UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
FACULDADE DE ODONTOLOGIA
PROGRAMA DE PÓS-GRADUAÇÃO EM ODONTOLOGIA

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"ALTERAÇÕES NA MORFOLOGIA DO OSSO ALVEOLAR APÓS A TRAÇÃO DOS CANINOS IMPACTADOS UNILATERALMENTE POR VESTIBULAR VERSUS PALATINO: UM ESTUDO EM TCFC"

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Tese apresentada no Programa de Pós-Graduação em Odontologia, linha de pesquisa Diagnóstico das Afecções Buco- Faciais, da Universidade Federal do Rio Grande do Sul, como parte dos pré-requisitos necessários para obter o título de Doutor em Clínica Odontológica.

Orientador: Prof. Dr. Heraldo Luís Dias da Silveira

Porto Alegre

2019

CIP - Catalogação na Publicação

RUIZ MORA, GUSTAVO ARMANDO
ALTERAÇÕES NA MORFOLOGIA DO OSSO ALVEOLAR APÓS TRAÇÃO DOS CANINOS IMPACTADOS UNILATERALMENTE POR VESTIBULAR VERSUS PALATINO: UM ESTUDO EM TCFC / GUSTAVO ARMANDO RUIZ MORA. -- 2019.
73 f.
Orientador: Heraldo Luís Dias da Silveira.

Tese (Doutorado) -- Universidade Federal do Rio Grande do Sul, Faculdade de Odontologia, Programa de Pós-Graduação em Odontologia, Porto Alegre, BR-RS, 2019.

1. Dente Impactado. 2. Tomografia Computadorizada de Feixe Cônico. I. Dias da Silveira, Heraldo Luís, orient. II. Título.

Elaborada pelo Sistema de Geração Automática de Ficha Catalográfica da UFRGS com os dados fornecidos pelo(a) autor(a).

"Por que essa maravilhosa tecnologia científica, que economiza trabalho e facilita nossas vidas, dá tão pouca felicidade? A resposta é simplesmente: porque ainda não aprendemos a usá-la corretamente ".

Albert Einstein (1879-1955)

Agradecimentos

Ao nosso grande e único **Deus**.

Para meus amores **Martha, Ana Manú** e **Silvia Vale**, minha principal razão para ser.

Aos meus irmãos pelo amor, apoio e respeito, em homenagem aos meus pais.

Aos meus pacientes, a pergunta e a resposta em pesquisa.

Ao meu orientador, Prof Dr **Heraldo Luis Dias da Silveira,** por sua amizade, apoio, ensino e orientação permanente.

Aos meus irmãos **Luchito** e **Yalil** por sua amizade, cumplicidade e intensidade na pesquisa.

À coordenação e professores do **Programa de Pós-Graduação da FO-UFRGS**

Resumo

Introdução: A tração ortodôntico-cirúrgica dos caninos superiores impactados (CSI) é um tratamento complexo que pode ter consequências sobre as raízes dos dentes e osso alveolar, de modo que este processo deve ser executado com cautela seguindo os princípios de remodelação óssea, "com osso" e "através do osso". Poucos estudos tem investigado as alterações do osso alveolar de CSI em posição palatina e vestibular, após o tratamento de tração sob protocolo estrito. Os objetivos deste estudo foram: 1. Comparar as mudanças na altura do osso alveolar de CSI unilateralmente, por vestibular ou palatino, antes e depois da tração com molas fechadas de Ni-Ti a partir de exames de Tomografia Computadorizada de Feixe Cônico (TCFC). 2. Determinar as alterações na largura do osso alveolar em condições idênticas. 3. Apresentar uma alternativa biomecânica para a tração do CSI. Metodologia: Seguindo um modelo de boca dividida, obtiveram-se 54 TCFC de pacientes com 27 CSI unilateralmente (14 palatais e 13 vestibulares) e 27 controles contralaterais não impactados antes e depois da tração utilizando molas helicoidais fechadas e um aparelho de ancoragem. Para o terceiro objetivo, foram selecionados dois casos de CSI bilateral com alta complexidade tratados com protocolo semelhante. Três ortodontistas calibrados avaliaram medidas de altura e largura do osso alveolar nas reconstruções multiplanares, além das características de impactação e das variáveis demográficas. Resultados: A altura alveolar apresentou uma diminuição significativamente maior junto ao CSI por palatino (2,09 a 2,79 mm) do que no CSI por vestibular (0,28 a 0,57 mm) ($P < 0,05$) em todas as superfícies. No entanto, a largura alveolar aumentou de forma semelhante nos dois grupos até 1,36 mm. Conclusões: A tração da CSI com molas helicoidais fechadas de níquel-titânio e ancoragem pesada causa alterações tridimensionais significativas no osso alveolar caracterizadas por decréscimos na altura do osso alveolar e aumento da largura do osso alveolar cervical. A diminuição da altura é maior nos CSI por palatino do que por vestibular.

Palavras-Chave: Dente Impactado. Tomografia Computadorizada de Feixe Cônico. Fenômenos Biomecânicos.

Abstract

Introduction: Orthodontic-surgical traction of maxillary impacted canines (MIC) is a complex treatment and may have consequences on the roots of the teeth and alveolar bone, so this process should be performed cautiously following the principles of bone remodeling, "with bone" and "through bone". Few studies have investigated the changes of alveolar bone of unilateral impacted maxillary canines in palatal and buccal position, after traction treatment under strict protocol. The objectives of this study were: 1. To compare changes in unilateral MIC alveolar bone height, buccal or palatine, before and after traction with Ni-Ti closed coil springs from Cone-Beam Computed Tomography (CBCT) examinations. 2. Determine changes in alveolar bone width under identical conditions. 3. Present a biomechanical alternative for traction of the MIC. Methodology: Following a split-mouth model, 54 CBCT images of 27 unilaterally MIC (14 palatally and 13 buccally) and 27 contralateral un-impacted controls before and after traction using nickel-titanium closed coil springs and a anchorage appliance. For the third objective, two cases of bilateral MIC with high complexity treated with similar protocol were selected. Three calibrated orthodontists evaluated measurements of alveolar bone height and width in multiplanar reconstructions, besides impaction characteristics and demographic variables. Results: Alveolar height showed a significantly greater decrease in palatal MIC (2.09 to 2.79 mm) than buccal MIC (0.28 to 0.57 mm) (P <0.05) in all surfaces. However, alveolar width increased similarly in both groups to 1.36 mm. Conclusions: MIC traction with nickel-titanium closed coil springs and heavy anchorage causes significant three-dimensional changes in the alveolar bone characterized by decreases in alveolar bone height and increased cervical alveolar bone width. The decrease in height is greater in palatine than buccal MIC.

Key-words: Tooth, Impacted. Cone-Beam Computed Tomography. Biomechanical Phenomena.

Lista de Abreviaturas e Siglas

CSI *Caninos superiores impactados*

TCFC *Tomografia computadorizada de feixe cônico*

MIC *Maxillary Impacted Canine*

CBCT *Cone Beam Computed Tomography*

T0 *Initial time, Before canine traction*

T1 *After canine traction*

SPSS *Statistical Package for Social Sciences*

DICOM *Digital Imaging and Communication in Medicine*

FOV *Field of View*

MPR *Multiplanar Reconstruction*

MIP *Maximum Intensity Projection*

RR *Root resorption*

ICC *Intraclass Correlation Coefficient*

mA *miliAmpere*

kVp *peak kilovoltage*

ALADA *As Low As Diagnostically Acceptable*

ALARA *As Low As Reasonably Achievable*

IC *Impacted Canine*

CC *Control Canine*

Ni-TiCCS *Nickel-Ttanium Closed Coil Springs*

Sumário

Introdução

Os dentes caninos são indispensáveis para estabelecer a forma, e a oclusão dentária estética e funcional. Sua grande sensibilidade em um esquema de oclusão mutuamente protegido e o papel fundamental na morfologia da arcada dentária justificam o tratamento conservador dos caninos superiores impactados (CSI)[1,2].

Erupção ectópica e impactação do canino superior são problemas frequentes na ortodontia. Após os terceiros molares, os caninos superiores são os dentes mais frequentemente impactados na arcada dentária [3-7]. A incidência de impactação canina maxilar tem sido informada em aproximadamente 2% dos pacientes que procuram tratamento ortodôntico [3,8]. Os caninos superiores são entre 10 e 20 vezes mais comumente impactados que os caninos inferiores [9,10]. A impactação palatina do canino (85%) é mais prevalente do que a impactação vestibular (15%) [3,4,11-14]. A impactação unilateral é muito mais comum que a impactação bilateral [13]. Sambataro et al e McConnell et al relataram que 8% das impações dos caninos são bilaterais [4,15]. Kuftinec et al relataram que as impactações unilaterais são mais comuns que as bilaterais por um fator de 5: 1 [9].

Existem dois conceitos no movimento dentário ortodôntico em termos de remodelação óssea alveolar. Se o osso alveolar for remodelado com coordenação de reabsorção e aposição, o movimento dentário e a remodelação óssea ocorrem na proporção de 1: 1, e o dente permanece no alojamento alveolar. Esse tipo de movimento dentário é conhecido como "com o osso" [16]. No entanto, se o equilíbrio entre a reabsorção e a aposição do osso alveolar não for estabelecido durante o movimento dentário, o dente sairá do alojamento alveolar, que é referido como "através do osso" [17-18].

A maioria dos estudos sobre alterações ósseas foi realizada com imagens bidimensionais periapicais e panorâmicas. Essas imagens apresentam limitações, principalmente na região anterior, devido à sobreposição de estruturas [19,20]. A tecnologia de tomografia computadorizada de feixe cônico (TCFC) supera essas limitações, permitindo a avaliação quantitativa exata das alterações na altura óssea, largura alveolar e espessura cortical em situações complexas [21,22]. Todavia, até o presente momento, nenhum estudo comparou, tridimensionalmente com TCFC, os efeitos dos tipos de tração de CSI no osso alveolar.

Muitos métodos tradicionais de tração têm sido usados para cirurgia combinada e tratamento ortodôntico, como: o botão ortodôntico com fio de ligadura [23]; cadeias ou fios elastoméricos [24,25]; arcos de aço inoxidável pré-fabricados [26-28]; Kilroy I e II *springs* [29]; ganchos e ilhós colados ao esmalte [30]; mini implantes ou dispositivos de ancoragem temporária (DATs) e tração elástica [31,32]; ímãs ortodônticos [33]; corrente de ouro anexada [34]; sistemas de *cantilever* [35-37]; mecânica de arco duplo [38] e arcos de extrusão [39,40] o sistema *Easy-Way-Coil* (EWC) [41]; braço auxiliar do arco transpalatino [42]; *spring* auxiliar[43]; níquel-titânio [44] sobreposições e perfuração da coroa [45] entre muitas outras alternativas disponíveis.

As diferentes alternativas que foram descritas para tração CSI incluem molas helicoidais de níquel-titânio fechadas, que requerem o uso de uma âncora palatina rígida personalizada para proteger os tecidos moles e os dentes adjacentes ao dente ectópico, e para controlar a magnitude, direção e sentido de tração nos eixos x-y-z [46-52].

Em ortodontia, os materiais de níquel-titânio (NiTi) são usados principalmente para aparelhos quando é necessária uma força constante em uma ampla faixa de extensão: por exemplo, arcos e molas helicoidais fechadas. Os espaços são fechados mais rapidamente e de forma mais fluente com as molas NiTi do que com os módulos elásticos [53-57]. As ligas de NiTi são diferenciadas por vários recursos incomuns, como efeitos de memória de forma, superelasticidade e superplasticidade [58]. “Superelasticidade” refere-se a suas curvas de tensão-deformação não elásticas [59-61], significando que um arame ou mola helicoidal superelástica produzirá uma força quase constante em uma grande faixa de deformações chamada platô [58,62].

De acordo com Crescini et al. (2007) [63], um dos indicadores fundamentais do sucesso do tratamento dos CSI é o resultado periodontal final. A literatura mostra que o dano periodontal mais grave que ocorre no tratamento de caninos impactados por palatino é a perda de osso de suporte. Essa, está associada a procedimentos cirúrgicos mais radicais envolvendo a exposição do dente embaixo da junção esmalte-cemento (Kohavi et al., 1984) [64,65].

O tratamento orto-cirúrgico dos CSI localizados por palatino, pode ser realizado por meio de retalho aberto ou fechado, seguido de tração ortodôntica do canino impactado (Crescini et al., 1994; McSherry, 1998; Burden et al., 1999; Kokich, 2004) [67,68-69]. A literatura contém menos críticas à técnica fechada, em termos de impacto periodontal, embora alguns autores ainda tenham relatado preocupações periodontais quando caninos alinhados com uma técnica fechada são comparados com caninos não operados [70,71]. Uma revisão sistemática recente não encontrou evidência robusta para apoiar uma técnica cirúrgica sobre a outra [72,73].

Pacientes com CSI são percebidos como mais difíceis e demorados para tratar do que aqueles com má oclusão de rotina, por isso alguns fatores como o tempo de erupção /extrusão do dente impactado, o tempo total de tratamento [74,75,76], o sucesso do tratamento [77,78], recidiva e resultados periodontais pós-tratamento [63,67,79,80,81-85], devem ser levados em consideração. Muitas investigações sobre o *status* pós-tratamento estão limitadas a avaliar a reabsorção radicular. Todavia, a perda óssea alveolar após a cirurgia e o movimento ortodôntico de tração extrusiva de caninos impactados com diferentes dificuldades devem ser estudados como uma importante contribuição para os ortodontistas clínicos interessados em preservar CSI.

