compression than in tension, Modified Von Mises stresses were also determined to show the significance of tensile stress components for models without mouthguard (19). The applied compressive and tensile strength values for enamel were 384.0 and 10.3 MPa and for dentin 297.0 and 98.7 MPa, respectively (19).

Finally, the movement of the mouthguard over the tooth during impact was evaluated. The distances between nodes on the mouthguard surface and on the tooth surface were calculated to characterize the relative mouthguard movement (mm) by the formula: $d = \sqrt{\{(x2 - x1)^2 + (y2 - y1)^2\}}$, where "$d$" is the mouthguard displacement away from the tooth, $x_1$ and $y_1$ are the x- and y- coordinates of the node at the tooth surface, and $x_2$ and $y_2$ are the coordinates of a corresponding node on the mouthguard surface (Fig. 7A).

## 3. Results

Stress distributions by Von Mises criterion in the models without bracket/MTG, MB, CB, MB-MTG and CB-MTG, at the peak of the impact are shown in Fig. 3. The stress values are shown according to a linear color scale, where blue indicates the lowest stress values, yellow and light gray the highest stress values. The mean of the 10% highest stresses for enamel and dentin for the models without bracket/MTG, MB, CB, MB-MTG and CB-MTG, during the impact analysis are shown in Fig. 4. Stress distributions were affected by the bracket presence and type (Fig. 3). The models with MB and CB concentrated higher stresses over a larger area at the impacted buccal enamel area (Fig. 3B and 3C). Stresses for the model without bracket/MTG (Fig. 3A) were concentrated at the buccal enamel and palatal surface. The model with CB had the highest stress values, higher than the MB and without bracket/MTG, during the impact at the enamel surface (Fig. 4). In the dentin structure there was no substantial effect for the bracket presence/type (ceramic or metallic) (Fig. 4). For the models MB-MTG (Fig. 3C) and CB-MTG (Fig. 3E), the location of the stress concentrations changed to the root regardless the type of orthodontic bracket. The analysis also showed lower stress values for the models with mouthguard compared to the models MB, CB and without bracket/MTG (Fig. 4).

Modified Von Mises stress distributions in the models without bracket/MTG, MB, CB, MB-MTG and CB-MTG, at the peak of the impact, are shown in Fig. 5. The models with metallic and ceramic brackets concentrated more tensile stresses at the palatal surface and over a larger area. The model with ceramic bracket had higher stress values (Fig. 5C). The history plot for the strain values during the impact collected on the palatal side of the tooth are shown in Fig. 6. Models without bracket/MTG, CB and MB generated higher strain values during the impact. The model without bracket/MTG reached higher strain values compared to MB and CB. The model with a ceramic bracket exhibited higher strain values compared to the model with a metallic bracket. The strain history plot also showed that the time to reach the peak strain was longer for the mouthguard models. The mouthguard shock absorption capability values were 88.37% for the metallic bracket (Fig. 6A) and 89.27% for the ceramic bracket (Fig 6B). There was no difference between the MB and CB for mouthguard displacement (Fig. 7). Displacements of the mouthguard were higher at the palatal surface.

**4. Discussion**

The results of our study show that mouthguards can significantly decrease the stress and strain values in the teeth with fixed orthodontic appliances, either metallic or ceramic. Nowadays, with the high demand for aesthetics and well aligned teeth, aesthetic orthodontic appliances (sapphire, composite or ceramics) are ubiquitous. Oral and facial traumas are common occurrences that affect people in deciduous, mixed and permanent dentition phases, often with severe aesthetic, functional, psychological and economic consequences (10). Increased positive overjet malocclusions are more prone to anterior trauma because of the anterior projection of the teeth and poor lip coverage (5, 6). Most of these conditions can be fully corrected by orthodontic treatment during childhood or adolescence (5). Some studies have reported that during the orthodontic treatment patients are also more susceptible to dental trauma and soft tissue traumas because of the bracket-wire presence. There is no consensus in the literature that the bracket can potentiate or influence the stresses and strains generated in the teeth during an impact. There is also little information about mouthguard biomechanics for patients during orthodontic treatment. Therefore, this study evaluated the influence of orthodontic bracket presence, type (metallic or ceramic), and mouthguard presence on stresses and strains, shock absorption ability, and mouthguard displacement in a patient with increased positive overjet, during a frontal impact.

This study used a specific-patient nonlinear dynamic finite element analysis (19) to evaluate the stress distributions and strains during a simulated impact of the patient-specific model, assuming a plane strain condition in the modeled cross-section. Although the model is 2D, the plane strain assumption represents a three-dimensional condition that may occur in the cross section of a structure with considerable thickness out of the plane, which is true for a cross section where the strain perpendicular to the cross-sectional plane is zero (19). The plane strain condition also simulated the orthodontic brackets attached to neighboring teeth. In a previous validation study, it was shown that despite the simplifications in stress-strain conditions and tissue properties, the finite element impact simulation showed a similar behavior as observed in an *ex vivo* impact experiment (10).

The Von Mises stress distributions were affected by the presence and type of orthodontic brackets during impact with a rigid object (Fig. 3). The models with orthodontic brackets showed high stress levels at the enamel and buccal surface over a larger area. On the other hand, the model without bracket and mouthguard concentrated higher stresses over a smaller area. This can be explained by the fact that the impact object hit different surfaces with same velocity. In this situation, the models with the orthodontic brackets (metallic or ceramic) will redistribute the stresses in a larger area of the enamel. Yapel and Quick evaluated the traumatic debonding of orthodontic brackets (metallic and ceramic) and they found that bracket debonding by impact forces presents a high risk of enamel damage, which supports our Von Mises and Modified Von Mises stress results (7). The high stress concentrations on the buccal enamel can be related to the reported enamel damage. Stresses in the dentin structure were not affected by the orthodontic bracket, regardless of bracket type (Fig. 4). This can be explained by the distance, composition, modulus of elasticity, density, structure morphology between the impacted bracket and dentin structure morphology. The enamel will have redistributed the impact forces before they reach the dentin, thus it makes little difference for the dentin if there was an orthodontic bracket or not. The Modified Von Mises stress distributions showed that the orthodontic brackets could increase the tensile stresses in the tooth structure, especially in the enamel and particularly for the ceramic bracket. This can be explained by the higher elastic modulus of this bracket material that will transfer more of the initial impact energy to the enamel. Studies discussed that ceramic brackets, because of their brittle behavior, may offer some protection by shattering in front of an impact load (7). Bracket shattering was not modeled in this analysis. However, any advantageous impact energy dissipation it may offer depends on the shattering to happen before the impact stress peak has reached the enamel.

Mouthguards are intraoral devices made by Ethylene Vinyl Acetate (EVA) that can decrease the stress and strain in the tooth structure during impact and prevent dental trauma (1, 9, 10). These devices are very important for sports practitioners who are under orthodontic treatment. Orthodontics societies and clinicians recommend that all orthodontic patients with fixed appliances wear mouthguards when playing contact sports. It is also recommended that these mouthguards are custom-fitted for their individual appliances. After the mouthguard fabrication, an orthodontist should check the fit and ensure that it does not interfere with the dental movements (11). Orthodontic clinicians who recommend the use of a mouthguard should consider a variety of factors, including the type of sport practiced, the type of malocclusion and overjet, the level and frequency of the game, previous history of trauma, and lip coverage (11). The current study indicated that the mouthguards reduced the stress and strain values in both enamel and dentin, regardless of the type of orthodontic brackets (Fig 3C and 3E). The EVA material of the mouthguards absorbed most of the impact deformation, which increased the time to absorb and redistribute the impact forces and thus decreased the stress and strain on the tooth structure (Fig 6). The presence of a mouthguard therefore allowed the impact stresses to be distributed through the dentin structures into the bone, which resulted in lower strain values at the palatal side of the crown. The mouthguard also reduced stresses between bracket and enamel, which can prevent the debonding or fracture of the orthodontic bracket itself, and thus not disrupt the orthodontic treatment. The lower values of traction and deformation obtained in the analysis are related to distance from the data collection site, since measurements were made on the vestibular face of the tooth.

