UNIVERSIDADE FEDERAL DE GOIÁS
FACULDADE DE ODONTOLOGIA
PROGRAMA DE PÓS-GRADUAÇÃO EM ODONTOLOGIA

KARINE EVANGELISTA MARTINS ARRUDA

AVALIAÇÃO DE DEISCÊNCIA E FENESTRAÇÃO POR MEIO DE TOMOGRAFIA COMPUTADORIZADA VOLUMÉTRICA EM PACIENTES COM MALOCLUSÃO DE CLASSE I E CLASSE II DIVISÃO 1

DISSERTAÇÃO DE MESTRADO
MODALIDADE ARTIGO CIENTÍFICO

GOIÂNIA
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Trabalho apresentado para Defesa de Mestrado ao Programa de Pós-Graduação em Odontologia da Universidade Federal de Goiás para obtenção do Título de Mestre em Odontologia.

Orientador: Profa. Dra. Maria Alves Garcia Santos Silva
Co-orientador: Prof. Dr. Axel Bumann

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DA UNIVERSIDADE FEDERAL DE GOIÁS

BANCA EXAMINADORA DA DEFESA DE DISSERTAÇÃO DE MESTRADO

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Data: 16/11/2009

Dedico este trabalho...

Dedico este trabalho ao meu esposo Jalles por estar ao meu lado e dividir seu tempo de lazer com meus estudos. Dedico também aos meus pais Alfredo e Sueli, às minhas irmãs Fabíola e Graziela pelo apoio constante e incentivo nos momentos de dificuldade e ao meu querido companheiro Saddam pelos momentos de solidariedade nas noites não dormidas.

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SUMÁRIO

LISTA DE ABREVIATURAS, SIGLAS E SÍMBOLOS*

%	Porcento
CBCT	*Cone beam computed tomography* (tomografia computadorizada por feixe cônico)
mm	Milímetros
TC	Tomografia computadorizada
Pág.	Página
mA	Miliamperagem
kV	Kilovoltagem
s	Segundos
FOV	*Field of view* (campo de visão)
x	Por
cm	Centímetros
®	Marca registrada
DICOM	*Digital imaging and communications in medicine* (imagem digital e comunicação em medicina)
ANB	Ângulo entre os pontos A, N (nasio) e B
°	Grau
≥	Maior ou igual
>	Maior

* Abreviaturas, siglas e símbolos citados no Resumo, Abstract, Caracterização do Problema e Material e Métodos em ordem de aparecimento.

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SN.GoGn	Ângulo entre os planos SN (sela-nasio) e GoGn (gônio-gnátio)
<	Menor
JCE	Junção cemento-esmalte
LCD	*Liquid cristal display* (monitor de cristal líquido)
“	Polegadas
ANOVA	*Analysis of variance* (Análise de variância)
SPSS	*Statistical product and service solutions* (produto estatístico e solução de serviço)

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RESUMO

Os efeitos do tratamento ortodôntico nas estruturas periodontais tem sido objeto de estudo da literatura, principalmente quanto à integridade óssea e saúde gengival dos dentes a serem deslocados. O objetivo deste estudo foi avaliar a presença de defeitos alveolares (deiscências e fenestrações) em pacientes com maloclusão de Classe I e Classe II divisão 1 e em diferentes tipos faciais por meio de tomografia computadorizada volumétrica. A amostra foi composta de 159 exames tomográficos de pacientes indicados para tratamento ortodôntico, totalizando 4319 dentes avaliados. A presença ou ausência de deiscência e fenestração nas faces vestibular e lingual/palatina era observada em tomogramas axiais e transversais. Os resultados demonstraram que 155 pacientes (96,9%) apresentaram algum tipo de defeito alveolar. Os pacientes com maloclusão de Classe I apresentaram maior prevalência das deiscências (35%) em relação aos pacientes com maloclusão de Classe II divisão 1. Entre os tipos faciais não houve diferença estatisticamente significante. Incisivos inferiores, caninos inferiores e primeiros pré-molares inferiores foram respectivamente os dentes com maior ocorrência dos defeitos. Este estudo concluiu que a tomografia computadorizada volumétrica está indicada nos casos de pacientes que necessitem de movimento ortodôntico mais extenso e possuam biótipo gengival desfavorável.