Alguns estudos avaliaram as alterações ósseas alveolares associadas à tração do CSI unilateral utilizando imagens tridimensionais, sem comparar a localização a partir da qual o CSI foi tracionado [19,20,22,45,65,83,85,86]. Além disso, é necessária uma comparação das alterações ósseas alveolares após a tração de CSI vestibularmente e palatalmente unilateral, o que seria útil para fornecer informações importantes aos ortodontistas para o planejamento e prognóstico do tratamento. Tendo em vista as considerações acima, o objetivo do presente estudo foi comparar as alterações dimensionais do osso alveolar após a tração de caninos superiores unilaterais impactados vestibular e palatalmente e comparar as alterações entre caninos contralaterais impactados e não-impactados a partir de imagens de TCFC.

Este estudo formula três hipóteses nulas: 1, que não há diferenças significativas na altura do osso alveolar da CSI, vestibular ou palatalmente, após tração com molas fechadas de Ni-Ti e aparelho de ancoragem rígida, utilizando TCFC. 2, que não há diferenças significativas na largura óssea alveolar da CSI, deslocadas por palatino e por vestibular, após tração com molas helicoidais fechadas de Ni-Ti e aparelho de ancoragem rígido, por TCFC. 3. que não há diferenças significativas ao comparar as mudanças entre os caninos contralaterais impactados e não-impactados nas imagens de TCFC.

Objetivos

Geral

Comparar as alterações dimensionais no osso alveolar após tração dos caninos impactados unilateralmente por vestibular versus palatino e comparar as alterações entre caninos contralaterais impactados e não impactados em imagens de TCFC.

Específicos

1. Comparar as alterações na altura do osso alveolar dos caninos impactados unilateralmente por vestibular ou palatal, antes e depois da tração com molas fechadas de Ni-Ti a partir de exames de TCFC.

2. Determinar as alterações na largura do osso alveolar dos caninos impactados unilateralmente por vestibular ou palatino, antes e após a tração com molas fechadas de Ni-Ti a partir de exames de TCFC.

3. Apresentar outra alternativa biomecânica para tração da CSI usando molas fechadas de Ni-Ti e aparelho de ancoragem palatina rígida.

Artigo 1

Changes in alveolar bone morphology after traction of buccally versus palatally unilaterally maxillary impacted canines: A CBCT study

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Formatado, enviado, revisado e reenviado ao ***American Journal of Orthodontics & Dentofacial Orthopedics***

Changes in alveolar bone morphology after traction of buccally versus palatally unilaterally maxillary impacted canines: a cbct study

Introduction: The objective of this study was to evaluate the three-dimensional changes in alveolar bone morphology after traction of buccally versus palatally unilateral maxillary impacted canines (MIC). **Methods**: Following a split-mouth model, 27 cone beam computed tomography (CBCT) images of unilaterally MIC (14 palatally and 13 buccally) and 27 contralateral un-impacted controls were obtained before and after traction using nickel-titanium closed coil springs and a rigid anchorage appliance. Alveolar bone height and width were measured in the axial, coronal and sagittal slides by three calibrated orthodontists, taking into account the impaction characteristics. A t-test was used to compare the two groups, and a paired t-test was applied for intragroup comparisons (both sides). A multiple linear regression model was used to evaluate the influence of the predictor variables on alveolar bone dimensional changes. **Results**: The alveolar height showed a significantly greater decrease in palatally MIC (2.09 to 2.79 mm) than buccally MIC (0.28 to 0.57 mm) ($P<0.05$) for all surfaces. However, the alveolar width increased similarly in both groups up to 1.36 mm. In general, the affected side had a more significant height loss and greater increases in alveolar width than the non-affected side. Regression analysis indicated that buccally MIC and age decreased the amount of alveolar changes, whereas female sex increased this situation ($P<0.05$). **Conclusions**: MIC traction with nickel-titanium closed coil springs and heavy anchorage induces significant three-dimensional changes in alveolar bone characterized by alveolar bone height decreases and cervical alveolar bone width increases. The height decrease is greater in palatally than in buccally MIC.

Orthodontic-surgical traction of maxillary impacted canines (MIC) is a complex treatment and may have consequences on the alveolar bone and roots of the involved teeth. The evaluation of alveolar bone changes after traction of impacted teeth helps to explain the therapeutic limits of the orthodontic dental movement considering the concepts of movement “with-the-bone”, “within the bone” and “through-the-bone”.[1,2]

The extrusive traction forces have an action/reaction effect that acts on the enamel-cement complex of dental roots and leads to important changes in the alveolar bone, including bone loss, dehiscence or cortical fenestrations and gingival recession. These changes can be observed in both the impacted canine and adjacent teeth.[3,4] The bucco-lingual, vertical and anterior-posterior position, associated with the severity of the MIC, may increase the treatment time, its complexity and the periodontal sequelae of the traction.[5]

Changes in the movement pathway may be different in palatal versus buccal traction of MIC. Periodontal damage has been shown to be more severe in palatally displaced canines and usually associated with more aggressive surgical procedures, exposing the root at the enamel-cement junction level. In contrast, Parkin et al[6] demonstrated that the traction of palatally displaced canines generates an irrelevant clinically periodontal affection, while buccal traction has been reported to represent a periodontal challenge that reduces the level of the attached gingiva and the width of the alveolar and cortical bone.[7]

Most studies concerning bone changes have been performed using 2-D intraoral x-ray periapical and panoramic images. These images have limitations, particularly in the anterior region, due to mid-sagittal over-projection.[8,9] Cone beam computed tomography (CBCT) technology overcomes these limitations, allowing the accurate quantitative and qualitative evaluation of changes in bone height, alveolar width and cortical thickness in complex situations.[10,11] However, no studies have compared, three-dimensionally with CBCT, the effects of both types of MIC traction on alveolar bone.

Different alternatives have been described for MIC traction, including the use of metallic chains and ligatures, elastomeric chains, bent loops and modified hooks.[12-15] To protect soft tissues and adjacent teeth, the use of rigid customized palatal anchorage and traction with nickel-titanium closed coil springs (Ni-TiCCS) has been proposed as a treatment alternative. Thus, MIC traction can be controlled in the orthogonal x-y-z axis.[16-18]

Some studies have evaluated the alveolar bone changes associated with the traction of unilateral MIC using 3-D images, without contrasting the location from which the MIC was tractioned.[8,9,11,19-23] Additionally, a comparison of alveolar bone changes after traction of buccally versus palatally unilateral MIC is required, which would be useful to provide important information to clinicians for treatment planning and prognosis. Therefore, the purpose of the present study was to compare the dimensional changes in alveolar bone after traction of buccally versus palatally unilaterally MIC and to compare the changes between impacted and non-impacted contralateral canines on CBCT images.

MATERIAL AND METHODS

This retrospective, longitudinal and split-mouth model study was approved by the Ethics in Research Committee of the Universidad Científica del Sur, Lima, Perú (Approval number: 0009). CBCT images of 27 patients (15 women and 12 men between 13 and 39 years old) with unilateral MIC were obtained before (T0) and after (T1) canine traction. Two groups were defined regarding to type of impaction, with 14 MIC located as palatal and 13 as buccal. In addition, the non-affected side was evaluated as a control. The CBCT scans were selected from a population of patients with a MIC diagnosis and treated in the same private practice (G.A.R.M.).

Sample size was calculated considering 80% study power with a significance level of 0.05 to obtain a significant difference between groups of 1 mm on alveolar height using a standard deviation of 0.85, which was obtained in a previous pilot study. Then, the minimum required sample size was eleven per group.

The inclusion criteria consisted of patients of both sexes, aged greater than 12 years old, with unilateral MIC, either buccal or palatal, treated with the same ortho-surgical traction technique. The exclusion criteria were subjects with syndromes or craniofacial deformities, endo-periodontal lesions, previous orthodontic treatment, history of maxillary surgery or dentoalveolar trauma in the maxillary anterior teeth

Some demographic data, MIC characteristics, such as the alpha angle, sector and height of impaction, and basic 2-D diagnostic data, were obtained from the clinical and radiographic registers. 27 CBCT images were obtained at (T0) and (T1), defining T1 as the moment when the MIC reached the occlusal plane and traction was ended.

The measurements obtained from the CBCT images were performed by three trained and calibrated orthodontists (G.A.R.M., L.E.A.G., Y.A.R.C.). The intra and inter-observer agreement in location and sector of MIC was evaluated with a kappa coefficient achieving values greater than 0.9. To evaluate the intra-observer reliability regarding the height and width change measurements, the same examiner (G.A.R.M.) re-evaluated the 30% of the sample, which was randomly selected, after a 30-day interval. The data were analyzed with the intra-class correlation coefficient, which also provided values greater than 0.9. In addition, the random error, estimated by Dahlberg´s formula, was less than 1 mm.[24]

The location of each unilateral MIC was defined as buccal or palatal following clinical criteria and CBCT axial section evaluations.[25-27] The clinical criteria were as follows: (1) prominence of the MIC over the mucoperiosteum; (2) in the axial view, cuspid appearance over the buccal or palatal cortical region; (3) MIC crown positioned over the buccal/palatal region of the lateral incisor root, (4) surgical access according to the surgeon.

CBCT scans of all patients were obtained with PaX-Uni 3D equipment (Vatech, Hwaseong, South Korea) set at 4.7 mA, 89 kVp, with a voxel size of 0.125 and exposure time of 15 seconds (mean). Each field-of-view mode was 8 x 8 cm. DICOM images were analyzed with 3D software (version 11.8; Dolphin Imaging, Chatsworth, Calif) using multiplanar and 3D reconstructions. The panoramic images derived from CBCT were used to determine the impaction sector according to Ericson and Kurol.[28] Five sectors were considered. Sector 1 was the cusp tip of the MIC located between the mesial aspect of the first premolar to the distal aspect of the lateral incisor. Sector 2 was the cusp tip of the MIC located between the distal aspect of the lateral incisor and the long axis of the lateral incisor. Sector 3 was the cusp tip of the MIC located between the long axis of the lateral incisor and the mesial aspect of the lateral incisor. Sector 4 was the cusp tip of the MIC located between the mesial aspect of the lateral incisor and the long axis of the central incisor. Sector 5 was the cusp tip of the MIC located between the long axis of the central incisor and the inter-incisor midline. The impaction alpha angle was defined as the angle between the long axis of the MIC and the interincisal midline, and the canine height was measured as the perpendicular distance from the cusp tip of the MIC to the incisal plane (Fig 1).[29-31]

Sagittal, coronal and axial sections were evaluated using the same software (Dolphin Imaging 11.8). Using the multiplanar reformation (MPR), a vertical axis was located in the middle of the canine alveolar space, delimited between the lateral incisor and the first premolar. This axis was also centered on the deciduous pulp conduct axis, when present at T0, or on the pulp conduct of the permanent canine at T1 (at the level of the cervical bone crest, as a reference). This procedure allowed rotations in the three planes prior to the measurements (red line, Figs 2 and 3). Palatal and buccal and mesial and distal heights were measured from the alveolar crest to the nasal floor on the sagittal and coronal views, respectively. In the sagittal view, the bucco-palatal widths were measured at three levels (cervical, middle and apical) every 6 mm from the alveolar crest. In the axial view, the bucco-palatal cervical widths were measured mesially (proximal to the lateral incisor) and distally (proximal to the premolar) to the canine at the level of the alveolar ridge. All measurements were performed for the MIC and the control canine (CC) at T0 and T1.

All patients were treated by an expert and trained orthodontist following the same treatment protocol (G.A.R.M.). The biomechanical sequence of orthodontic treatment followed a rigorous protocol in all subjects. Fixed orthodontic appliances with 0.022x0.028-inch (Synergy; Rocky Mountain Orthodontics, Denver, Col.) and copper nickel-titanium (Ormco, Glendora, Calif) 0.016 x 0.022-inch archwires were used. The deciduous canine in the impaction side was always present during the beginning of the mechanics. Thus, once the anterior and posterior segments were aligned and leveled, the space preparation for the MIC was performed with 0.012 x 0.045-inch open coil springs (Rocky Mountain Orthodontics). One month before surgery, the rigid anchorage device (1.1 mm or 1.2-mm stainless steel, Dentaurum, Ispringen, Germany) associated with a palatal acrylic button, and with occlusal-palatal-buccal stepped extensions distal to the lateral incisor and on the proximal sides of premolars and molars (performed with a 0.028-inch wire), was cemented. The buccal extensions protect the tissues and avoid immersions of the Ni-TiCCS in the soft muco-periosteal tissue. Ni-TiCCS 0.010 x 0.036 inches and of 8 and 13 mm (Dentos, Daegu, Korea) were used to provide 100-150 g of force when they were activated for trans-alveolar traction of the MIC (Fig 4).

A 0.017x0.025-inch stainless steel archwire, passively placed and distally cinched to the most distal molar, was used before traction for maxillary arch consolidation. A closed surgical technique was performed in all cases with an individualized osteotomy that never exceeded the MIC cement-enamel junction.[3,5,6,29] Prior to the Ni-TiCCS fixation, an absolute trans-surgical isolation was performed. The activation was performed immediately after the spring fixation and individualization of the anchorage (Fig 5), and it was maintained during traction (6-7 mm every 6 weeks). Four to six months after the initiation of traction, the anchorage and traction springs were removed, and the MIC was leveled. Then, the finalization phase was initiated.

A new CBCT was taken (T1) to evaluate the three-dimensional changes in the root and alveolar bone and to visualize the consequences of the traction on MIC and on the non-impacted teeth after the end of MIC traction. This decision was adopted according to the ALARA-principle, international guidelines and is supported by evidence-based science.[32,33]

Statistical analyses

The statistical analyses were performed using SPSS Ver. 19.0 for Windows (IBM, Armonk, NY, USA). Descriptive statistics of height and width changes in mm were calculated for both groups, palatally and buccally MIC. Data normality was assessed with the Shapiro-Wilk test. The independent t-test or U Mann-Whitney test were used (depending on the data normality) to compare height and width changes between groups (buccally versus palatally unilateral maxillary impacted canine groups), and the paired t-test or Wilcoxon signed-rank test were used (depending on the data normality) to compare the affected versus the non-affected sides in each MIC group. Finally, multiple linear regression analyses were applied only to the outcome variables that fulfilled the assumptions of normality and homoscedasticity to evaluate the influence of each variable on height and width changes. An initial regression analysis with all predictor variables followed by a second regression analysis with only predictor variables showing P values smaller than 0.25 was performed (overfit method).[34] Statistical significance was set at 0.05 for all statistical tests.