Were observed that shock absorption ability was lower than 90%. Veríssimo et al. reported levels for custom-fitted mouthguards shock absorption ability ranging from 95 to 98% based on finite element analysis studies and experimental impact tests of teeth without brackets (8-10). The presence of the space created for the orthodontic bracket and the overjet condition thus slightly reduced the effectiveness of the mouthguard protection. It is obvious that a custom-fitted mouthguard made for a patient with orthodontic brackets has less retention and fit because the brackets should be isolated or fully covered during the impression procedure. This reaffirms that the orthodontic clinician should always check the fit and adaptation of a mouthguard. Mouthguard displacement is an important factor because these devices need to be in proper position to play their role. Our results showed that there was no difference in mouthguard displacement for the type of brackets, but the pattern of displacement was different from previously reported conventional custom-fitted mouthguards (9). The mouthguards custom-fitted in this study to accommodate brackets had higher displacements at the palatal side.

Therefore, it is crucial that the orthodontic clinician evaluates the risk of a patient for dental trauma, especially during sport practices, and indicate the use of a custom-fitted EVA mouthguard in order to decrease the risk of dental and orofacial injuries.

## 5. Conclusion

From the results of this study it can be concluded that orthodontic bracket presence and type influenced the stress and strain generated in the teeth when impacted with a rigid object. Ceramic brackets generated higher stresses than metallic brackets. Mouthguards reduced peak stresses and strains in the impacted tooth regardless of bracket type. In addition, considering the results of this finite element analysis, mouthguards should be provided for all patients contact sports practitioner in orthodontic treatment with fixed appliances and also for any contact sportsmen.

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**Tables**

Table 1. Mechanical properties applied for the dental structures and materials.

| Structure | Elastic Modulus (MPa) | Poisson's ratio | Density (g/cm$^3$) | References |
|---|---|---|---|---|
| Enamel | 84,100 | 0.30 | 2.14 | (20) |
| Dentin | 18,600 | 0.30 | 2.97 | (21) |
| Periodontal ligament | 50 | 0.45 | 0.95 | (22) |
| Trabecular bone | 1,400 | 0.31 | 0.70 | (23) |
| Cortical bone | 13,700 | 0.33 | 2.00 | (23) |
| Soft tissue | 1.8 | 0.30 | 0.9 | (15) |
| EVA | 18.075 | 0.30 | 0.95 | (9, 24) |
| Steel | 200.000 | 0.30 | 7.8 | (25) |
| Ceramic bracket | 380.000 | 0.30 | 3.4 | (26) |
| Metallic bracket | 210.000 | 0.30 | 7.8 | (26) |

**Figures Legends**

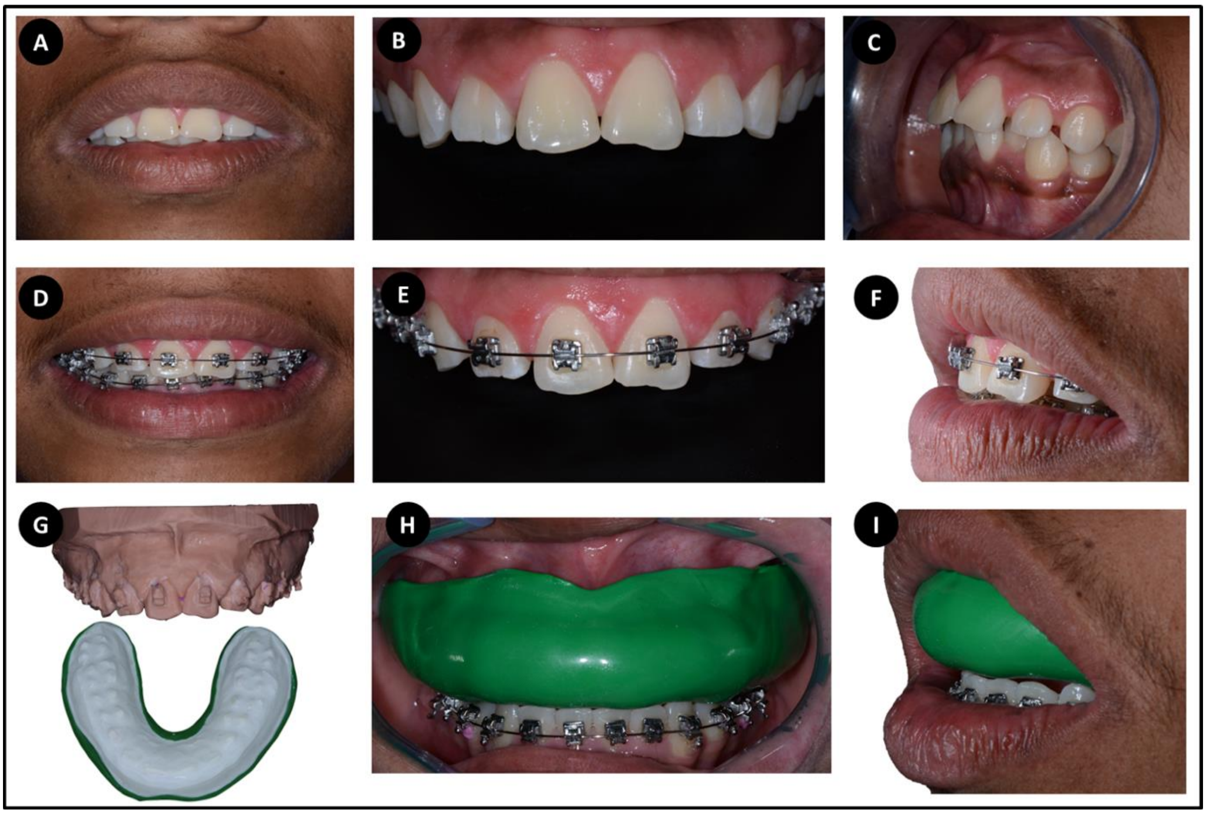


**Figure 1.** Patient with increased positive overjet selected for finite element impact analysis with and without the orthodontic appliance. (a) Frontal view and poor lip coverage; (b) Intra-oral view without the orthodontic appliance; (c) Lateral view showing the increased positive overjet; (d) Frontal view and poor lip coverage with the orthodontic appliance installed; (e) Intra-oral view with the orthodontic appliance installed; (f) Lateral view showing the increased positive overjet after the orthodontic procedure. (g) Custom-fitted mouthguard for an orthodontic patient; (h and i) Orthodontic patient wearing a custom-fitted mouthguard.