Descritores: Classe I, Classe II divisão 1, deiscência, fenestração, tomografia.

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ABSTRACT

The effects of orthodontic treatment on periodontal structures have been studied in literature, especially regarding the integrity of alveolar bone and gingival health of the teeth to be displaced. The aim of this study was to evaluate the presence of alveolar defects (dehiscence and fenestrations) in patients with Class I and Class II division 1 malocclusions and in different facial types using cone beam computed tomography (CBCT). The sample comprised 159 tomography exams of patients with no previous orthodontic treatment, giving a total of 4319 teeth. The presence or absence of dehiscence and fenestration in the buccal and lingual surfaces was checked in axial and cross-sectional views. The results showed that 155 patients (96.9%) presented some type of alveolar defect. The Class I malocclusion patients presented higher prevalence of dehiscences (35%) than those with Class II division 1 malocclusion. There was no statistically significant difference between the facial types. Lower incisors, lower canines and lower first premolars were respectively the teeth with more occurrences of alveolar defects. This study concluded that CBCT is indicated for patients who need extensive tooth movement and have unfavorable gingival biotype.

Key-words: Class I, Class II division 1, dehiscence, fenestration, tomography.

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1- CARACTERIZAÇÃO DO PROBLEMA

O processo alveolar, composto pelo osso medular e osso alveolar propriamente dito ou osso cortical, tem a função de sustentação dos dentes e proteção das raízes[1]. Morfologicamente, o processo alveolar apresenta-se com espessura variável em diferentes regiões da mandíbula e maxila. A redução em espessura do osso alveolar favorece o surgimento de defeitos alveolares (deiscência e fenestração) nas faces vestibular e lingual, sem significar necessariamente a presença de doença periodontal[1]. Deiscência é caracterizada pela ausência de cobertura óssea a partir da porção coronária das raízes. A ausência de osso em parte da raiz, mantendo-se a porção óssea na região coronária denomina-se fenestração[1]. Os preditores clínicos para as deiscências e fenestrações não são ainda bem definidos, embora alguns fatores predisponentes sejam relatados, como o desenvolvimento ósseo alveolar anormal, a inserção inadequada dos freios labiais, a movimentação ortodôntica, doenças periodontais e endodônticas, assim como o volume radicular e o posicionamento dentário[2].

A movimentação ortodôntica ocorre por eventos biológicos de remodelamento ósseo do processo alveolar através da aposição óssea no lado de tensão da força ortodôntica e reabsorção no lado de pressão, acarretando o deslocamento dentário na direção de reabsorção[3]. Nas regiões do processo alveolar em que o volume ósseo está reduzido ou ausente, a extensão da movimentação ortodôntica fica limitada para pequenos deslocamentos, no sentido de prevenir sequelas iatrogênicas, como o aparecimento ou exacerbação das deiscências e fenestrações [4-6].

Apesar do conhecimento das alterações ósseas pelo tratamento ortodôntico, a extensão da movimentação dentária no sentido vestíbulo-lingual tornou-se um importante conceito teórico dentro da ortodontia em função do planejamento de diferentes abordagens terapêuticas[7]. Proffit e Ackerman[7] introduziram um diagrama para quantificar a movimentação vestíbulo-lingual na região de incisivos e pré-molares denominado de “envelope de discrepância”. A quantificação do deslocamento dentário necessário determinava a escolha do tipo de tratamento, variando em três possibilidades com graus sucessivos de complexidade (ortodôntico, ortopédico e ortodôntico-cirúrgico). Assim, quanto maior discrepância oclusal, mais extensa seria a movimentação ortodôntica vestíbulo-lingual, determinando tipos de tratamentos mais complexos. Estes princípios teóricos visavam à correção oclusal e harmonia facial, sem considerar as barreiras anatômicas do processo alveolar.