RESULTS

The age and sex distribution of the sample and MIC characteristics by group are summarized in Table I. Also, the traction time in months (5.71±1.06, palatal; 5.46±1.26, buccal) was similar between groups (P=0.579). The palatally MIC group showed significant higher impaction than the other group. The MIC were mainly located in sectors 3, 4 and 5 in both groups (78% of the sample, Table II).

The alveolar height changes (T0-T1) showed statistically significant differences between the groups (buccally versus palatally unilateral maxillary impacted canine groups) for all measurements. The palatally MIC height changes ranged from 2.09 to 2.79 mm, while the buccally MIC height changes ranged from 0.28 to 0.57 mm. Otherwise, the alveolar width changes were not statistically significant different between groups (Table III).

After palatally MIC traction, the buccal, mesial and distal alveolar heights showed statistically significant greater decreases (2.52 to 2.79 mm), and the cervical and mesial widths showed significant increases (0.74 to 1.36 mm) on the affected side, as compared to the non-affected side (Table IV).

After buccally MIC traction, the palatal, buccal, mesial and distal alveolar heights showed statistically significant greater decreases (0.28 to 0.57 mm), and the cervical width showed a significant increase (1.26 mm) on the affected side, as compared to the non-affected side (Table V).

The multivariate analysis (Table VI) indicated that the buccally impacted canine condition decreased the alveolar height. Likewise, age and sex had a significant influence on some alveolar heights. For each year, reductions of 0.18 mm and 0.17 mm occurred in palatal and buccal heights, respectively. Women presented greater palatal, buccal and distal height loss (1.83 mm, 1.76 mm and 2.25 mm, respectively) than men.

Finally, the alpha angle of canine impaction was the only variable that had a significant influence on the cervical width (Table VII).

DISCUSSION

The traction of MIC is associated with morphological changes in the involved tooth, in the adjacent teeth and in the surrounding dentoalveolar structure. This study was performed to evaluate the dimensional changes in the alveolar bone of the tractioned canine and its corresponding control, considering the position of the impacted tooth (either palatal or buccal). It is important to emphasize that groups were quite similar regarding MIC characteristics (except for the impaction height), traction time and impaction sector. In this way, the alveolar bone dimension changes would not be affected by these variables, making group comparisons more reliable. Additionally, this study did not aim to perform measurements of the buccal of the periodontal status nor clinical evaluation of the vestibular keratinized margin of attached gum. Remodeling changes in height and width of the alveolar bone were only analyzed. Moreover, the methodology for alveolar height and width evaluations used on this study, as parameters of dimensional changes, were based on previously reported morphometric measurements.[21,22]

Although CBCT offers geometric advantages over conventional intraoral radiographs as documented by many authors,[7-11] no studies have evaluated dimensional changes in the alveolar bone or bone loss in unilateral impacted maxillary canine teeth undergoing orthodontic-surgical traction. Few studies have provided CBCT control comparing two times (T0 and T1) corresponding to initial and after traction movement. According to evidence-based guidelines and the ALARA principle, the use of 3D images can be justified before/after a specific treatment for diagnosis and follow-up in some circumstances, e.g., impacted teeth. This procedure allows axial and coronal evaluations, which are impossible to perform with 2D radiographs. Each CBCT is necessary to evaluate the severity of malposition, root resorption and possible bone loss effects consequent to the traction.[30-33]

The orthodontic treatment followed the same protocol for all patients and all of them were treated by the same trained orthodontist, an expert in the orthodontic management of impacted canines (G.A.R.M.); Of this way, the orthodontic protocol associating Ni-TiCCS with a reinforced customized anchorage was standardized for all patients. This association allowed biomechanical control of the magnitude, direction and x-y-z axis sense of force using superelasticity, memory, and light continued force concepts with a wide range of activation, as previously reported for orthodontic mechanics (Figs 4 and 5).[14-18] Manhartsberger and Seidenbusch[16] as well as Schubert[17] have documented the control, simplicity, efficiency and cost benefits of Ni-TiCCS for retraction mechanics. These advantages were complemented with the use of a custom rigid palatal anchorage, with buccal extensions, which was adapted for the short period of traction (approximately 6 months) to protect adjacent teeth and soft tissues against the effects of action-reaction forces, avoiding immersion of the springs in the mucoperiosteum. This mechanics also approximated the canine center of resistance to the force of traction. It can be argued that, currently, mini-implants could be used for these purposes. However, the system presented in this study has a reduced fabrication cost and avoids the use of mini-implants. Thus, it could be considered as an alternative for institutional public health or when the use of mini-implants is refused by patients or are difficult to obtain (Figs 4 and 5). [31]

Many studies have focused in the periodontal clinical effects of MIC traction using conventional periapical and panoramic X-ray films. Some studies[3-6] have compared periodontal conditions between treated MIC and contralateral controls, with no significant clinical nor significant differences. Quirynen et al.[22] in a split-mouth clinical study, recommended traction as a method with small periodontal impact. However, Szarmach et al.[35] found an association between the mechanic factors and oral hygiene with periodontal deterioration. Silva et al.[19] used CBCT after traction only to evaluate the effects of traction on roots and bone of the canine and adjacent teeth over the long term. They observed minimal damage to these structures. Because some studies have observed important bone loss and lingual cortical width reduction after orthodontic treatment, specifically in the anterior mandibular region,[20,21,36,37] it is possible that MIC traction mechanics may reflect a similar behavior. However, these effects are not usually studied regarding MIC traction.

According to Lund11 and Garlock,[37] conventional orthodontic treatment with and without extraction produces tridimensional alveolar changes on CBCT per se. The results of the present study indicate that the traction treatment produced significant changes mainly in alveolar height in both groups (Tables IV and V). The forces of traction with Ni-TiCCS remodel the alveolar shape and size in the MIC region,[14-18] which can be expected because of the intrusive effect on the adjacent lateral incisor and first premolar, with reciprocal action/reaction forces. In addition, this phenomenon could be considered as a response of remodeling and bone resistance to extrusive traction, specifically for the complex palatal and transalveolar path of traction (from palatal to buccal) in palatally MIC (Table III). For this reason, Caprioglio[3], Hansson[4] and Parkin[6] explain how palatally impacted canines still present some challenges. The significant greater alveolar height reduction observed in the traction of palatally MIC compared with buccally MIC probably occurred as a side effect of the complex crown-root movement on the x-y-z axes until the achievement of an adequate buccal and occlusal position (Figs 5 and 6).[14]

Another factor that has not been clearly described by other authors and that may be involved in the reduction of alveolar height is the absence of follicle and periodontal ligament on the enamel of the MIC crown, which does not produce osteogenesis or remodeling when the tooth moves through the bicortical bone toward the occlusal plane. In addition, the greater impaction of palatal canines could be influenced by the greater alveolar height reduction in this group (Table III). However, additional studies are needed to examine these possibilities. The alveolar height of the buccal MIC was less affected, which could be related to the low resistance to traction for the evident thinness of its cortical and mucoperiosteum (Fig 6).

Coinciding with Quirynen,[22] the statistically significant increase in alveolar width at the cervical and mesial levels of the MIC (Tables IV and V) was probably related to the increase in mesial and distal alveolar cervical width of the MIC associated with the increase in width at the bone crest level due to differences in mesio-distal and bucco-palatal dimensions between the deciduous canine before traction and permanent MIC after traction (Fig 7).

Crescini,[5,29] using different biomechanics and methodology, found that the final periodontal status does not depend on age, gender, or pre-treatment radiographic features. In our study, the regression analysis estimated the influence of co-variables (sex, age, position, sector, angle and distance) and indicated that the sex variable had a significant influence on the dimensional alveolar height changes (Table VI). The change in palatal, buccal and distal height (1.83 mm, 1.76 mm and 2.25 mm, respectively) was greater in women than in men. Age had a slight influence on the palatal and buccal width reduction (calculated amount of reduction per year: 0.18 mm and 0.17 mm, respectively). Finally, the regression analysis corroborated that palatally MIC traction had a greater impact on the alveolar height change compared with buccally MIC traction.

In contrast to conventional orthodontic mechanics, unilateral MIC traction requires a 3D diagnosis, an individualized anchoring device, oral surgery, three-dimensional biomechanical control, efficient force and transalveolar extrusive traction. This traction causes alveolar bone changes (remodeling) with evident reductions in the alveolar bone height and increases in cervical alveolar width. Further studies evaluating the effects of the orthodontic traction of maxillary impacted canines on the buccal and palatal cortical thickness and in the periodontal status are necessary to better clarify the concepts of traction “with the bone”, “inside the bone” and “through the bone”.[1]

CONCLUSIONS

- Palatally maxillary impacted canine traction showed a greater alveolar bone height decrease than buccally impacted canine traction. Sex and age influence these alveolar dimensional changes.
- Alveolar width increased similarly in both palatal and buccal impaction traction cases.
- Use of the nickel-titanium closed coil spring and reinforced anchorage seems to be an adequate alternative method for orthodontic traction of impacted teeth.

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FIGURE LEGENDS

Fig 1. Sectors 1-2-3-4-5, alpha angle (α) and height of the cusp to the incisal plane (h) according to Ericson and Kurol.[28]

Fig 2. Maxillary impacted canine (MIC) before (T0) and after (T1) traction. Heights from the alveolar crest to nasal floor (dotted white line). Mesial (M) and distal (D) height measurements in the coronal section. Palatal (P) and buccal (B) heights, and cervical (C), middle (M) and apical (A) width measurements every 6 mm from the alveolar crest, in sagittal section. Mesial (M) and distal (D) cervical width measurements at the level of the alveolar ridge in axial section.

Fig 3. Control canine (CC) from the non-affected side before (T0) and after (T1) traction. Heights from the alveolar crest to the nasal floor (dotted white line). Mesial (M) and distal (D) height measurements in the coronal section. Palatal (P) and buccal (B) heights, and cervical (C), middle (M) and apical (A) width measurements every 6 mm from the alveolar crest, in sagittal section. Mesial (M) and distal (D) cervical width measurements at the level of the alveolar ridge in axial section.

Fig 4. Control of buccal and palatal traction of unilateral MIC in the x, y, and z axes. Traction with nickel-titanium closed coil springs and a rigid palatal anchorage appliance with buccal extensions and palatal hooks. Distal traction on the x-axis (white arrow), buccal traction on the y-axis (yellow arrow), and extrusive traction on the z-axis (red arrow).

Fig 5. Clinical and radiographic images of palato-buccal movement in the y-axis (yellow arrow), mesio-distal movement in the x-axis (white arrow), and extrusive movement in the z-axis (red arrow) of palatally and buccally MIC with Ni-Ti closed coil springs activated over the rigid anchorage.

Fig 6. Complex palatal and trans-alveolar path in the x-y-z axis of a palatally MIC (P) towards the buccal and occlusal position, with a reciprocal action/reaction effect, remodeling and bone resistance to extrusive traction, which can cause greater palatal bone height reduction. The height of the buccally MIC (B) can be less affected due to the thinness of its cortical and mucoperiosteum, and the low resistance to traction. Palato-buccal movement in the y-axis (yellow arrow), mesio-distal movement in the x-axis (white arrow), and extrusive movement in the z-axis (red arrow).

Fig 7. Increase in mesial (M) and distal (D) cervical alveolar width in maxillary impacted canines (MIC) associated with the increase in width at the bone crest level due to differences in mesio-distal (MD) and bucco-palatal (BP) diameters between deciduous canine before traction (T0) and permanent MIC after traction (T1).

Table I. Sample demographic and MIC characteristics

Sex	n	Age		P
		Mean	**SD**	
Male	12	19.08	5.48	0.510
Female	15	20.93	8.22	
Impaction type	**n**	**Alpha angle**		**P**
		Mean	**SD**	
Palatally	14	51.57	22.67	0.332
Buccally	13	43.77	17.74	
Impaction type	**n**	**Impaction height**		**P**
		Mean	**SD**	
Palatally	14	14.43	4.38	0.010
Buccally	13	10.69	2.18	
Impaction type	**n**	**Traction time**		**P**
		Mean	**SD**	
Palatally	14	5.71	1.06	0.579
Buccally	13	5.46	1.26	

t-test

Table II. Association between type and sector of maxillary canine impaction

Type of impaction	Impaction sector					
	1	**3**	**4**	**5**	**Total**	**P**
Palatally	2	5	5	2	14	
Buccally	4	5	2	2	13	0.590
Total	6	10	7	4	27	

Chi Square test

Table III. Comparison of alveolar changes in mm (T_0 - T_1) between buccally versus palatally maxillary impacted canines.