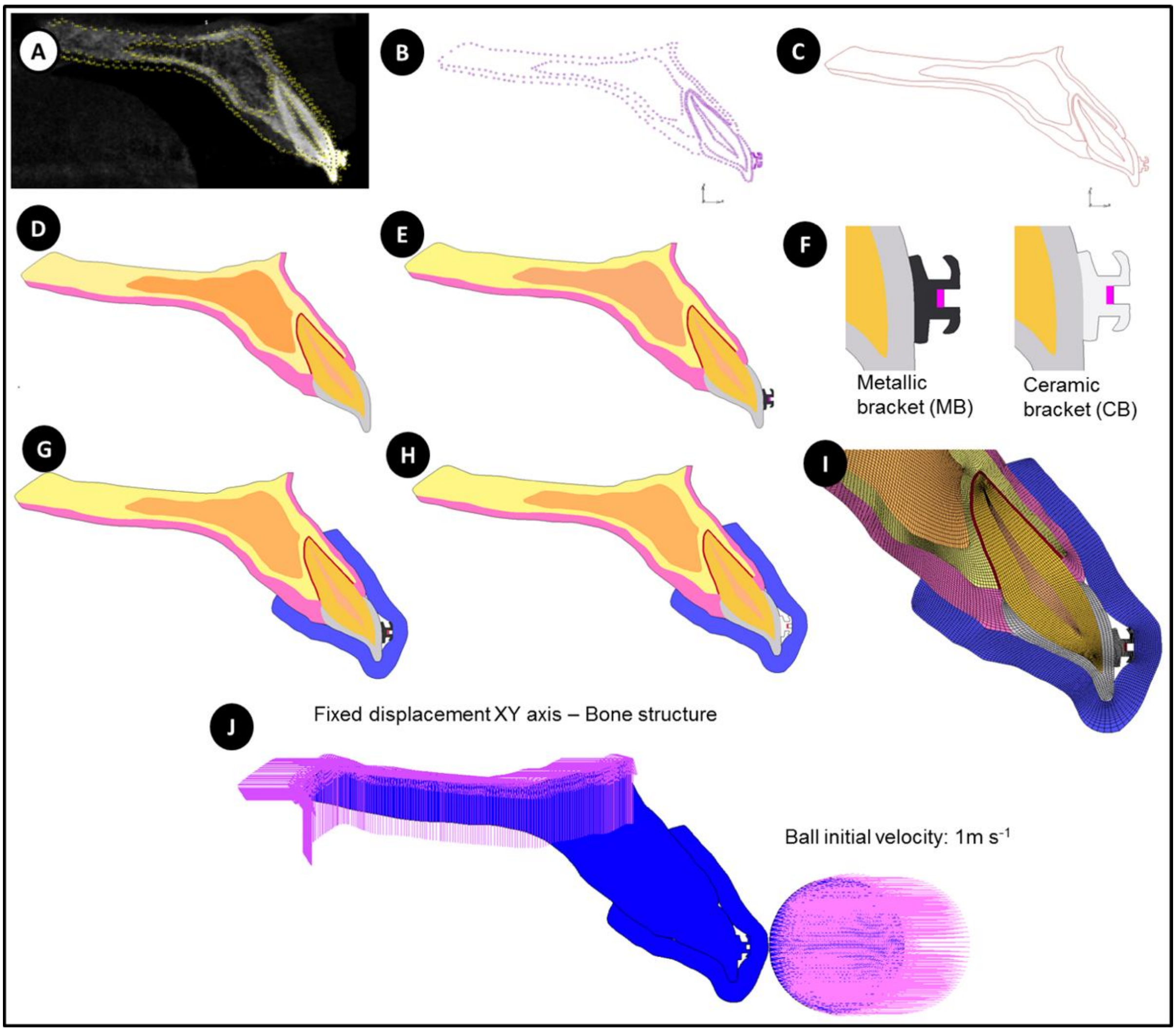


**Figure 2.** Generation of two-dimensional finite element models. (a) maxillary central incisor CT-tomography image of the selected patient immediately after the orthodontic appliance installation; (b) coordinates of the CT image imported from Image J; (c) cubic-splines curves generated from the imported coordinates; (d) model without bracket/MTG; (e) and (f) model with metallic (MB) and ceramic bracket (CB); (g) model with metallic bracket and mouthguard (MB-MTG); h) model with ceramic bracket and mouthguard (CB-MTG); (i) finite element mesh distribution; (j) boundary conditions.

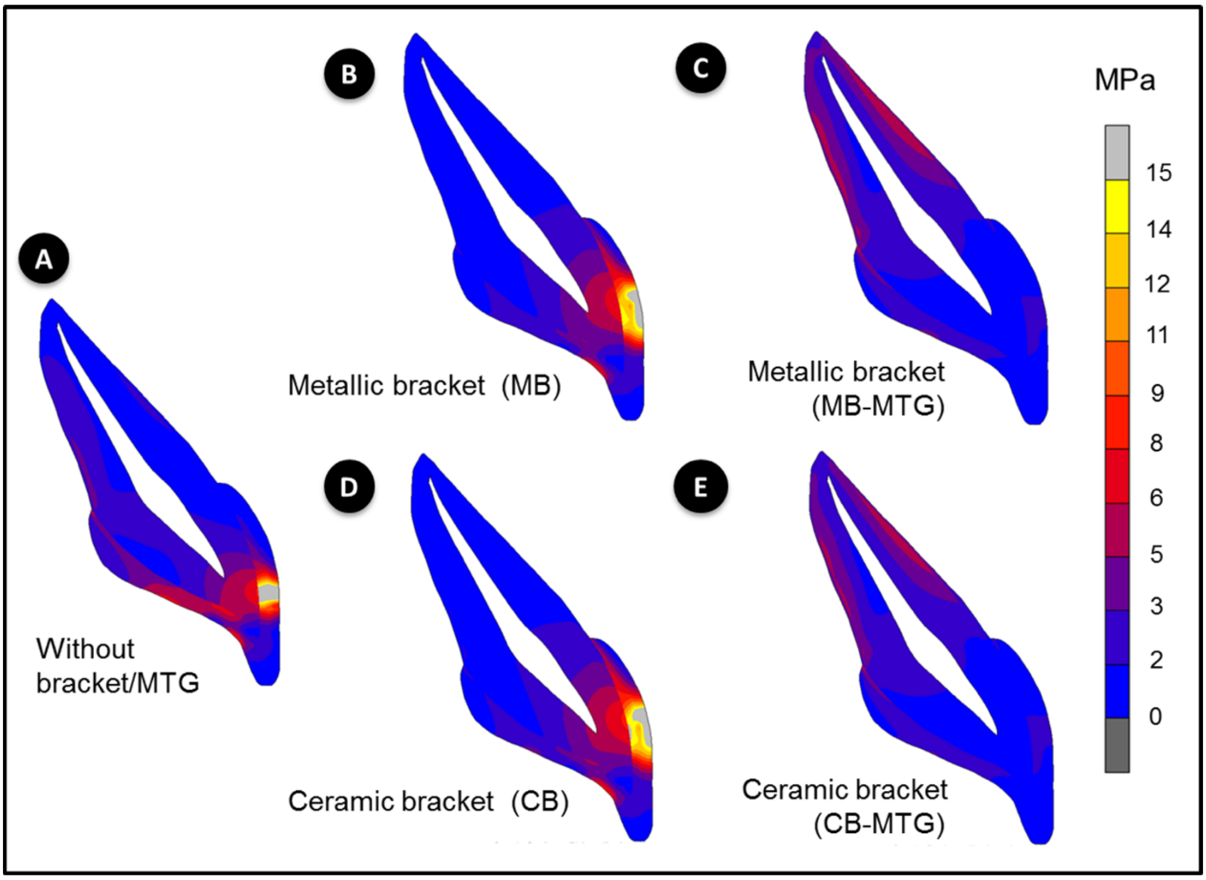


**Figure 3.** Von Mises stress distributions at the peak of the impact. (a) model without bracket/MTG; (b) metallic bracket without mouthguard (MB); (c) metallic bracket with mouthguard (MB-MTG); (d) ceramic bracket without mouthguard (CB); (e) ceramic bracket with mouthguard (CB-MTG).