A preocupação com a preservação periodontal de pacientes ortodônticos tem sido enfaticamente discutida na literatura, uma vez que estudos e relatos de caso observaram que, à medida que as raízes eram deslocadas e se distanciavam do centro do processo alveolar, havia maior risco de manifestação de deiscências e fenestrações[4-6] e consequentemente alterações mucogengivais[8-10]. Estudos da morfologia do processo alveolar afirmam que, quanto mais finas as camadas corticais e medulares, maior a predisposição às deiscências e fenestrações decorrentes da movimentação dentária induzida[5,11,12]. As repercussões clínicas das deiscências em pacientes ortodônticos resultam na perda de ancoragem dentária ou aumento da mobilidade, como também na maior predisposição à recessão gengival[6,8-10], a qual pode se manifestar durante o tratamento ortodôntico ou até mesmo anos depois[9].

A ocorrência ou não dos defeitos alveolares durante o tratamento ortodôntico dependerá de vários fatores, como a direção da movimentação, frequência e magnitude da força ortodôntica aplicada, associados ao volume e integridade anatômica dos tecidos periodontais de suporte[3,5,6]. O conhecimento desses fatores veio colaborar para que o planejamento ortodôntico considerasse o diagnóstico da morfologia dos tecidos ósseos e gengivais periodontais. Desta forma, para pacientes com necessidade de grande extensão de movimentação ortodôntica e espessura reduzida do processo alveolar, deveriam ser planejados deslocamentos dentários menos extensos ou considerar a possibilidade de substituição do tratamento ortodôntico por uma abordagem ortodôntico-cirúrgica em pacientes limítrofes[11]. Em pacientes com biótipo gengival desfavorável, como espessura de gengiva menor que 0,5mm, a indicação de avaliação periodontal[10] e enxerto gengival[12] previamente à movimentação seria uma conduta preventiva aos efeitos ortodônticos iatrogênicos.

Apesar destes estudos, a associação da movimentação ortodôntica e o desenvolvimento imediato ou tardio de recessão gengival tem sido uma questão controversa na literatura. Alguns estudos mostram evidência de recessão gengival associada ao movimento ortodôntico[6,8,9], especialmente em biótipos gengivais desfavoráveis[8,10]. Entretanto, outras pesquisas não tem evidenciado essa associação[13-16].

O diagnóstico das deiscências e fenestrações previamente ao tratamento ortodôntico se faz por meio de exames por imagem, que revelam a topografia e anatomia alveolar. A telerradiografia lateral, embora seja um exame de grande popularidade em ortodontia, mostra a espessura do processo alveolar apenas na região de incisivos centrais, além de apresentar sobreposição das estruturas anatômicas[11,12,17-20]. Historicamente, a tomografia convencional associada a radiografias oclusais foram os primeiros recursos de imagem que objetivaram avaliar a região alveolar ântero-inferior em pacientes ortodônticos[21]. Estas foram logo suplantadas pela tomografia computadorizada (TC). As imagens obtidas por TC permitem visualizar tridimensionalmente estruturas extremamente finas, como a cortical óssea do processo alveolar, diferenciando as corticais vestibular e lingual sem sobreposições[5,17-19]. Atualmente, a tomografia computadorizada volumétrica ou tomografia computadorizada de feixe cônico, vem sendo a opção de escolha para a maioria das situações clínicas em odontologia, nas quais um exame seccional é indicado, principalmente por ser um método que gera menor dose de radiação ionizante[22-26], melhor resolução de imagem[27-34] e custo mais reduzido em comparação às TC de feixe em leque.