Measure	Impacted canine position	n	Mean	SD	P	Mean difference	95% CI	
							Lower limit	Upper limit
Palatal height changes	Palatally	14	2.09	2.64	0.034*†	1.81	0.04	3.59
	Buccally	13	0.28	1.70				
Buccal height changes	Palatally	14	2.52	2.34	0.011*†	1.95	0.33	3.58
	Buccally	13	0.57	1.68				
Mesial height changes	Palatally	14	2.76	2.95	0.019*‡	2.37	0.42	4.31
	Buccally	13	0.39	1.75				
Distal height changes	Palatally	14	2.79	2.22	0.006*‡	2.32	0.73	3.92
	Buccally	13	0.47	1.76				
Cervical width changes	Palatally	14	-1.36	1.14	0.836‡	-0.1	-1.04	0.85
	Buccally	13	-1.26	1.24				
Middle width changes	Palatally	14	-0.07	2.23	0.274†	-0.86	-2.51	0.78
	Buccally	13	0.79	1.89				
Apical width changes	Palatally	14	-0.14	2.45	0.262‡	-0.99	-2.75	0.78
	Buccally	13	0.85	1.95				
Mesial width changes	Palatally	14	-0.74	1.02	0.328‡	-0.39	-1.17	0.41
	Buccally	13	-0.35	0.96				
Distal width changes	Palatally	14	-0.76	0.99	0.063‡	-0.64	-1.32	0.04
	Buccally	13	-0.12	0.69				

* Statistically significant at $P<0.05$, (- value) = increase and (+ value) = decrease

†U Mann-Whitney test

‡Independent t-test

Table IV. Alveolar changes (T_0 - T_1) after canine traction between palatally impacted canine side and the non-impacted side.

Measurement	n	Mean	SD	Mean difference	95% CI Lower limit	95% CI Upper limit	P
Palatal height changes - affected side	14	2.09	2.64	1.71	-0.45	3.88	0.111†
Palatal height changes - non affected side	14	0.38	2.72				
Buccal height changes - affected side	14	2.52	2.34	2.71	0.61	4.81	0.015*†
Buccal height changes - non affected side	14	-0.19	3.02				
Mesial height changes - affected side	14	2.76	2.95	3.15	0.87	5.43	0.011*†
Mesial height changes - non affected side	14	-0.39	2.82				
Distal height changes - affected side	14	2.79	2.22	2.54	0.9	4.19	0.013*‡
Distal height changes - non affected side	14	0.25	1.89				
Cervical width changes - affected side	14	-1.36	1.14	-1.71	-2.44	-0.97	<0.001*†
Cervical width changes - non affected side	14	0.35	1.20				
Middle width changes - affected side	14	-0.07	2.23	-0.18	-1.3	0.94	0.735†
Middle width changes - non affected side	14	0.11	1.07				
Apical width changes - affected side	14	-0.14	2.45	-0.73	-2.3	0.85	0.336†
Apical width changes - non affected side	14	0.59	1.41				
Mesial width changes - affected side	14	-0.74	1.02	-0.78	-1.5	-0.05	0.037*‡
Mesial width changes - non affected side	14	0.04	0.96				
Distal width changes - affected side	14	-0.76	0.99	-1.31	-2.12	-0.51	0.105*†
Distal width changes - non affected side	14	0.55	1.04				

* Statistically significant at $P<0.05$, (- value) = increase and (+ value) = decrease
†Paired t-test
‡Wilcoxon signed-rank test

Table V. Alveolar changes (T_0 - T_1) after canine traction between buccally impacted canine side and non-impacted side.

Measurement	n	Mean	SD	Mean difference	95% CI Lower limit	95% CI Upper limit	P
Palatal height changes - affected side	13	0.28	1.70	2.16	0.46	3.87	0.013*‡
Palatal height changes - non affected side	13	-1.88	2.96				
Buccal height changes - affected side	13	0.57	1.68	2.60	0.87	4.33	0.007*‡
Buccal height changes - non affected side	13	-2.03	2.93				
Mesial height changes - affected side	13	0.39	1.75	2.28	1.12	3.45	0.003*‡
Mesial height changes - non affected side	13	-1.89	1.83				
Distal height changes - affected side	13	0.47	1.76	1.95	0.47	3.42	0.014*†
Distal height changes - non affected side	13	-1.48	1.97				
Cervical width changes - affected side	13	-1.26	1.24	-1.31	-2.07	-0.56	0.003*†
Cervical width changes - non affected side	13	0.05	0.67				
Middle width changes - affected side	13	0.79	1.89	0.94	-0.24	2.13	0.100‡
Middle width changes - non affected side	13	-0.15	0.88				
Apical width changes - affected side	13	0.85	1.95	0.59	-0.94	2.11	0.420†
Apical width changes - non affected side	13	0.26	1.25				
Mesial width changes - affected side	13	-0.35	0.96	-0.01	-0.51	0.48	0.947†
Mesial width changes - non affected side	13	-0.34	1.11				
Distal width changes - affected side	13	-0.12	0.69	0.42	-0.20	1.03	0.166†
Distal width changes - non affected side	13	-0.54	0.87				

* Statistically significant at $P<0.05$, (- value) = increase and (+ value) = decrease
†Paired t-test
‡Wilcoxon signed-rank test

Table VI. Multiple linear regressions for alveolar height measurements.

Model		B	P	95% CI for B		r^2
				Lower limit	Upper limit	
Palatal height changes	Constant	6.77	0.001*	3.16	10.37	0.568
	Age	-0.18	0.002*	-0.28	-0.08	
	Sex (Female)	1.83	0.013*	0.42	3.25	
	Canine Position (Buccal)	-1.65	0.046*	-3.27	-0.04	
	Height	-0.18	0.085	-0.38	0.03	
Buccal height changes	Constant	6.45	<0.001*	3.23	9.67	0.611
	Age	-0.17	0.001*	-0.27	-0.08	
	Sex (Female)	1.76	0.009*	0.49	3.02	
	Canine Position (Buccal)	-1.61	0.030*	-3.06	-0.17	
	Height	-0.12	0.172	-0.3	0.06	
Distal height changes	Constant	3.79	0.042*	0.15	7.44	0.527
	Age	-0.07	0.196	-0.17	0.04	
	Sex (Female)	2.25	0.003*	0.82	3.68	
	Canine Position (Buccal)	-2.05	0.016*	-3.68	-0.41	
	Height	-0.08	0.403	-0.29	0.12	

* Statistically significant at $P<0.05$

Table VII. Multiple linear regressions for alveolar width measurements

Model		B	P	95% CI for B Lower limit	95% CI for B Upper limit	r^2
Cervical width changes – affected side	Constant	-0.79	0.389	-2.66	1.08	0.298
	Canine Position	0.18	0.709	-0.79	1.14	
	Alfa angle	-0.04	0.007*	-0.07	-0.01	
	Height	0.11	0.195	-0.06	0.27	
Apical width changes – affected side	Constant	-2.76	0.153	-6.62	1.11	0.184
	Canine Position	1.88	0.064	-0.12	3.88	
	Alfa angle	-0.04	0.180	-0.10	0.02	
	Height	0.32	0.065	-0.02	0.66	
Mesial width changes – affected side	Constant	-0.53	0.557	-2.36	1.31	0.060
	Canine Position	0.27	0.565	-0.68	1.22	
	Alfa angle	0.01	0.426	-0.02	0.04	
	Height	-0.05	0.505	-0.22	0.11	
Distal width changes – affected side	Constant	0.20	0.784	-1.31	1.72	0.228
	Canine Position	0.32	0.402	-0.46	1.11	
	Alfa angle	0.01	0.284	-0.01	0.04	
	Height	-0.11	0.102	-0.24	0.02	

* Statistically significant at $P<0.05$

Figures and Legends

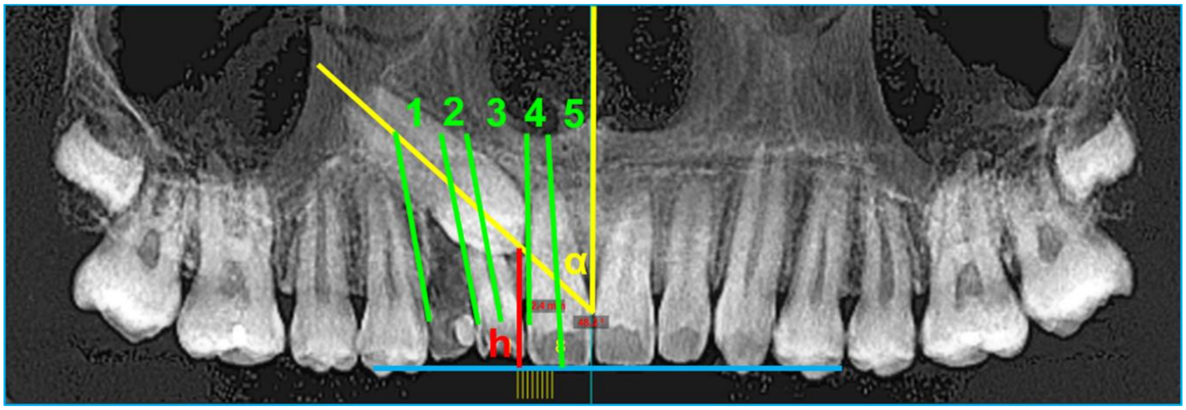

Fig 1. Sectors 1-2-3-4-5, alpha angle (α) and height of the cusp to the incisal plane (h) according to Ericson and Kurol.[28]

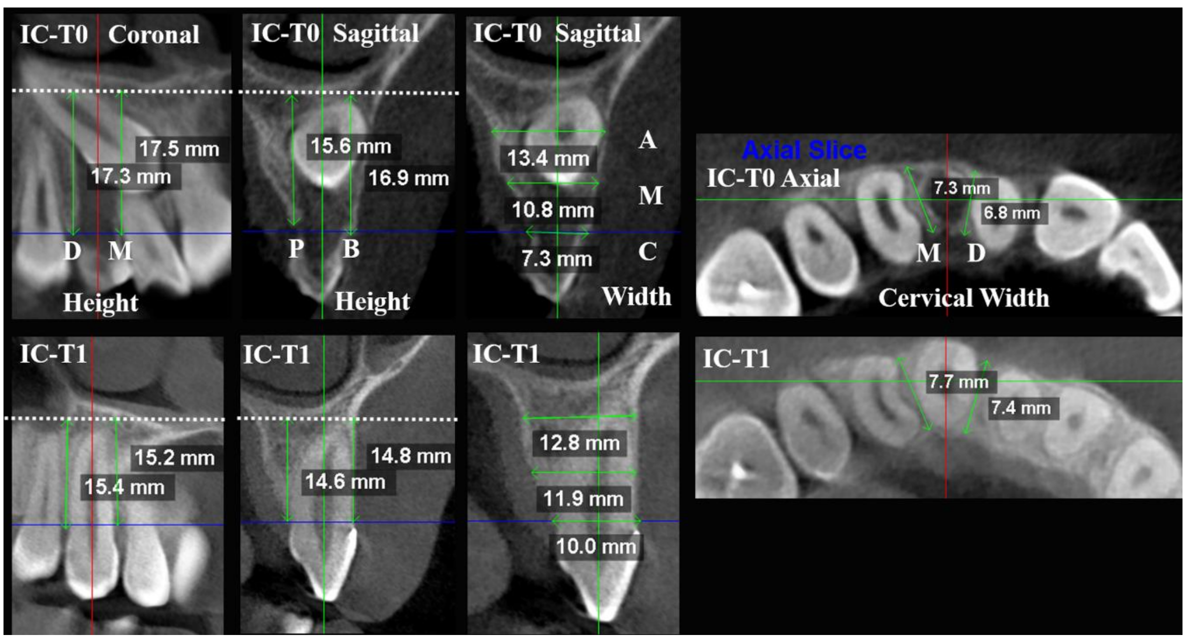

Fig 2. Maxillary impacted canine (MIC) before (T0) and after (T1) traction. Heights from the alveolar crest to nasal floor (dotted white line). Mesial (M) and distal (D) height measurements in the coronal section. Palatal (P) and buccal (B) heights, and cervical (C), middle (M) and apical (A) width measurements every 6 mm from the alveolar crest, in sagittal section. Mesial (M) and distal (D) cervical width measurements at the level of the alveolar ridge in axial section.

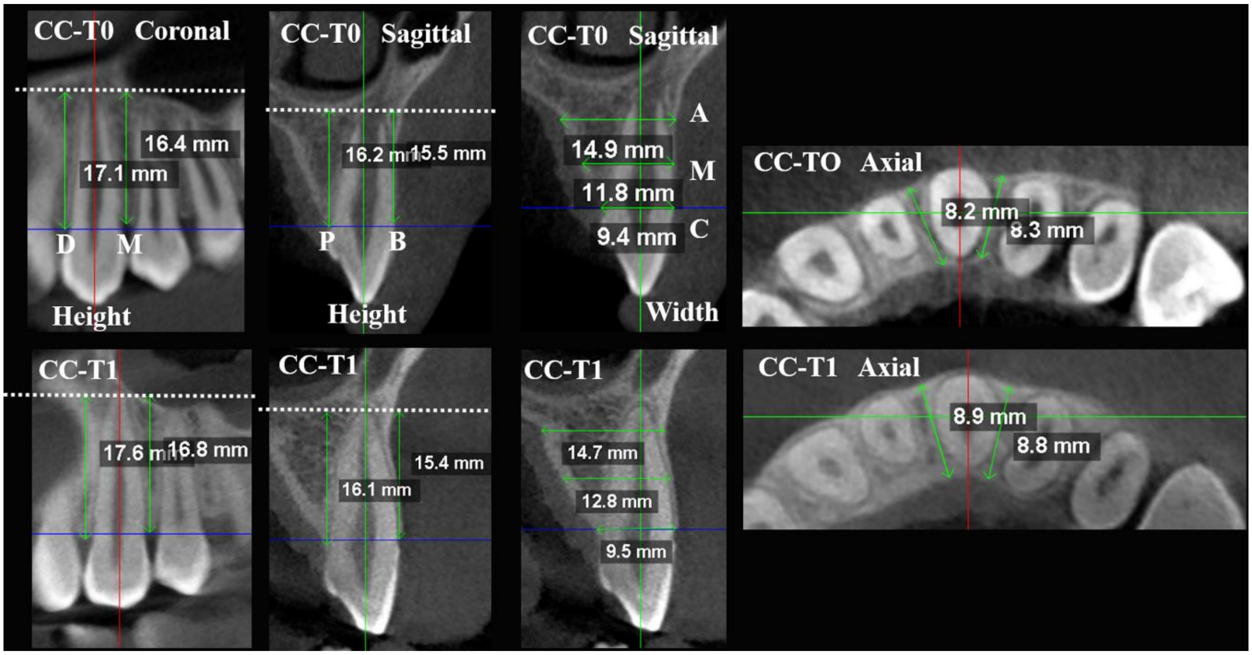

Fig 3. Control canine (CC) from the non-affected side before (T0) and after (T1) traction. Heights from the alveolar crest to the nasal floor (dotted white line). Mesial (M) and distal (D) height measurements in the coronal section. Palatal (P) and buccal (B) heights, and cervical (C), middle (M) and apical (A) width measurements every 6 mm from the alveolar crest, in sagittal section. Mesial (M) and distal (D) cervical width measurements at the level of the alveolar ridge in axial section.