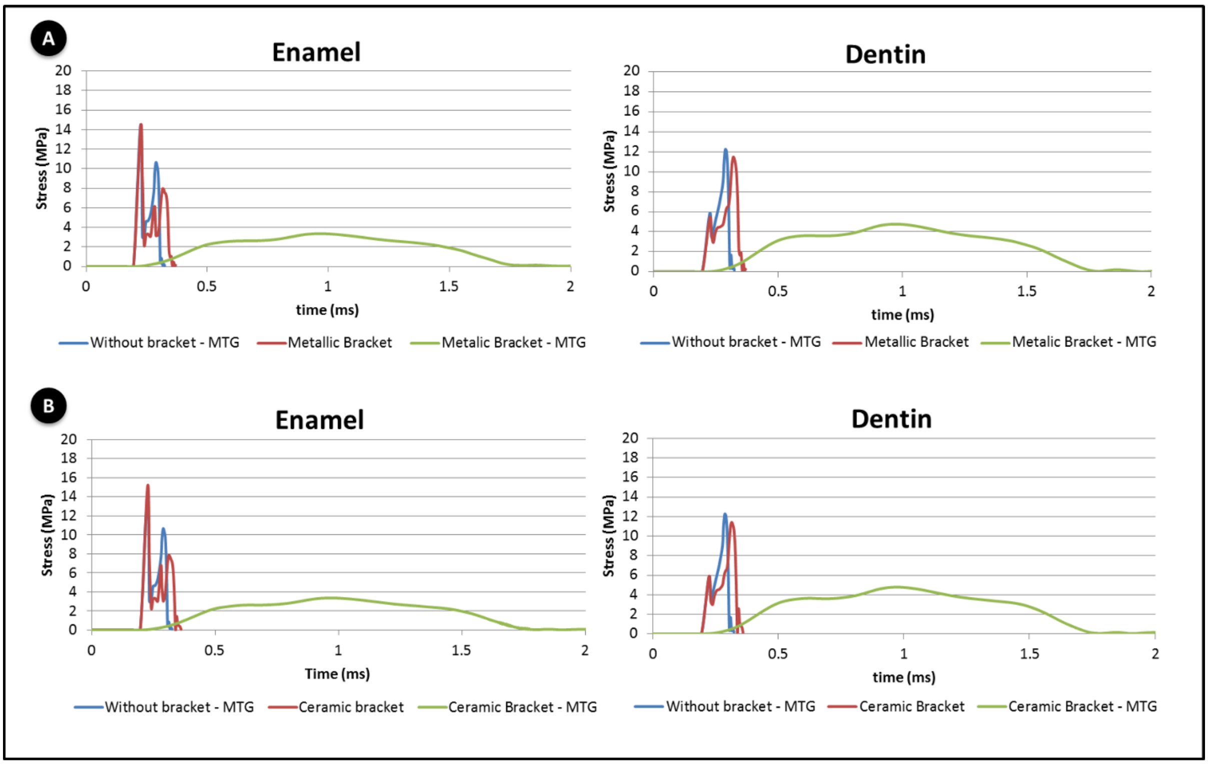


**Figure 4.** Mean of the 10% highest stress values (Von Mises) for enamel and dentin during the impact. (a) comparison between the models without bracket – MTG, metallic bracket (MB) and Metallic bracket with mouthguard (MB-MTG); (b) comparison between the models without bracket – MTG, ceramic bracket (CB) and ceramic bracket with mouthguard (CB-MTG).

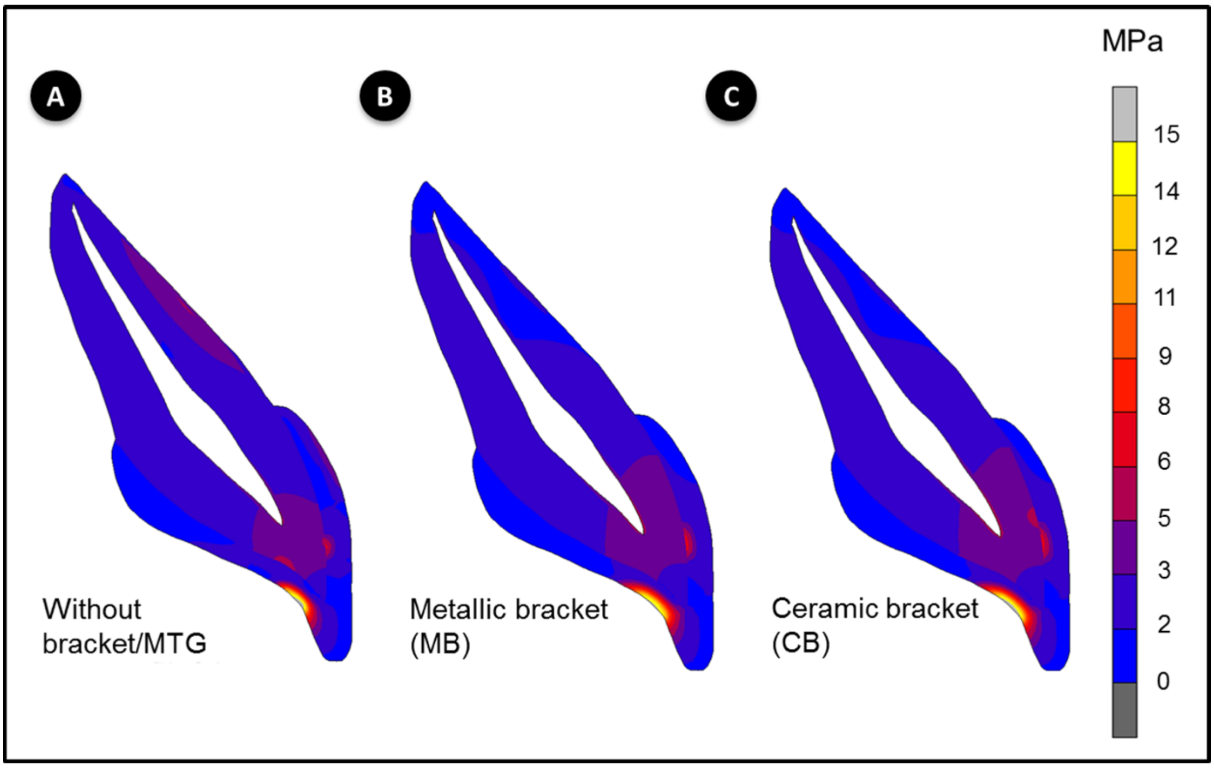


**Figure 5.** Modified Von Mises stress distributions at the peak of the impact for the models without mouthguard. (a) without bracket/MTG; (b) metallic bracket (MB) and (c) ceramic bracket (CB).