Em ortodontia, a tomografia computadorizada volumétrica tem sido utilizada em várias situações, como a análise tridimensional morfológica e cefalométrica craniofacial[35], avaliação tridimensional de dentes retidos[36-38], diagnóstico de reabsorção radicular[37], visualização tridimensional das vias aéreas[37], análise da articulação têmporo-mandibular[39-41] e confeccão de guias cirúrgicos para minimplantes[42].

O uso de imagens tomográficas para avaliação do processo alveolar previamente ao tratamento ortodôntico tem sido também enfatizado[5,19], porém com maior enfoque à região ântero-inferior. Outros estudos tem observado a ocorrência de reabsorção do osso cortical alveolar na região de pré-molares superiores, em casos de expansão rápida da maxila na região de pré-molares superiores, em imagens de tomografia computadorizada volumétrica[43,44].

Em função de vários fatores, como a necessidade cada vez mais frequente de avaliação tridimensional, a qualidade da imagem e facilidade de acesso, principalmente em países desenvolvidos, a tomografia computadorizada volumétrica, tem se tornado exame quase rotineiro na avaliação prévia ao tratamento ortodôntico. Entretanto, o uso de qualquer exame por imagem, especialmente aqueles que geram radiação ionizante, deve seguir princípios éticos, sendo considerados o risco e o benefício. Estudos que demonstrem a necessidade desses exames devem ser considerados como evidência científica para orientar essa indicação com critério e responsabilidade.

2- JUSTIFICATIVA

Embora a literatura apresente estudos referentes à avaliação do processo alveolar de pacientes sem tratamento ortodôntico prévio[5,6,11,19-21], ainda não foram encontradas na bibliografia investigada pesquisas comparativas entre a presença de deiscências e fenestrações em diferentes tipos de maloclusões e tipos faciais.

No presente estudo, a avaliação da prevalência destes defeitos alveolares foi realizada em pacientes vivos, de faixa etária compatível com a população em tratamento ortodôntico, diferente do que é relatado nos demais estudos sobre o assunto[2,45-53], os quais utilizam crânios macerados variando entre indivíduos jovens e idosos .

Pelo exposto, supõe-se que esta pesquisa assume um caráter inovador e relevante. Consideramos que a avaliação da cobertura óssea de pacientes indicados para tratamento ortodôntico e em diferentes maloclusões, possa contribuir para o planejamento em ortodontia, bem como ser fonte de comparação a futuros estudos sobre o tema.

3. OBJETIVOS

3.1-Objetivo geral

Avaliar a presença de deiscências e fenestrações por tomografia computadorizada volumétrica em pacientes indicados para tratamento ortodôntico.

3.2-Objetivos específicos

- Comparar a presença de deiscências e fenestrações nas maloclusões de Classe I e Classe II divisão 1;
- Investigar diferenças na presença de deiscências e fenestrações entre os diferentes tipos faciais;
- Verificar os grupos de dentes que possuem maior prevalência de deiscências e fenestrações;
- Localizar a região radicular com maior prevalência de fenestrações.

4. MATERIAL E MÉTODOS

4.1- Tipo de estudo: epidemiológico transversal.

4.2- Locais de execução: Universidade Federal de Goiás, Brasil e Clínica Mesantis-Berlim, Alemanha.

4.3-Delineamento do estudo

Unidade amostral: 159 exames de tomografia computadorizada volumétrica de indivíduos alemães com maloclusão de Classe I e Classe II divisão 1 distribuídos nos tipos faciais braquifacial, mesofacial e dolicofacial, totalizando 4319 dentes.

Fatores estudados: deiscência e fenestração;

Variáveis de resposta:

- Presença de deiscência/ fenestração;
- Ausência de deiscência/ fenestração.

4.4-Aspectos éticos e legais

Por se tratar de estudo em imagens tomográficas de seres humanos, o projeto de pesquisa foi submetido ao Comitê de Ética em Pesquisa da Charitè – Universitätsmedizin, em Berlim- Alemanha, recebendo parecer favorável, com protocolo de aprovação de número EA1/ 112/08 (APÊNDICES A- pág. 56 e B- pág. 57).