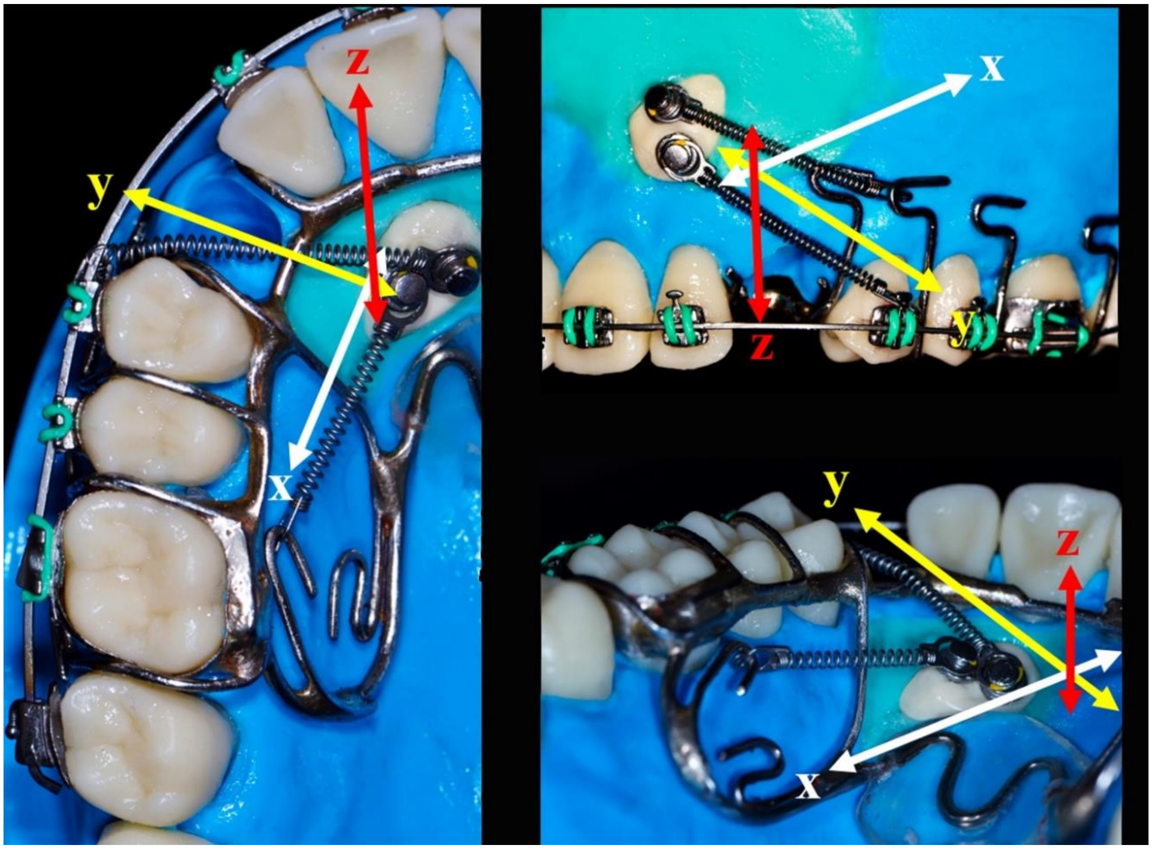

Fig 4. Control of buccal and palatal traction of unilateral MIC in the x, y, and z axes. Traction with nickel-titanium closed coil springs and a rigid palatal anchorage appliance with buccal extensions and palatal hooks. Distal traction on the x-axis (white arrow), buccal traction on the y-axis (yellow arrow), and extrusive traction on the z-axis (red arrow).

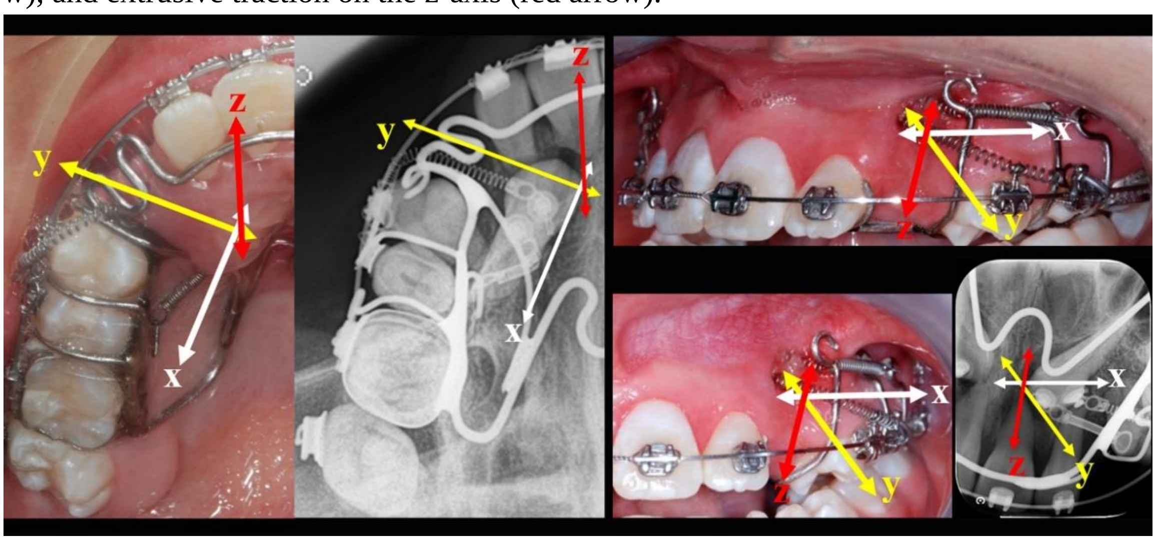

Fig 5. Clinical and radiographic images of palato-buccal movement in the y-axis (yellow arrow), mesio-distal movement in the x-axis (white arrow), and extrusive movement in the z-axis (red arrow) of palatally and buccally MIC with Ni-Ti closed coil springs activated over the rigid anchorage.

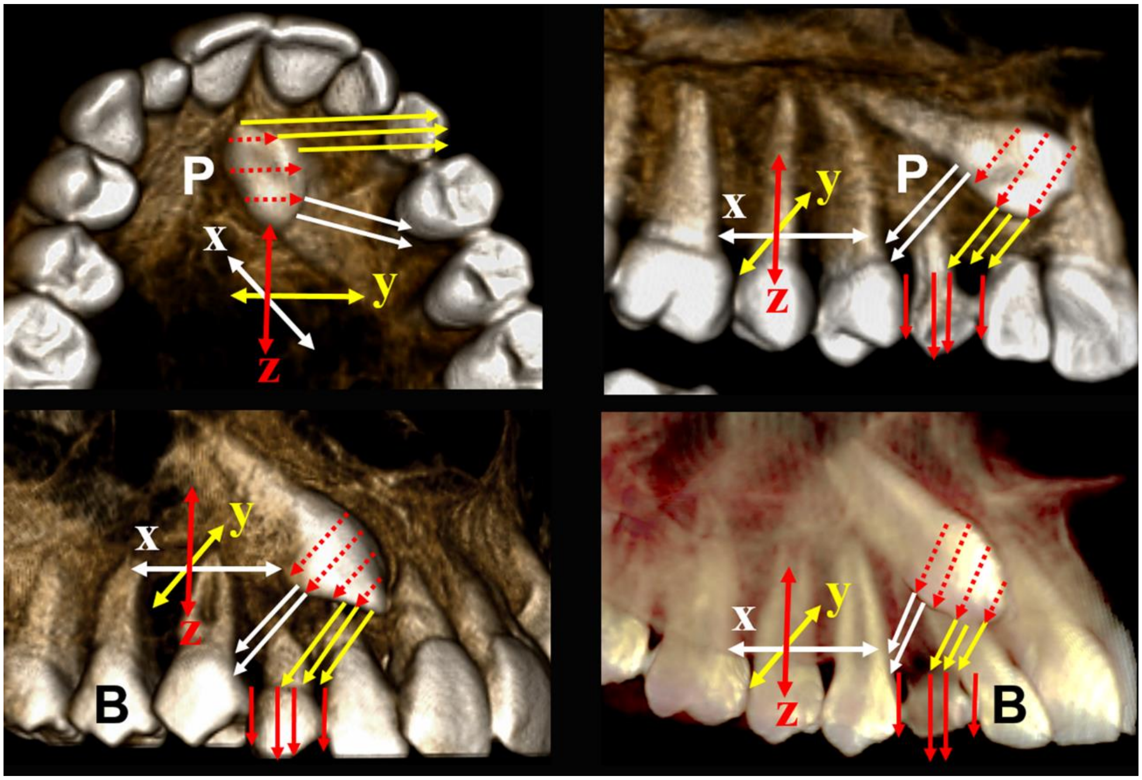

Fig 6. Complex palatal and trans-alveolar path in the x-y-z axis of a palatally MIC (P) towards the buccal and occlusal position, with a reciprocal action/reaction effect, remodeling and bone resistance to extrusive traction, which can cause greater palatal bone height reduction. The height of the buccally MIC (B) can be less affected due to the thinness of its cortical and mucoperiosteum, and the low resistance to traction. Palato-buccal movement in the y-axis (yellow arrow), mesio-distal movement in the x-axis (white arrow), and extrusive movement in the z-axis (red arrow).

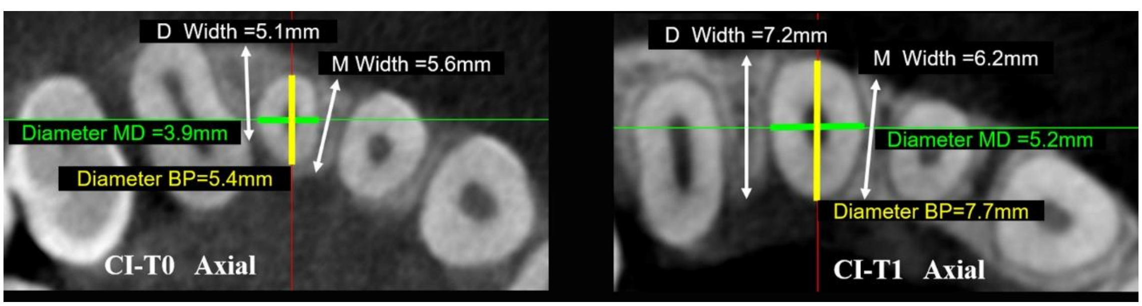

Fig 7. Increase in mesial (M) and distal (D) cervical alveolar width in maxillary impacted canines (MIC) associated with the increase in width at the bone crest level due to differences in mesio-distal (MD) and bucco-palatal (BP) diameters between deciduous canine before traction (T0) and permanent MIC after traction (T1).

Artigo 2

Biomechanic alternative for impacted maxillary canine traction in adults with severe incisor root resorption

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Formatado, enviado, revisado, reenviado ao ***Journal of Clinical Orthodontics***

Biomechanic alternative for impacted maxillary canine traction in adults with severe incisor root resorption

Altered resorption in deciduous canines, severe dentoalveolar discrepancies, failures in the biochemical eruptive process and unspecific morphologic alterations that facilitate the deviation and uncontrolled ectopic migration of permanent canines, are the most frequent causes of canine uneruption. These eruptive disorders may produce a close proximity of the pericoronal follicle over the incisors apex leading to severe root resorption.[1,2]

The ectopic eruption of bilaterally impacted canines in a bi-cortically centered position between buccal and palatal cortical bone and over the roots of maxillary incisors increases the risk of severe root resorption.[3,4] This may be augmented when the orthodontic traction with canine surgical exposure approach is performed.[5,6] A major secondary effect of this traction is severe root resorption, highly difficult to manage, where the reciprocal intrusive/extrusive forces affect the root size of the adjacent teeth to the traction, tipping the occlusion plane,[6,7] and inducing undesirable changes on the orthodontic wires and brackets.[8]

Usually, conventional mechanic appliances used for traction impacted teeth are not able to control the action/reaction effects over the adjacent teeth, and this could produce deforming effects in the main archwires.[6,9-11] Sometimes, the use of Temporary Anchorage Devices (TADs) in complex cases demands a constant change of TADs position or the use of different miniscrews as the canine migrates.[9]

Some protocols that showed the diagnosis and treatment planning for traction maxillary impacted canines have been reported.[10-12] However, a step by step sequence description including diagnosis, biomechanical and surgical planning and intervention for this treatment is rarely described. Therefore, the following case reports illustrate a conservative biomechanic approach for the traction of impacted teeth. This includes the use of nickel-titanium closed coil springs anchored to a rigid appliance having a Nance button on the palate, as the base matrix, and modified with palatal-buccal extensions. Two complex cases are presented, these adult patients presented severe root resorption of the maxillary incisors associated to bilateral impacted maxillary canines.

These case reports describe the success treatment of two adult patients with impacted maxillary canines (IMCs) located in a complex position and with previous root resorption of incisors.