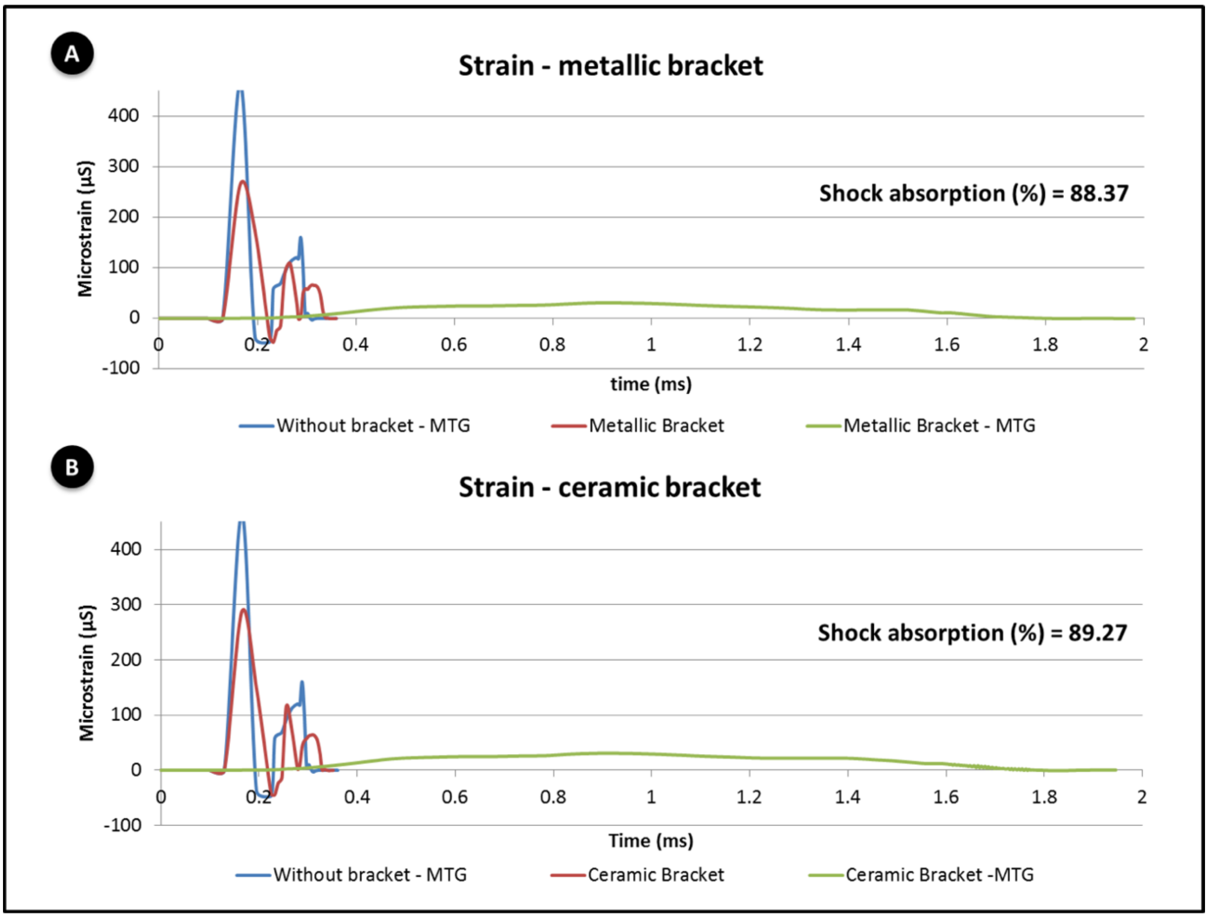


**Figure 6.** History plot for the strain values at the palatal side of the tooth and mouthguard shock absorption (%). (a) metallic bracket (MB) and (b) ceramic bracket (CB).

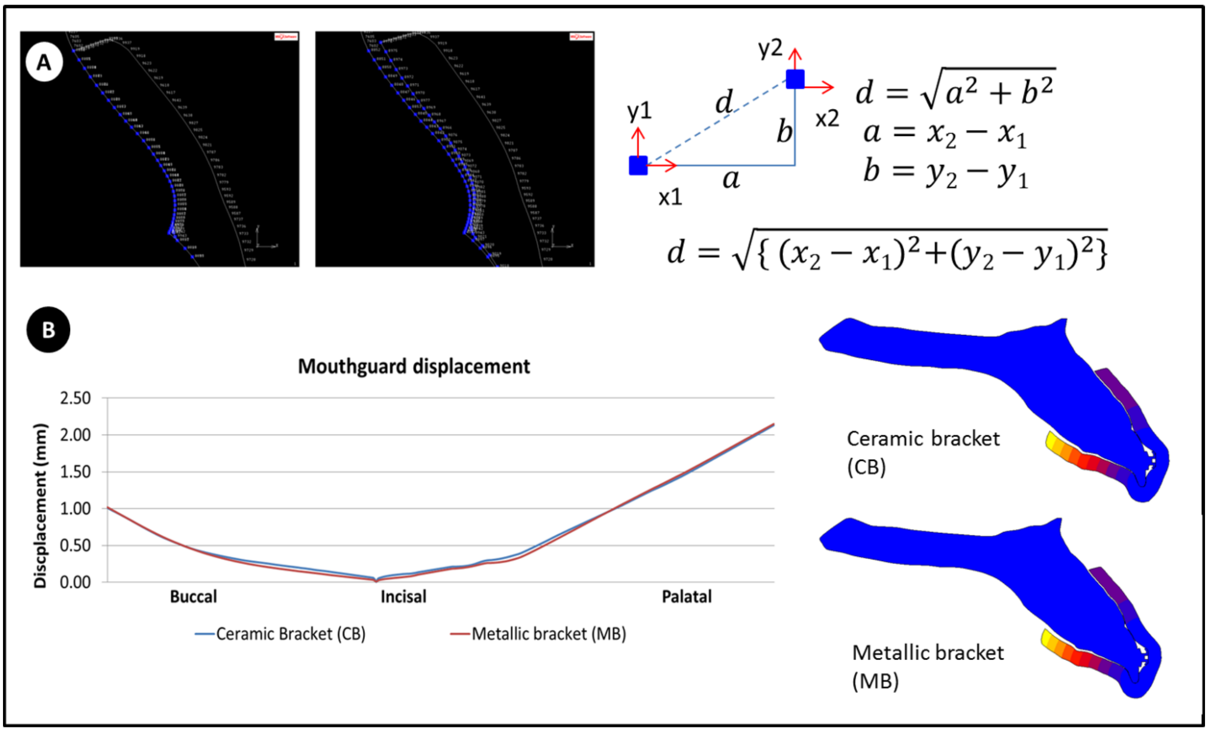


**Figure 7.** Path plot of the mouthguard displacement (mm) at the end of the impact. (a) Formula used for the displacement calculation; (b) displacement distribution.

# Conclusão

## 4. CONCLUSÃO

Baseado nos resultados deste estudo computacional as seguintes conclusões podem ser descritas:

1. A presença e o tipo de bráquete ortodôntico influenciaram na distribuição de tensão nos dentes quando submetidos a impacto frontal com um objeto rígido.
2. Os bráquetes cerâmicos geraram maiores tensões do que os bráquetes metálicos.
3. O protetor bucal reduziu as tensões máximas geradas independentemente do tipo de bráquete ortodôntico.