4.5-Seleção da amostra

Este estudo é caracterizado por uma amostra intencional, obtida de um banco de 3800 exames de tomografia computadorizada volumétrica da clínica Mesantis (Berlim-Alemanha) realizados no período de 2003 à 2009. A seleção dos exames foi realizada seguindo os critérios de inclusão e exclusão, por um observador não participante do estudo, treinado em imagens seccionais e capacitado para a avaliação de pacientes ortodônticos (observador 1). As imagens foram obtidas sob os parâmetros de 47,7 mA, 120 kV, 40 s de tempo exposição e FOV de 18 *x* 22 cm pelo tomógrafo i-CAT® (Imaging Sciences International, PA-EUA). O volume de imagem resultante teve voxel isotrópico de 0,4 *x* 0,4 *x* 0,4 mm e os arquivos foram exportados para uma matriz de 512 *x* 512 pixels, em formato DICOM 3 e processados pelo *software* InVivoDental® (Anatomage, CA- EUA). A cabeça do paciente era posicionada com o plano oclusal paralelo ao plano horizontal e em oclusão cêntrica durante o exame.

Os critérios gerais de inclusão foram:

- exames de tomografia computadorizada volumétrica de;
    - ✓ indivíduos adultos acima de 18 anos;
    - ✓ ambos os gêneros;
    - ✓ portadores de maloclusão de Classe I ou Classe II divisão 1;
    - ✓ braquifaciais, mesofaciais e dolicofaciais.

A diferenciação entre as maloclusões fundamentou-se nos seguintes critérios:

- Classe I: trespasse horizontal entre 1 e 4 mm, ângulo ANB entre 2° e 4° e relação molar e canino de Classe I bilateral;
- Classe II divisão 1: trespasse horizontal ≥ a 4mm, ângulo ANB > 4° e relação molar e canino de Classe II bilateral.

Todos os pacientes foram categorizados quanto ao tipo facial pelo ângulo SN.GoGn de acordo com os valores estabelecidos por Reidel[54], seguindo os seguintes critérios :

- Braquifaciais: SN.GoGn < 27°
- Mesofaciais: SN.GoGn entre 27° e 37°
- Dolicofaciais: SN.GoGn ≥ 37°

Os valores dos ângulos ANB, SN.GoGn e do trespasse horizontal foram obtidos através de traçado cefalométrico computadorizado pelo *software* Diagnostiksoftware für Zahnärzte und Kieferorthopäden® (Computer Konkret AG-Alemanha) realizado pelo observador 1. A confirmação da relação de molares e caninos se fez através da imagem do volume dos arcos dentários em oclusão por um ortodontista (observador 2).

Os critérios de exclusão do estudo abrangeram:

- pacientes com ausências dentárias (perdas e agenesias);
- pacientes com imagens sugestivas de doença periodontal, visualizada pela perda horizontal e/ou vertical das cristas alveolares proximais e das cristas interradiculares (lesões de furca) e pela presença de cálculos dentários;
- dentes com restaurações extensas envolvendo a JCE;
- imagens com baixa qualidade, caracterizadas por imagens parciais e/ou com baixa resolução.

Após atender os critérios de inclusão e exclusão, a amostra deste estudo reuniu 159 exames de tomografia computadorizada volumétrica atendendo a análise de força da amostra, que determinou o mínimo de 139 exames para que uma diferença de 5% pudesse ser detectada entre os grupos. A distribuição dos grupos da amostra está apresentada no Quadro 1.

Tipo Facial Maloclusão	Braquifacial	Mesofacial	Dolicofacial	Total
Classe I	32	29	18	79
Classe II, divisão1	27	30	23	80
Total	59	59	41	159

Quadro 1-Distribuição da amostra quanto à maloclusão e tipo facial

4.6 Avaliação das imagens

A avaliação das imagens foi realizada por um ortodontista (observador 2) e um cirurgião-dentista (observador 3), previamente calibrados por meio da interpretação de 48 exames de tomografia computadorizada volumétrica , sob orientação de um radiologista experiente em interpretação de imagem tomográfica volumétrica. Os exames utilizados para treinamento não fizeram parte da amostra desse estudo.