Diagnosis and etiology

Two patients with the presence of deciduous canines visited a private practice [redacted] asking for treatment. Both presented IMCs bicortically centered in the alveolar bone and near to midline associated with severe resorption of the four maxillary incisors. The final position of the IMCs closed to the midline eliminated the diagnostic of ankyloses.[1] These problems were observed from previous panoramic radiographs requested by the general dentist. Severity was evaluated according to previous reported criteria.[13,14]

Patient 1

A 34-year-old male patient asked for dental treatment because of the color change in his deciduous maxillary canines and for the central diastema. The patient did not present medical contributory history, and he was worried about the finding, reported by the general dentist related to the permanent impacted canines evidenced in the panoramic radiograph. The facial and intraoral clinic examination indicated signs of subclinical asymmetry. He presented a mild anterior cross-bite on the right side (Fig. 1).

The panoramic radiograph confirmed the ectopic position of the maxillary canines, permanence of deciduous canines and Severe Root Resorption (SRR) in all maxillary incisors (Fig. 2). Multiplanar CBCT sections were used to locate the bilateral retention, bi-cortically centered in the alveolar bone,[5,15,16] suggesting a surgical palatal approach. The right canine was located in sector 5, with α angle of 44°, at 11 mm from the incisal plane, causing severe resorption in approximately more than 70% of the roots of central and lateral incisors. The left canine was placed in sector 5, with α angle of 48°, at 10 mm of the incisal plane, causing approximately 80% of resorption on the central incisor and 60% on the lateral (Fig. 3).[17] The cephalometric values indicated a mild Class III skeletal sagittal relationship, with moderate maxillary deficiency and labial inclination of incisors (Table 1).

Patient 2

A 18 year-old female patient, skeletal Class I sagittal relationship with no contributory medical history. She asked treatment because of the presence of deciduous maxillary canines and the unerupted permanent maxillary canines. She presented a good proportional facial balance, but her smile esthetics was affected by the bilateral presence of deciduous maxillary canines and malposition of lateral incisors. The posterior intercuspidation was favorable showing Class I molar relationship in both sides and midline coincidence (Fig. 4). The cephalometric and panoramic radiographs, confirmed the Class I skeletal relationship with mild hyperdivergent pattern, notorious buccal tipping of maxillary incisors, and the obliquus bilateral position of IMCs, respectively (Fig. 5, Table 1).

CBCT scans showed the ectopic bilateral position of both IMCs, located in the mid-line over the roots of the maxillary central incisors and they were causing more than 70% root resorption in these teeth. Root resorption was more than 60% in the mesial side of lateral incisors (Fig. 6). In addition, the canine cuspids appear bicortically centered over the root canal of the two central incisors and with a tendency towards labial side. The right canine was in sector 5, with α angle of 60° and at 14 mm from the incisal plane; the left canine was in sector 5, with α angle of 48° and at 13 mm from the incisal plane.

Treatment Objectives

The main treatment objective in the two cases was to traction the IMCs, maintain the maxillary incisor with SRR in order to preserve the alveolar bone in width and height in the anterior region of the maxilla for future prosthetic rehabilitation with implants, if it would be necessary, and to correct the malocclusions.

Treatment Alternatives

The first treatment option was extract the two maxillary central incisors due to SRR and traction the MICs to replace them. The second option considered the traction of IMCs to a natural morphologically and functionally stable position and the preservation of maxillary incisors in order to keep the bicortical bone width and the alveolar height for a future prosthetic rehabilitation with implants, if it would be necessary. Prognosis for traction, the risk on the maxillary incisors, the dental extractions and the future need of prosthetic rehabilitation was clearly informed to the patients for both options. Thus, the patients chose the second alternative.

Protocol description and treatment planning

The treatment protocol included four consecutive phases (Fig. 7). Following the ALARA principle and the recommendations for the proper use of the ionizing radiation,[18] CBCT images before treatment were obtained using i-CAT scanner (Imaging Science International, Hatfield, PA). The scanning parameters were 120 kV, 47.7 mA, 20 seconds acquisition, 8cm x 8cm field of view (FOV), and voxel size of 0.4 mm. DICOM files images were analyzed with Dolphin-3D (Dolphin software version 11.8. Dolphin Imaging, Chatsworth, Calif), using multiplanar and 3D reconstructions.

The criteria established by Ericson and Kurol[17] was evaluated on panoramic transaxial sections synthetized from CBCT to determine the sector of impaction. All IMCs were bicortically located.[5,16,19,20] (Figs. 3 and 6).

Treatment Progress

The patients were treated under a strict orthodontic and surgical protocol. A segmental alignment and leveling phase was performed with 0.016” x 0.022” Copper nickel-titanium (Ormco, Glendora, Calif) wire on metal brackets, slot 0.022” x 0.028” (Synergy RMO, Inc. Rocky Mountain Orthodontics Denver, Colorado, USA) in incisors and in the premolar and molar regions, always ensuring the permanence of the deciduous canine in the oral cavity. The space was prepared with 0.012” x 0.045” open coil springs (RMO, Inc. Rocky Mountain Orthodontics Denver, Colorado, USA) between lateral incisor and first premolar on 0.017” x 0.025” nickel-titanium archwires. Subsequently, a single and rigid temporary anchorage was placed on bands in first permanent molars with rigid palatal acrylic button and arch over all palatal surfaces of all maxillary teeth present, in 1.1mm (0.043”) or 1.2 mm (0.047”) stainless steel wire (Remanium, Dentaurum, GmbH & Co., Ispringen, Germany) with multiple palatal and occlusal-vestibular hooks in 0.028” wire in the proximal surface between molars and premolars, and distal lateral incisors (Fig. 8). This anchorage device was cemented at four weeks prior to surgery. Vestibular hooks and extensions allowed to fasten the buckles of the nickel-titanium closed coils springs (8 mm and 13 mm long and 100g or 150g force, NT25-13M and H, Dentos Inc. Daegu, Korea). These were activated 6 to 10mm every 6 to 8 weeks to perform intraosseous transalveolar traction, avoiding the springs immersion in the attached gingiva and mucoperiosteum. (Fig. 9).[21,22]

A wide flap suitable to facilitate bilateral palatal (in Patient 1) or buccal (Patient 2) osteotomy was designed. The surgical planning required clearing each crown up to 2 mm before the cement-enamel junction, completely removing the follicle, not dislocating the canine to avoid damage to the periodontal ligament, and fully controlling bleeding and moisture. Any means for hemostasis and absolute drying was essential before the adhesion of each button. The vectors and forces with two closed coil springs of 13 mm x 100 g (medium) and another of 13 mm x 150 g (heavy) in each canine were also planned before the surgical intervention. The use of two 13 mm springs was programmed due to the considerable distance, the high canine resistance and the friction of the spring to bone, mucoperiosteum, hooks and curvature of the maxillary arch.

When the spring activations were completed and it was not necessary further vertical traction of the canines, the palatal anchorage was removed. At this time, all the necessary procedures to complete the orthodontic treatment were performed and finalization phase was initiated.

A stable morphological and functional relationship required to initiate the finalization was obtained in Patient 1 after 13 months. Patient 2 demanded 11 months of traction, and was additionally difficult due to the correction of crown buccal proclination of the four incisors.

In the two cases, retention was provided using 3x3 fixed lingual retainer in the mandibular arch and upper Hawley retainer for daily use and an acetate splint for night use. Even tough patients were not diagnosed with bruxism, this splint was prescribed in order to prevent any anterior occlusal trauma due to physiological bruxism that patients could have during sleeping.

Treatment results

Strictly following the traction protocol, the treatment was completed in 36 months in Patient 1 (Figs. 10 and 11), and 30 months in Patient 2 (Figs. 12 and 13).

The two cases showed a successful positioning of the initially IMCs in functional occlusion and the preservation of all maxillary incisors in oral cavity. Patients showed evident proclination of the maxillary incisors, without mobility, although the resorption was mildly increased in the eight compromised incisors (Figs. 10 and 12).

None of the patients was interested in rehabilitation with implants or any other treatment except for the esthetic reconstruction of the incisal border of maxillary incisors in Patient 1 and the use of occlusal acetate splints to control any kind of physiological bruxism during sleeping. Patient 2 did not accept the indication to remove unerupted mandibular third molars.

The cephalometric analyses confirmed the proclination of the maxillary incisors in both patients (greater in Patient 2). No significant sagittal and vertical skeletal changes were observed (Figs. 11 and 13). Pre- and post-treatment values are showed in Table 1. CBCT scans were taken after 10 years of follow-up in Patient 1 (Fig. 14) and after 5 years of follow-up in Patient 2 (Fig. 15). In the two patients, SRR of the four maxillary incisors were maintained without significant changes in the follow-up period and the orthodontic treatment was considered stable.

Discussion

The protocol used in these patients highlights the use of two conservative and classic approaches: 1. The use of transalveolar closed nickel-titanium coil springs, double or single, of 8 and 13 mm; 2. A reinforced and cost-effective anchorage customized for each case.

In this protocol, the steps of space preparation and anchorage, before surgery, are necessary. The surgery for bilaterally impacted canines, close to dentine and to the apical foramen of central incisors, demands broad and deep osteotomies. The conventional open surgical windows are not useful due to the risk of bone exposure to the oral environment and the presence of incisor root resorption and likelihood of pulpar tissue exposition. The different kinds of flaps in the closed method, designed for each case, are highly recommended in this protocol.[23]

The forces produced by nickel-titanium closed springs are not submitted to overstretching or fatigue, and represent an alternative with biomechanical advantages such as better control of force magnitude and direction during their activation when compared to rigid threaded ligatures, metallic chains, elastomers, springs with loops and hooks of different alloys.[24]

Aiming the control of traction movement, the anchorage system was basically able to perform the traction at the level of the center of resistance of the ectopic canines, to avoid the spring immersion in the mucoperiosteum of the attached gingival margin, and to control the frictional resistance during the periodic activation of the spring.

Proclination of the maxillary incisors was observed in both cases, especially on Patient 2. It was expected because of the nonextraction treatment approach. Then, this proclination of maxillary incisors were necessary to increase the arch perimeter in the maxillary arch and create space for the traction of IMCs.

A relevant finding in these cases was that the remnant periodontal ligament around the extremely short roots of the incisors was maintained, assuring the integrity of alveolar bone width and height during 5 or 10 years after traction. This is useful for a future implant rehabilitation planning, if necessary.

There is no evidence of dental loss or spontaneous tooth detachment during the normal masticatory activity when the roots are extremely short. Taking into account a periodontal principle; teeth with complete roots and optimal length that loss bone and periodontal ligament, either slowly or aggressively by periodontitis, develop extreme mobility and should be extracted. Contrarily, teeth with severe root resorption secondary to the ectopic eruption of adjacent teeth and that conserve sufficient healthy periodontal ligament, could be stable for years.[25] Although the patients presented SRR before traction, the indication of incisor extraction in the absence of mobility before, during or after IMCs, should be questioned. This approach agreed with the patient´s desire to keep their natural smile and teeth, as it was before traction. Finally, two adult patients with bilateral IMCs and severe root resorption of maxillary incisors were treated by the suggested alternative treatment, providing evidence of success after 5 and 10 years post treatment follow-up.

Conclusions

Treatment of IMCs must follow a sequential and predictable process. The presented conservative protocol demonstrated successful and stable results in the two patients. In cases with SRR of maxillary incisors, orthodontists may consider conservative approaches, even to preserve the bone for future rehabilitation keeping in mind that treatment planning should be individualized.

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FIGURE CAPTIONS

Fig. 1. Patient 1. Pretreatment facial and intraoral photographs.

Fig. 2. Patient 1. Pretreatment records: lateral radiograph, cephalometric tracing and panoramic radiograph.

Fig. 3. Patient 1. Pretreatment records: Panoramic radiograph generated from the CBCT and CBCT images of maxillary incisors, indicating severity. d, distance; 5, sector five of impaction; P, palatal; I, intermediate alveolar or bicortically centered in the alveolar bone.

Fig. 4. Patient 2. Pretreatment facial and intraoral photographs.

Fig. 5. Patient 2. Pretreatment records: lateral radiograph, cephalometric tracing and panoramic radiograph.

Fig. 6. Patient 2. Pretreatment records: Panoramic radiograph generated from the CBCT and CBCT images of maxillary incisors, indicating severity. d, distance; 5, sector five of impaction; P, palatal; I, intermediate alveolar or bicortically centered in the alveolar bone.

Fig. 7. Treatment protocol synthesis (step-by-step procedures). *Avoid canine luxation to reduce the risk of periodontal ligament injury and ankylosis. **Isolation before spring adhesion must be absolute. ***During buccal traction, the risk of vestibular cortical reduction must be controlled

Fig. 8. Simulation of the anchorage system and x-y-z traction control with closed springs. A and A', palatal traction in patient 1. B and B', changes by buccal traction in patient 2. C, D, and D', level changes for activations on buccal hooks.

Fig. 9. Treatment progress. A, x-y-z traction in occlusal radiography. B, mucoperiosteal relief of the crowns. C, canines emerging. D, canines in position and anchorage removal.

Fig. 10. Patient 1. Posttreatment facial and intraoral photographs.

Fig. 11. Patient 1. Posttreatment records: lateral radiograph, cephalometric tracing and panoramic radiograph.

Fig. 12. Patient 2. Posttreatment facial and intraoral photographs.

Fig. 13. Patient 2. Posttreatment records: lateral radiograph, cephalometric tracing and panoramic radiograph.

Fig. 14. Patient 1. Panoramic radiograph generated from the CBCT and CBCT images of maxillary incisors at 10 years of follow-up for stability control of alveolar width and height, and root size of incisors. 12, right lateral incisor; 11, right central incisor; 21, left lateral incisor; 22, left central incisor.