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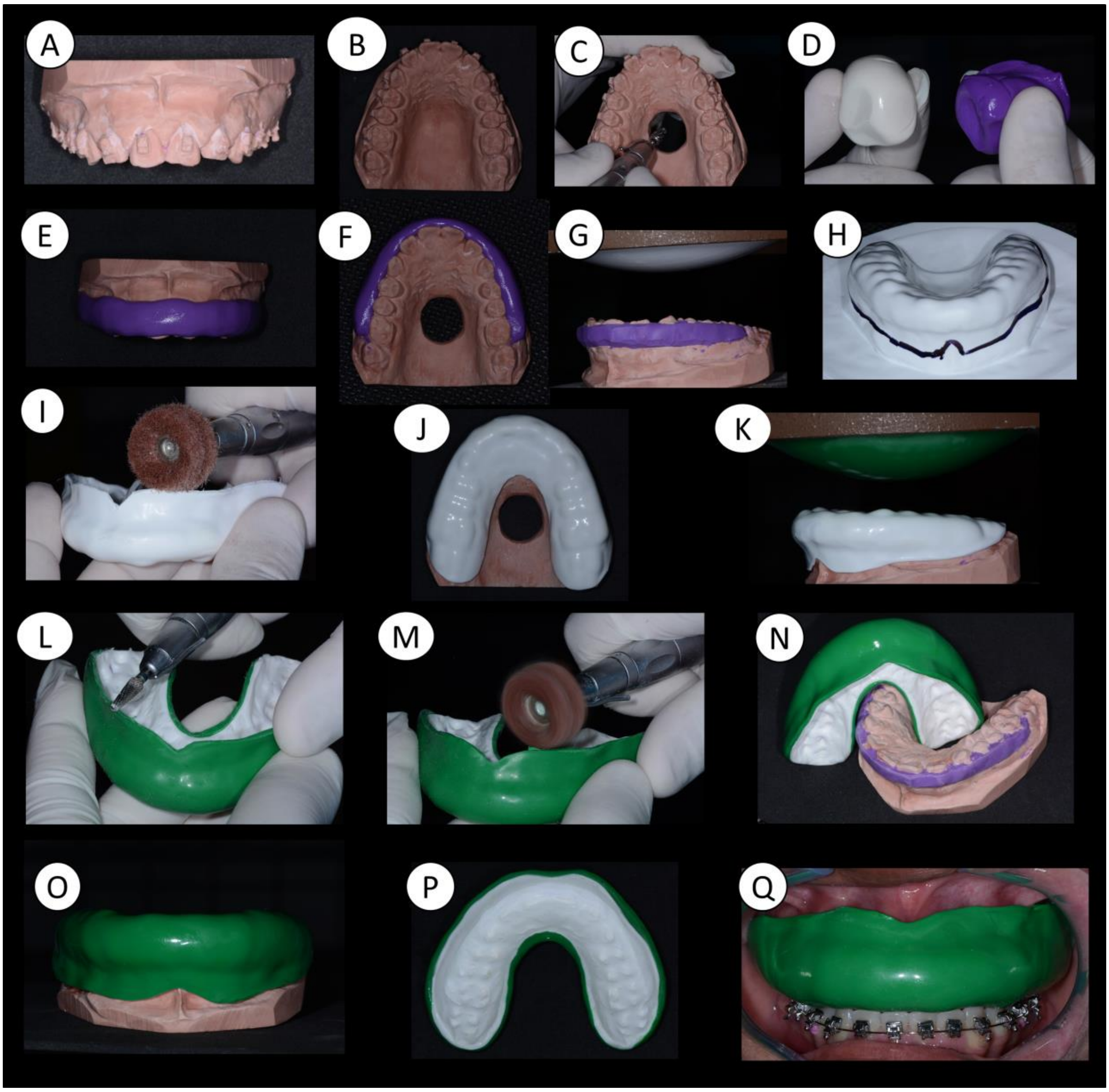
# APÊNDICE A – SEQUÊNCIA DE CONFECÇÃO DO PROTETOR BUCAL PERSONALIZADO PARA PACIENTE ORTODÔNTICO




Apêndice A- Fig.1. Modelo de trabalho (A, B); Perfuração do modelo com diâmetro 10mm(C); Confecção do alívio de silicone (D,E,F); Termo-plastificação e prensagem da primeira placa de EVA de 3mm (G); Primeira placa de EVA prensada e demarcação dos limites anatômicos para recorte; (H) Recorte, acabamento e polimento; (I,J) Adaptação da primeira placa ao modelo de gesso concluído; (K) Termo-plastificação e prensagem da segunda placa de EVA de 3mm – Observe a bolha formada pelo EVA à 10 cm da superfície do modelo (K); Acabamento e

Polimento (L,M); Protetor bucal personalizado de 3-4mm concluído (N,O,P); Protetor bucal personalizado ajustado no paciente(Q)

# ANEXO A – NORMAS DE PUBLICAÇÃO DA REVISTA DENTAL TRAUMATOLOGY

## Author Guidelines


gas
**Useful Websites**: Submission Site, Articles published in Dental Traumatology, Author Services, Wiley-Blackwell's Ethical Guidelines, Guidelines for Figures

### 1. GENERAL

Dental Traumatology is an international peer-reviewed journal which aims to convey scientific and clinical progress in all areas related to adult and pediatric dental traumatology. It aims to promote communication among clinicians, educators, researchers, administrators and others interested in dental traumatology. The journal publishes original scientific articles, review articles in the form of comprehensive reviews or mini reviews of a smaller area, short communication about clinical methods or techniques and case reports. The journal focuses on the following areas ***as they relate to dental trauma***:

Epidemiology and Social Aspects
Periodontal and Soft Tissue Aspects
Endodontic Aspects
Pediatric and Orthodontic Aspects
Oral and Maxillofacial Surgery / Transplants/ Implants
Esthetics / Restorations / Prosthetic Aspects
Prevention and Sports Dentistry
Epidemiology, Social Aspects, Education and Diagnostic Aspects.

Please read the instructions below carefully for details on the submission of manuscripts, the journal's requirements and standards as well as information concerning the procedure after a manuscript has been accepted for publication in *Dental Traumatology*. Authors are encouraged to visit Wiley-Blackwell Author Services for further information on the preparation and submission of articles and figures.

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#### 2.1. Authorship and Acknowledgements

Authors submitting a paper to the journal do so on the understanding that the manuscript has been read and approved by all authors and that all authors have agreed to submit the manuscript to the Journal. ALL authors MUST have made an active and significant contribution to the development of the concept and/or design of the study, and/or analysis and interpretation of the data and/or the writing of the paper. ALL authors must have critically reviewed its content and must have approved the final version that is submitted to the journal for consideration for publication. Participation solely in the acquisition of funding or the collection of data does not justify authorship.

*Dental Traumatology* adheres to the definition of authorship set up by The International Committee of Medical Journal Editors (ICMJE). According to the ICMJE, the criteria for authorship should be based on: 1) substantial contributions to the concept and design of, or acquisition of data or analysis and interpretation of data, 2) drafting the article or revising it critically for important intellectual content, and 3) final approval of the version to be published. Authors should meet conditions 1, 2 and 3.

It is a requirement that all authors have been declared as appropriate upon submission of the manuscript. Contributors who do not qualify as authors should be mentioned under the Acknowledgements section on the title page.

**Acknowledgements**: In the Acknowledgements section, you can specify contributors to the article other than the authors. The acknowledgements should be placed on the title page, and not in the main document, in order to allow blinded review.

**2.2. Ethical Approvals**

Experimentation involving human subjects will only be published if such research has been conducted in full accordance with ethical principles, including the World Medical Association Declaration (version, 2008 http://www.wma.net/en/30publications/10policies/b3/index.html) and the additional requirements, if any, of the country and/or institution where the research has been carried out. Manuscripts must be accompanied by a statement that the experiments were undertaken with the understanding and written consent of each subject and according to the above mentioned principles. A statement regarding the fact that the study has been independently reviewed and approved by an ethical board should also be included. In the online submission process,it is a requirement that all authors submitting manuscripts to Dental Traumatology must answer in the affirmative to a statement 'confirming that all research has been carried out in accordance with legal requirements of the study country such as approval of ethical committees for human and/or animal research or other legislation where applicable.' Editors reserve the right to reject papers if there are doubts as to whether appropriate procedures have been used.

**2.3 Clinical Trials**

Clinical trials should be reported using the CONSORT guidelines available at www.consort-statement.org. A CONSORT checklist should also be included in the submission material.

All manuscripts reporting results from a clinical trial must indicate that the trial was fully registered at a readily accessible website, e.g., www.clinicaltrials.gov.

**2.4 DNA Sequences and Crystallographic Structure Determinations**

Papers reporting protein or DNA sequences and crystallographic structure determinations will not be accepted without a Genbank or Brookhaven accession number, respectively. Other supporting data sets must be made available on the publication date from the authors directly.

**2.5 Conflict of Interest**

*Dental Traumatology* requires that sources of institutional, private and corporate financial support for the work within the manuscript must be fully acknowledged, and any potential grant holders should be listed. Acknowledgements should be brief and should not include thanks to anonymous referees and editors. The

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The Editor's decision to accept, reject or require revision of a paper is final and it cannot be appealed.

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Manuscripts should be submitted electronically via the online submission site http://mc.manuscriptcentral.com/dt. The use of an online submission and peer review site enables immediate distribution of manuscripts and consequentially speeds up the review process. It also allows authors to track the status of their own manuscripts. Complete instructions for submitting a paper are available online and below. Further assistance can be obtained from the Editorial Office: EDToffice@wiley.com.