Fig. 15. Patient 2. Panoramic radiograph generated from the CBCT and CBCT images of maxillary incisors at 5 years of follow-up for stability and root size of incisors control. 12, ight lateral incisor; 11, right central incisor; 21, left lateral incisor; 22, left central inciso

Table 1. Cephalometric values.

	Patient 1		Patient 2	
Variables	Initial	Final	Initial	Final
Maxillary and mandibular				
SNA (°)	89	87	87	84
SNB (°)	88	87	84	83
Maxillomandibular sagittal				
ANB (°)	1	0	3	1
Witts appraisal mm	-6	-4	3	3
Vertical relationship				
FMA (°)	18	18	29	30
Occ Plane SN (°)	13	12	15	16
Dentoalveolar component				
Mx1.PP (°)	116	128	116	130
Md1.MP (°)	87	91	88	93
Overjet (mm)	0	1	1.5	2
Overbite (mm)	0	1	2	2

Mx1, maxillary incisor; Md1, mandibular incisor; PP, palatal plane; MP, mandibular plane.

Fig. 1. Patient 1. Pretreatment facial and intraoral photographs.

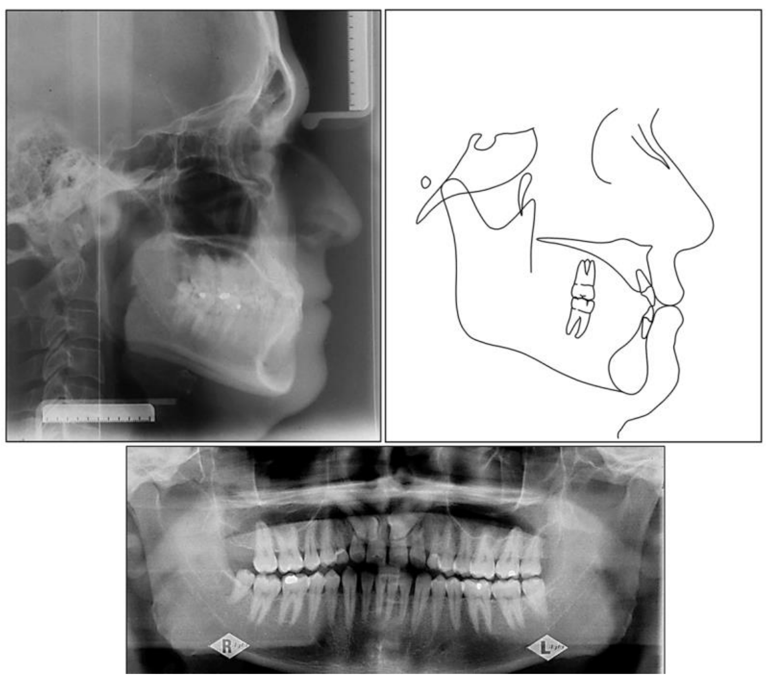

Fig. 2. Patient 1. Pretreatment records: lateral radiograph, cephalometric tracing and panoramic radiograph.

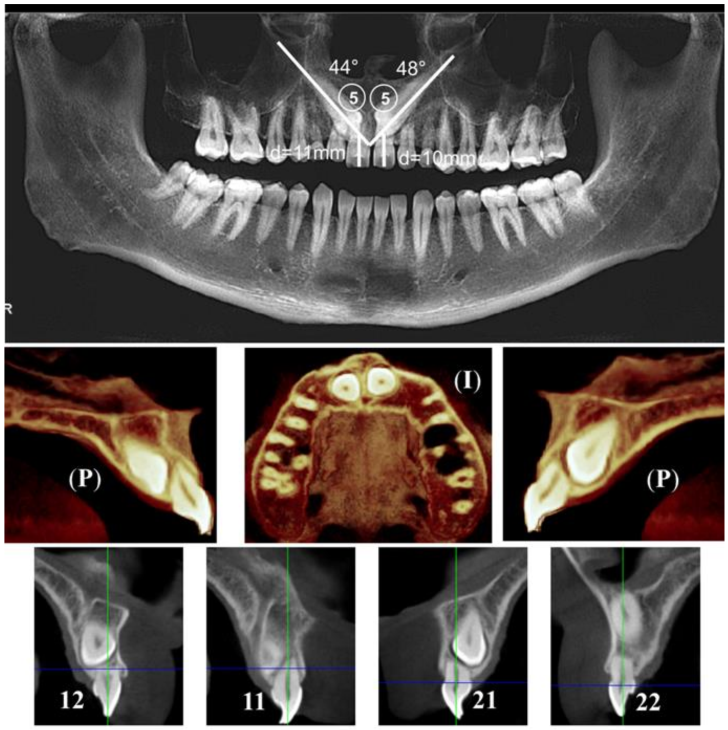

Fig. 3. Patient 1. Pretreatment records: Panoramic radiograph generated from the CBCT and CBCT images of maxillary incisors, indicating severity. d, distance; 5, sector five of impaction; P, palatal; I, intermediate alveolar or bicortically centered in the alveolar bone.

Fig. 4. Patient 2. Pretreatment facial and intraoral photographs.

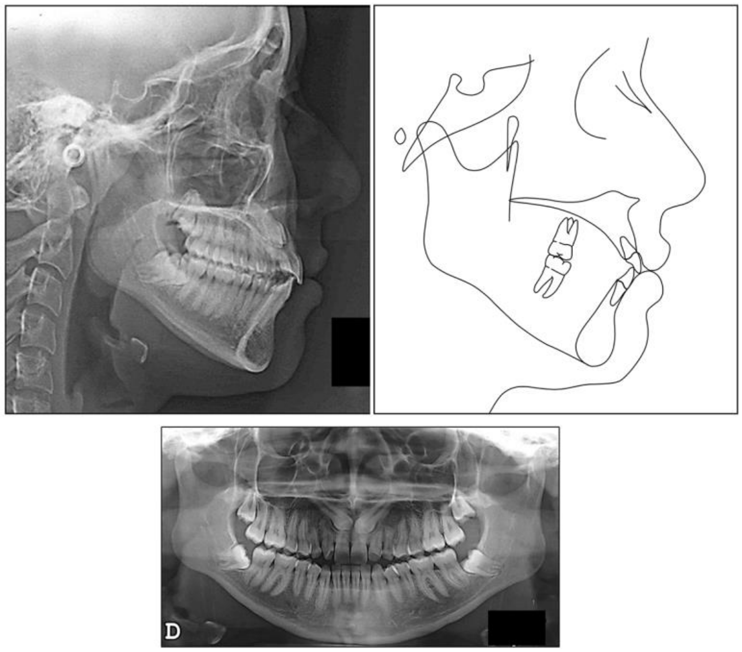

Fig. 5. Patient 2. Pretreatment records: lateral radiograph, cephalometric tracing and panoramic radiograph.

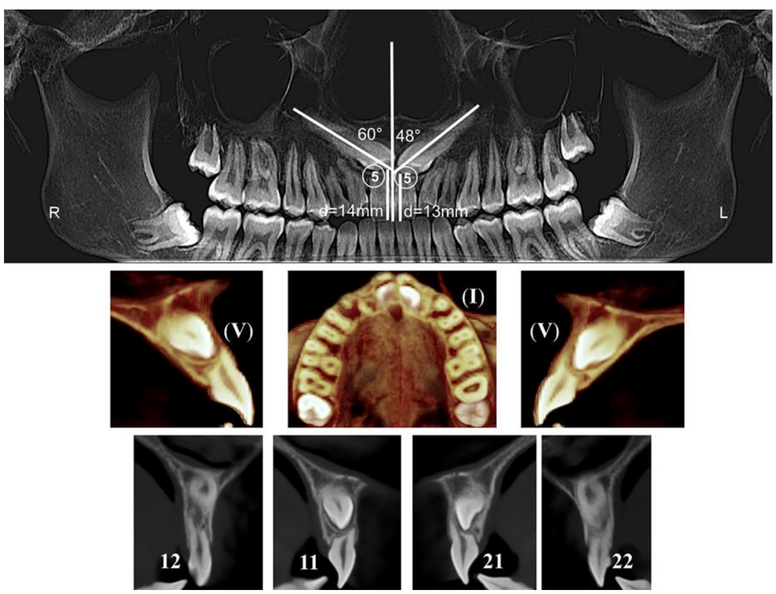

Fig. 6. Patient 2. Pretreatment records: Panoramic radiograph generated from the CBCT and CBCT images of maxillary incisors, indicating severity. d, distance; 5, sector five of impaction; P, palatal; I, intermediate alveolar or bicortically centered in the alveolar bone.

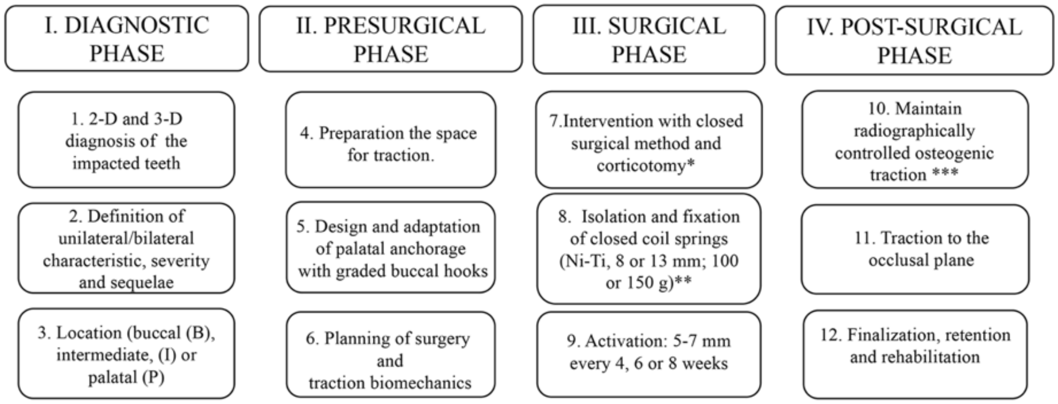

Fig. 7. Treatment protocol synthesis (step-by-step procedures). *Avoid canine luxation to reduce the risk of periodontal ligament injury and ankylosis. **Isolation before spring adhesion must be absolute. ***During buccal traction, the risk of vestibular cortical reduction must be controlled

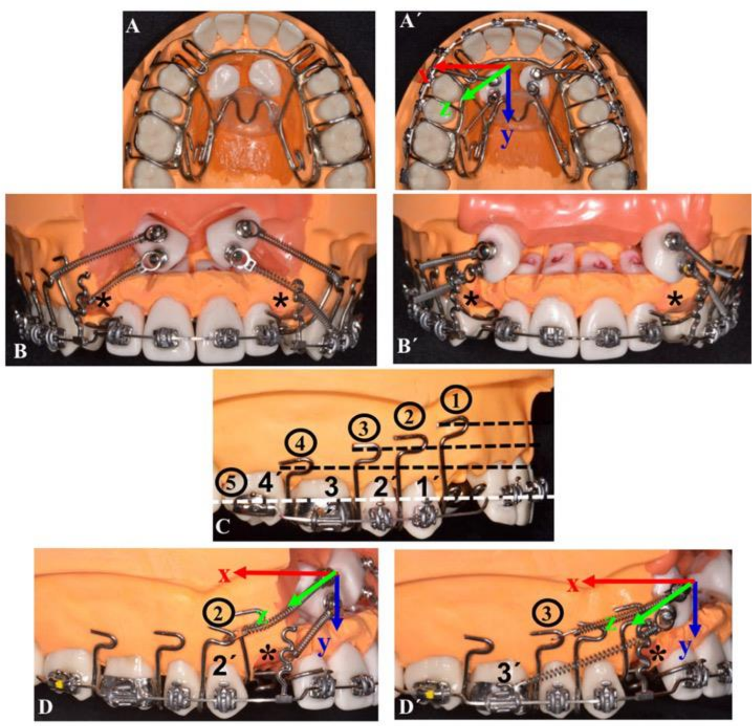

Fig. 8. Simulation of the anchorage system and x-y-z traction control with closed springs. A and A', palatal traction in patient 1. B and B', changes by buccal traction in patient 2. C, D, and D', level changes for activations on buccal hooks.

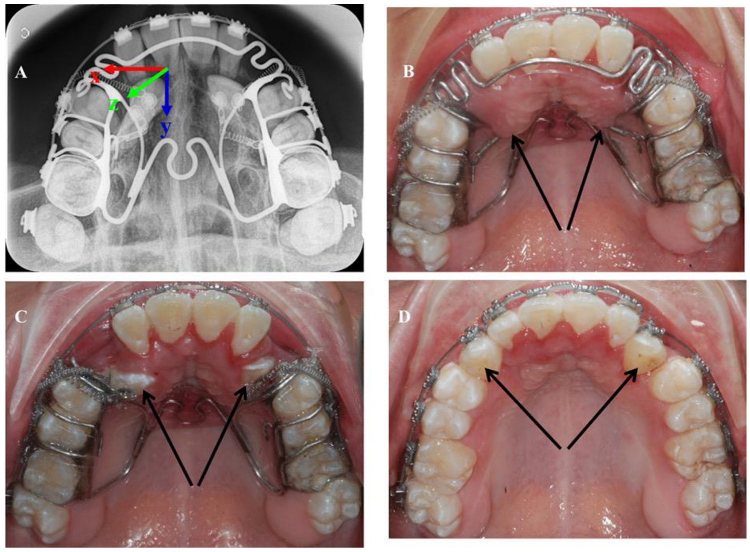

Fig. 9. Treatment progress. A, x-y-z traction in occlusal radiography. B, mucoperiosteal relief of the crowns. C, canines emerging. D, canines in position and anchorage removal.

Fig. 10. Patient 1. Posttreatment facial and intraoral photographs.

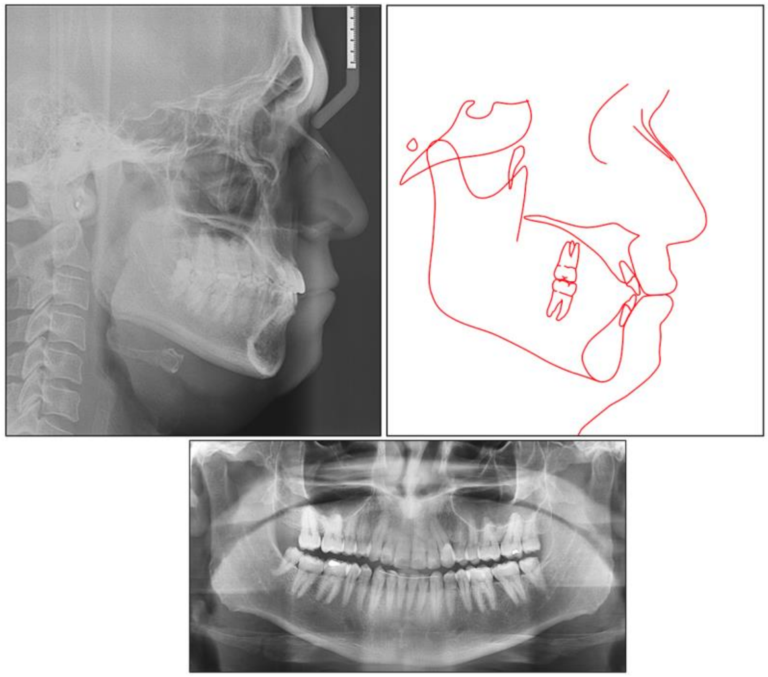

Fig. 11. Patient 1. Posttreatment records: lateral radiograph, cephalometric tracing and panoramic radiograph.

Fig. 12. Patient 2. Posttreatment facial and intraoral photographs.

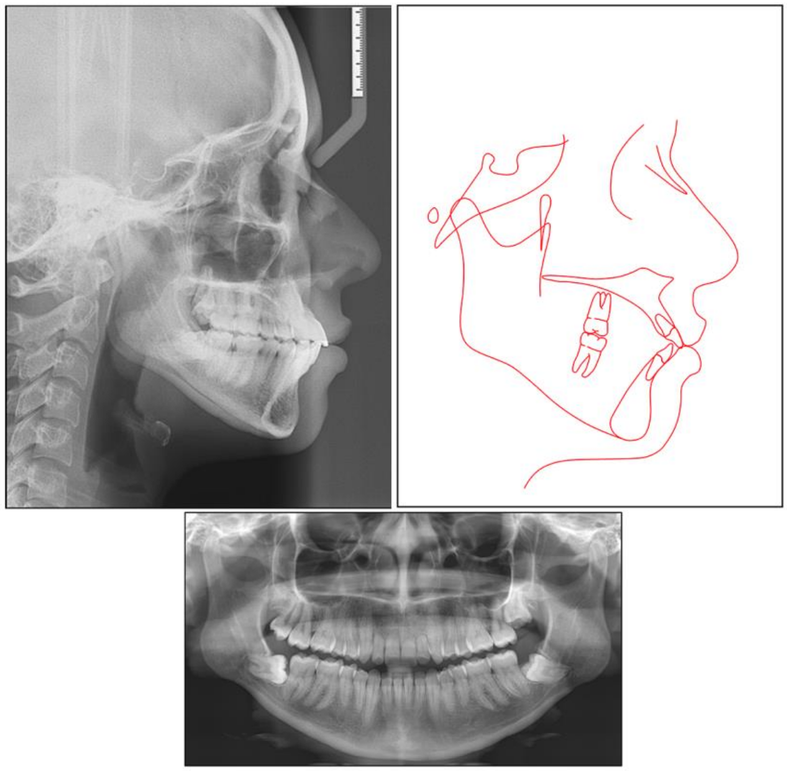

Fig. 13. Patient 2. Posttreatment records: lateral radiograph, cephalometric tracing and panoramic radiograph.

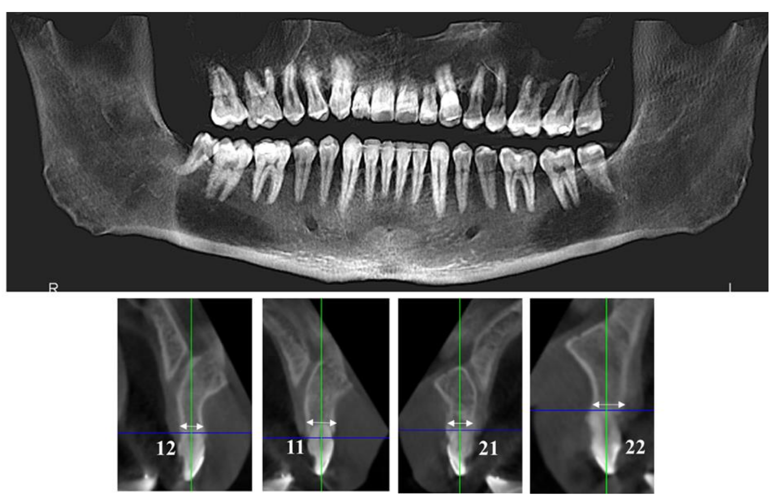

Fig. 14. Patient 1. Panoramic radiograph generated from the CBCT and CBCT images of maxillary incisors at 10 years of follow-up for stability control of alveolar width and height, and root size of incisors. 12, right lateral incisor; 11, right central incisor; 21, left lateral incisor; 22, left central incisor.

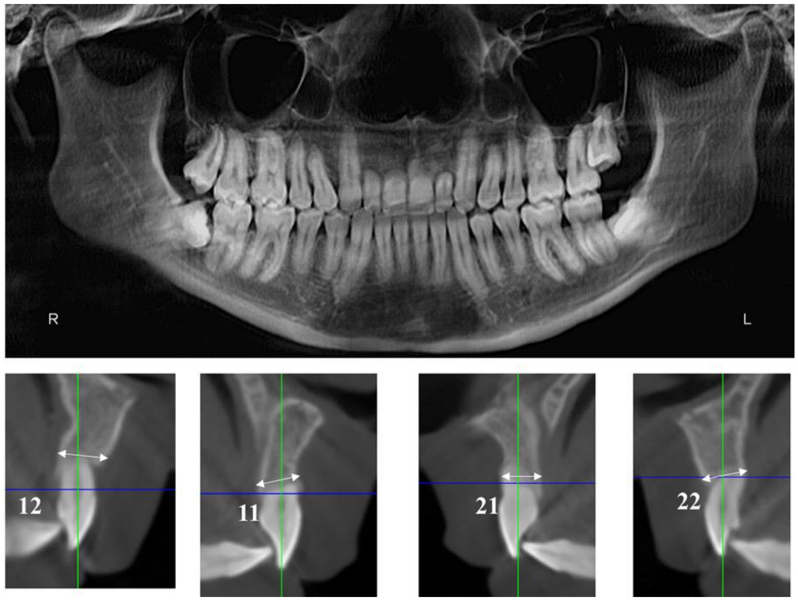

Fig. 15. Patient 2. Panoramic radiograph generated from the CBCT and CBCT images of maxillary incisors at 5 years of follow-up for stability and root size of incisors control. 12, ight lateral incisor; 11, right central incisor; 21, left lateral incisor; 22, left central inciso

Considerações Finais

O tratamento de um canino maxilar impactado não é feito apenas com seu alinhamento ortodôntico. O estado dentário e periodontal final e a morfometria óssea alveolar são fundamentais para avaliar o sucesso da terapia dos caninos superiores impactados [33,34].

Caninos maxilares unilateralmente impactados por palato e vestibular constituem um modelo para o desenvolvimento de estudos comparativos que permitem um grupo de controle contralateral. Para controlar as mudanças como resultado da tração com molas de Ni-Ti fechadas, nossa amostra utilizou um dispositivo de ancoragem ortodôntica palatina rígida fixada imediatamente antes da cirurgia, o controle no lado não operado poderia tornar as medidas obtidas mais confiáveis [33].

As alterações ósseas morfométricas alveolares encontradas em nosso estudo, constataram uma importante mudança óssea que torna o processo alveolar mais curto e mais fino, com redução significativa de sua altura depois que a coroa e a raiz do CSI inseridas no osso, estiverem alinhadas. Esta resposta óssea à tração ortodôntica pode ser verificada com medidas volumétricas ou sobreposição tridimensional.

Essa linha de pesquisa relativa às alterações morfométricas grossas do processo alveolar da CSI e dos dentes próximos à impactação após tração com molas helicoidais fechadas de Ni-Ti e ancoragem palatina rígida como alternativa biomecânica, deve ser continuada considerando as medidas das alterações, a espessura cortical e altura da crista óssea palatina e vestibular.

A discussão e a pesquisa aplicáveis na prática clínica são enriquecidas, ao propor tratamentos alternativos orientados por protocolos, onde são aplicadas forças com magnitude, direção e sentido controláveis, usando sistemas biomecânicos reproduzíveis e padronizáveis e identificando outros sistemas de ancoragem que protejam os tecidos circundantes.

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Anexo 1

UFRGS

- Linhas de Pesquisa
- Projetos de Pesquisa
- Áreas de Atuação
- Bolsas de Pesquisa
- Iniciação Científica/Tecnológica Voluntário
- Programa de Fomento à Pesquisa(auxílio)

Origem: Faculdade de Odontologia
Programa de Pós-Graduação em Odontologia

Projeto da linha de pesquisa: DIAGNÓSTICO DE AFECÇÕES BUCO-FACIAIS

Local de Realização: não informado

Não apresenta relação com Patrimônio Genético ou Conhecimento Tradicional Associado.

Objetivo:

Introduction. Both space closure and extrusive/ intrusive dental traction are important aspects of orthodontic treatment. The traction treatment of impacted maxillary canines may result in iatrogenic sequelae such as root resorption, alveolar bone loss, dehiscence, fenestration, and gingival recession. Therefore, 3D evaluation of the alveolar bone before and after transalveolar traction with Ni-Ti closed coil springs, may be a good model to explain some therapeutic

Palavras Chave:

CANINOS IMPACTADOS; CBCT

Equipe UFRGS:

Nome: HERALDO LUIS DIAS DA SILVEIRA
Coordenador - Início: 16/08/2017 Previsão de término: 17/07/2021

Nome: Gustavo Armando Ruiz Mora
Outra: Aluno de Doutorado - Início: 16/08/2017 Previsão de término: 17/07/2021

Avaliações:

Comissão de Pesquisa de Odontologia - **Aprovado** em 25/08/2017 Clique aqui para visualizar o parecer

Anexo 2

ATTACHMENTS

APPENDIX 1

APPROVAL OF ETHICS COMMITTEE

CIENTIFICA
UNIVERSIDAD CIENTIFICA DEL SUR

CARTA N° 072-EE-FCS-U.CIENTIFICA/2017

Miraflores, 06 de julio del 2017

Mg. Esp.
Gustavo Armando Ruiz Mora
Presente.-

ASUNTO: Constancia de inscripción y aprobación ética de trabajos de investigación.

De mi consideración:

Por medio del presente documento lo saludo cordialmente y en atención al asunto de la referencia la comisión de ética e investigación para trabajos de investigación de la Escuela de Estomatología de la Universidad Científica del Sur, Lima-Perú, señala que el trabajo de investigación titulado: **"ALVEOLAR CHANGES IN IMPACTED MAXILLARY CANINES PALATALLY AND BUCCALLY DISPLACED AFTER TRACTION WITH NI-TI CLOSED COIL SPRINGS. A COMPARATIVE CBCT STUDY"**, ha sido inscrito en nuestra Escuela y ha sido aprobado en los aspectos éticos que involucra la aplicación del mismo, con el número de aprobación **00009.**

Agradeciendo la atención brindada a la presente, quedo de usted.

Atentamente,

Dr. Fernando Ortiz Culca
Coordinador de Investigación
Escuela de Estomatología
Universidad Científica del Sur

APPENDIX 2

COMMITMENT TERM FOR DATA USE

Title of research project

ALVEOLAR CHANGES ASSOCIATED TO IMPACTED MAXILLARY CANINES PALATALLY AND BUCCALLY DISPLACED, AFTER TRACTION WITH Ni-Ti CLOSED COIL SPRINGS. A COMPARATIVE CBCT STUDY.

The researchers of the present project commit themselves to preserve the privacy of patients whose data will be collected in medical records and databases of Dr. Gustavo Ruíz's Clinic, (Bogotá, Colombia). They also agree that this information will be used solely and exclusively for the execution of this project. The information may only be disclosed anonymously.

Porto Alegre, July 1, 2015.

Principal Author	**Signature**
Gustavo Armando Ruiz Mora	

Anexo 4

APPENDIX 3

AUTHORIZATION FOR USE TOMOGRAPHIC INFORMATION

Porto Alegre, July 19 2007

Gustavo Armando
Ruiz Mora

Ortodoncista
Universidad Nacional de Colombia
Magister Especialista Radiólogo Oral y Maxilofacial
Universidad Peruana Cayetano Heredia

I am **GUSTAVO ARMANDO RUIZ MORA** with ID. # PE130267 and I agree to maintain confidentiality with the tomographic information of my patients and to use tomographic records of my database related to treatment of maxillary impacted canines.

These files must be kept confidential, and should only be used for me exclusively to execute the project namely: **ALVEOLAR CHANGES ASSOCIATED TO IMPACTED MAXILLARY CANINES PALATALLY AND BUCCALLY DISPLACED, AFTER TRACTION WITH Ni-Ti CLOSED COIL SPRINGS. A COMPARATIVE CBCT STUDY.**

All information may be used strictly of form anonymous.

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