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• Launch your web browser (supported browsers include Internet Explorer 6 or higher, Netscape 7.0, 7.1, or 7.2, Safari 1.2.4, or Firefox 1.0.4) and go to the journal's online Submission Site:http://mc.manuscriptcentral.com/dt

• Log-in or click the 'Create Account' option if you are a first-time user.

• If you are creating a new account.

- After clicking on 'Create Account', enter your name and e-mail information and click 'Next'. Your e-mail information is very important.

- Enter your institution and address information as appropriate, and then click 'Next.'

- Enter a user ID and password of your choice (we recommend using your e-mail address as your user ID), and then select your area of expertise. Click 'Finish'.

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• Log-in and select 'Author Centre.'

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• After you have logged into your 'Author Centre', submit your manuscript by clicking the submission link under 'Author Resources'.
• Enter data and answer questions as appropriate. You may copy and paste directly from your manuscript (e.g. the Abstract) and you may upload your pre-prepared covering letter.
• Click the 'Next' button on each screen to save your work and advance to the next screen.
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- When you have selected all files you wish to upload, click the 'Upload Files' button.
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- Figure files under the file designation 'figures'.
- The title page, Acknowledgements and Conflict of Interest Statement where applicable, should be uploaded under the file designation 'title page'
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All manuscripts submitted to Dental Traumatology will be reviewed by two experts in the field. Dental Traumatology uses a double blinded review process – hence, the names of the reviewers will not be disclosed to the author(s) who have submitted the paper and the name(s) of the author(s) will not be disclosed to the reviewers.

To allow double blinded review, please submit (upload) your main manuscript and title page as separate files. Please upload:

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• Figure files under the file designation 'figures' – each figure should be uploaded individually
• The title page, Acknowledgements and Conflict of Interest Statement where applicable, should be uploaded under the file designation 'title page'

All documents uploaded under the file designation 'title page' will not be viewable in the HTML and PDF files that you will be asked to review at the end of the submission process. The files viewable in the HTML and PDF format are the files that will be available to the reviewers during the review process.

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Dental Traumatology attempts to keep the review process as short as possible to enable rapid publication of new scientific data. In order to facilitate this process, you may suggest the names and current email addresses of potential international reviewers whom you consider capable of reviewing your manuscript. Please note that these are suggestions only and the Editor may or may not invite the suggested people to review your paper. In addition to any suggestions you make, the journal editor will choose one or two independent reviewers.

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**Original Research Articles** in all areas related to adult and pediatric dental traumatology are of interest to *Dental Traumatology*. Examples of such areas are Epidemiology and Social Aspects, Periodontal and Soft Tissue Aspects, Endodontic Aspects, Pediatric and Orthodontic Aspects, Oral and Maxillofacial Surgery/Transplants/Implants, Esthetics/Restorations/Prosthetic Aspects, Prevention and Sports Dentistry, Epidemiology, Social Aspects, Education and Diagnostic Aspects.

**Review Papers**: *Dental Traumatology* commissions specific topical review papers and mini reviews of small areas of interest. The journal also welcomes uninvited reviews. Reviews should be submitted via the online submission site and are subject to peer-review.

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**Mini Reviews** cover a smaller area and may be written in a more free format.

**Case Reports:** *Dental Traumatology* may accept Case Reports that illustrate unusual and clinically relevant observations or management. Case reports should demonstrate something new or unique, and they should not present common clinical scenarios. Case reports should be kept brief (within 3-4 printed pages) and need not follow the usual division into material and methods etc. There should be an Abstract written as a short paragraph. The Abstract should not be structured with specific sections (i.e. do not use aims, methods, results, conclusions). The Introduction should be kept short. Thereafter the case is described followed by a short Discussion. Case reports should have adequate follow-up to demonstrate the outcome of the treatment provided or the long-term prognosis of the presented problem. Typically, cases with treatment should have at least 4-5 years follow-up radiographs, photographs, etc to show the outcome. Case reports are subject to peer review.
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**Short Communications** of 1-2 pages may be accepted for publication. These papers need not follow the usual division into Material and Methods, etc., but should have an Abstract. They should contain important new information to warrant publication and may reflect improvements in clinical practice such as introduction of new technology or practical approaches. They should conform to high scientific and high clinical practice standards. Short communications are subject to peer review.

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Care must be taken with the use of tense, and use of singular and plural words.

Numbers may be written as numbers or spelt out as words, according to the context in which the number is being used. In general, if the number is less than 10, it should be spelt out in words (e.g. five). If the number is 10 or greater, it should be expressed as a number (e.g. 15). When used with units of measurement, it sholdul eb expressed as a number (e.g. 5mm, 15mL).

When referring to a figure at the beginning of a sentence, spell the word out (e.g. *Figure 2 shows the patient’s injuries on initial presentation*). When referring to a figure as part of the sentence, use the abbreviation “Fig.” (*e.g. The pre-operative radiograph shown as Fig. 3 demonstrates the degree of displacement of the tooth*). When referring to a figure at the end of a sentence, use the abbreviation “Fig.” and enclose it in parentheses - e.g. *The patient’s maxillary central incisor was repositioned and splinted* (Fig. 5).

**Abbreviations, Symbols and Nomenclature**: Abbreviations should be kept to a minimum, particularly those that are not standard. Non-standard abbreviations must be used three or more times – otherwise they should not be used. The full words should be written out completely in the text when first used, follwoed byt eh abbreviation in parentheses. Consult the following sources for additional abbreviations: 1) CBE Style Manual Committee. Scientific style and format: the CBE manual for authors, editors, and publishers. 6th ed. Cambridge: Cambridge University Press; 1994; and 2) O'Connor M, Woodford FP. Writing scientific papers in English: an ELSE-Ciba Foundation guide for authors. Amsterdam: Elsevier-Excerpta Medica; 1975.

As Dental Traumatology is an international journal with wide readership from all parts of the world, the FDI Tooth Numbering system MUST be used. This system uses two digits to identify teeth according to quadrant and tooth type. The first digit refers to the quadrant and the second digit refers to the tooth type. – for example: tooth 11 is the maxillary right central incisor and tooth 36 is the mandibular left first molar. Alternatively, the tooth can be described in words. Other tooth numbering systems will not be accepted.

**Font**: When preparing your file, please use only standard fonts such as Times, Times New Roman or Arial for text, and Symbol font for Greek letters, to avoid inadvertent character substitutions. In particular, do not use Japanese or other Asian fonts. Do not use automated or manual hyphenation. Use double spacing and left alignment of text when preparing the manuscript. Do not use Arabic or other forms of software that automatically align text on the right.

**5.2. Structure**

All papers submitted to Dental Traumatology should include: Title Page, Abstract, Main text, References and Table Legends, Figure Legends, Tables, Figures, Conflict of Interest Statement and Acknowledgements where appropriate. The Title page, Conflict of Interest Statement and any Acknowledgements must be submitted as separate files and uploaded under the file designation Title Page to allow blinded review. Tables should be included as part of the Main Document. Figures should be uploaded as separate files and must not be embedded in the Main Document. Manuscripts must conform to the journal style. Manuscripts not complying with the journal style will be rejected and returned to the author(s) without being peer reviewed.

During the editorial process, reviewers and editors frequently need to refer to specific portions of the manuscript, which is difficult unless the pages are numbered. Hence, authors should number all of the pages consecutively at the bottom of the page.

**Title Page**: The Title page should be uploaded as a separate document in the submission process under the file designation 'Title Page' to allow blinded review. The Title page should include: Full title of the manuscript, author(s)' full names (Family names should be underlined) and institutional affiliations including city, country, and the name and address of the corresponding author. The title page should also include a running title of no more than 60 characters and 3-6 keywords.

The tile of the paper should be concise and informative with major key words. The title should not be a question about the aim and it should not be a statement of the results or conclusions.

**Abstract** is limited to 250 words in length and should contain no abbreviations. The abstract should be included in the manuscript document uploaded for review as well as inserted separately where specified in the submission process. The abstract should convey a brief background statement plus the essential purpose and message of the paper in an abbreviated form. For Original Scientific Articles, the abstract should be structured with the following headings: Background/Aim, Material and Methods, Results and Conclusions. For other article types (e.g. Case Reports, Reviews Papers, Short Communications) headings are not required and the Abstract should be in the form of a paragraph briefly summarizing the paper.

**Main Text of Original Articles** should be divided into the following sections: Introduction, Material and Methods, Results and Discussion, References, Legends to Tables, Legends to Figures, and the Tables.

**Introduction** This section should be focused, outlining the historical or logical origins of the study. It should not summarize the results and exhaustive literature reviews are inappropriate. Give only strict and pertinent references and do not include data or conclusions from the work being reported. The introduction should close with an explicit, but brief, statement of the specific aims of the investigation or hypothesis tested. Do not include details of the methods in the statement of the aims.

**Materials and Methods** This section must contain sufficient detail such that, in combination with the references cited, all clinical trials and experiments reported can be fully reproduced. As a condition of publication, authors are required to make materials and methods used freely available to academic researchers for their own use. Describe your selection of observational or experimental participants clearly. Identify the method, apparatus and procedures in sufficient detail. Give references to established methods, including statistical methods, describe new or modified methods. Identify precisely all drugs used by their generic names and route of administration.

***(i) Clinical trials*** should be reported using the CONSORT guidelines available at www.consort-statement.org. A CONSORT checklist should also be included in the submission material. All manuscripts reporting results from a clinical trial must indicate that the trial was fully registered at a readily accessible website, e.g., www.clinicaltrials.gov.

***(ii) Experimental subjects***: experimentation involving human subjects will only be published if such research has been conducted in full accordance with ethical principles, including the World Medical Association Declaration (version, 2008 http://www.wma.net/en/30publications/10policies/b3/index.html) and the additional requirements, if any, of the country and institution where the research has been carried out. Manuscripts must be accompanied by a statement that the experiments were undertaken with the understanding and written consent of each subject and according to the above mentioned principles. A statement regarding the fact that the study has been independently reviewed and approved by an ethical board should also be included. Editors reserve the right to reject papers if there are doubts as to whether appropriate procedures have been used.

***(iii) Suppliers of materials*** should be named and their location (town, state/county, country) included.

**Results** should clearly and simply present the observations/results without reference to other literature and without any interpretation of the data. Present the results in a logical sequence in the text, tables and illustrations giving the main or most important findings first. Do not duplicate data in graphs and tables.
**Discussion** usually starts with a brief summary of the major findings. Repetition of parts of the Introduction or of the Results sections should be avoided. Statements and interpretation of the data should be appropriately supported by original references. A comment on the potential clinical relevance of the findings should be included. The Discussion section should end with a brief conclusion but the conclusion should not be a repeat of the results and it should not extrapolate beyond the findings of the study. Link the conclusions to the aim of the study.

Do not use sub-headings in the Discussion section, The Discussion should flow from one paragraph to the next in a cohesive and logical manner.

**Main Text of Review Articles** should comprise an introduction and a running text structured in a suitable way according to the subject treated. A final section with conclusions may be added.

**Acknowledgements**: Under acknowledgements, specify contributors to the article other than the authors. Acknowledgements should be brief and should not include thanks to anonymous referees and editors.

**Conflict of Interest Statement**: All sources of institutional, private and corporate financial support for the work within the manuscript must be fully acknowledged, and any potential grant holders should be listed. The Conflict of Interest Statement should be included as a separate document uploaded under the file designation 'Title Page' to allow blinded review.

**5.3. References**

As the Journal follows the Vancouver system for biomedical manuscripts, the author is referred to the publication of the International Committee of Medical Journal Editors: Uniform requirements for manuscripts submitted to biomedical journals. Ann Int Med 1997;126:36-47.

The references should be numbered consecutively in the order in which they are first mentioned in the text. Identify references in the text, tables, and legends by Arabic numerals (in parentheses). Use the style of the examples below, which are based on the format used by the US National Library of Medicine in Index Medicus. For abbreviations of journals, consult the 'List of the Journals Indexed' printed annually in the January issue of Index Medicus. Authors can also review previous articles published in the journal to see the style used for references.

Authors are advised to use a tool such as EndNote or Reference Manager for reference management and formatting. EndNote reference styles can be searched for here: www.endnote.com/support/enstyles.asp. Reference Manager reference styles can be searched for here: www.refman.com/support/rmstyles.asp

**Examples of reference styles used by *Dental Traumatology***

**Journal Articles:**

Lam R, Abbott PV, Lloyd C, Lloyd CA, Kruger E, Tennant M. Dental trauma in an Australian Rural Centre. Dent Traumatol 2008; 24: 663-70.

**Text book chapters:**

Andreasen J, Andreasen F. Classification, etiology and epidemiology. IN: Andreasen JO, Andreasen FM, eds. Textbook and Color Atlas of Traumatic Injuries to the Teeth. 3rd Edn. Munksgaard, Copenhagen. 1994;151-80.

**Thesis or Dissertation:**

Lauridsen, E. Dental trauma – combination injuries. Injury pattern and pulp prognosis for permanent incisors with luxation injuries and concomitant crown fractures. Denmark: The University of Copenhagen. 2011. PhD Thesis.

**Corporate Author:**

European Society of Endodontology. Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. Int Endod J 2006:39;921-30.

American Association of Endodontists. The treatment of traumatic dental injuries. Available at: URL: 'http://www.aae.org/uploadedfiles/publications_and_research/newsletters/endodontics_colleagues_for_excellence_newsletter/ecfe_summer2014%20final.pdf'. Accessed September 2015.

# ANEXO B – PARECER COMITÊ DE ÉTICA EM PESQUISA

UNIVERSIDADE DE UBERABA - UNIUBE

Continuação do Parecer: 1.781.132

**Conclusões ou Pendências e Lista de Inadequações:**

Não há pendência.

**Considerações Finais a critério do CEP:**

Em 19/10/2016, o projeto foi aprovado Add referendum de acordo com autorização do colegiado do CEP. O CEP-UNIUBE lembra ao pesquisador da necessidade de atender ao estabelecido na Resolução 466/2012, especialmente no que se refere ao encaminhamento do Relatório ao término do projeto (item IX.2.d)

**Este parecer foi elaborado baseado nos documentos abaixo relacionados:**

| Tipo Documento | Arquivo | Postagem | Autor | Situação |
|---|---|---|---|---|
| Informações Básicas do Projeto | PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_771513.pdf | 12/09/2016 17:42:54 | | Aceito |
| Outros | Autorizacao.pdf | 12/09/2016 17:42:33 | Crisnicaw Verissimo | Aceito |
| Folha de Rosto | Folhaderosto.pdf | 08/08/2016 20:35:36 | Crisnicaw Verissimo | Aceito |
| Projeto Detalhado / Brochura Investigador | Projeto.pdf | 08/08/2016 10:01:10 | Crisnicaw Verissimo | Aceito |
| TCLE / Termos de Assentimento / Justificativa de Ausência | TCLE.docx | 08/08/2016 09:59:10 | Crisnicaw Verissimo | Aceito |

**Situação do Parecer:**

Aprovado

**Necessita Apreciação da CONEP:**

Não

UBERABA, 19 de Outubro de 2016

**Assinado por:**
**Geraldo Thedei Junior**
**(Coordenador)**

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