A avaliação das imagens foi realizada em ambiente escurecido, em um monitor de LCD de 24,1" com resolução de 1920 *x* 1200 pixels. Os observadores avaliaram em estudo cego, sem conhecimento do tipo de maloclusão, do tipo facial dos pacientes e dos resultados do outro observador. As mesmas imagens foram avaliadas pelos dois observadores nos cortes axiais e transversais. Quando necessário, as imagens eram ajustadas para melhor contraste e brilho por cada observador.

A análise do processo alveolar foi realizada obedecendo a sequência dos quadrantes dentários, iniciando pelo quadrante 1 e sucessivamente pelos quadrantes 2, 3 e 4. Primeiramente, o eixo axial vestíbulo-lingual e mésio-distal de cada dente era colocado em posição perpendicular ao plano horizontal. De forma dinâmica, percorria-se toda a extensão radicular avaliando o osso alveolar nas faces vestibular e lingual com intervalos de 1mm para cada imagem. Para a confirmação da presença do defeito alveolar, este deveria apresentar-se obrigatoriamente em pelo menos três imagens consecutivas (nos eixos axial e transversal). O defeito era classificado em deiscência quando houvesse ausência contínua de cortical óssea à JCE maior que 2mm, ou fenestração, quando era observada abertura óssea do osso alveolar com exposição da superfície radicular, porém com preservação do osso na região mais coronária a esta abertura (Figura 1). Estas referências milimétricas foram baseadas nos achados de altura óssea alveolar de Persson et al[55].

Para a localização vertical do defeito alveolar, primeiramente verificava-se o tamanho da raiz dentária, definido como a distância entre a JCE até o ápice radicular. A dimensão encontrada era dividida em três partes iguais, determinando os terços cervical, médio e apical (Figura 2). A posição vertical dos defeitos alveolares era registrada de acordo com o terço radicular acometido, podendo envolver somente um, dois ou todos os três terços.

Figura 1-Deiscência (A) e fenestração (B) observados em crânio macerado. (de:Rateitschak KH, ed. Farbatlanten der Zahnmedizin. Stuttgart: Thieme, 1984[56])

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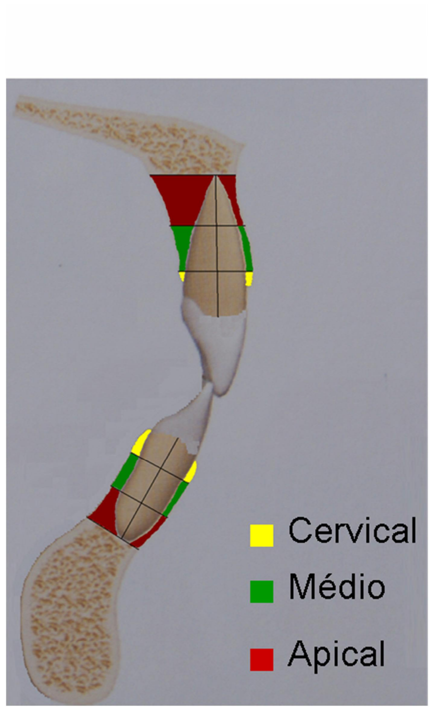

Figura 2-A extensão radicular (JCE até o ápice radicular) dividida igualmente em três partes (terço cervical, médio e apical).

4.7 Reprodutibilidade do método

Com o objetivo de avaliar a reprodutibilidade do método, foi efetuada pelo observador 2, após 20 dias de intervalo, uma segunda avaliação de 25% das imagens tomográficas empregadas nesta pesquisa, selecionadas ao acaso.

4.8 Tratamento dos dados

A concordância intra e interobservador foi verificada pelo teste Kappa. Os testes *t* de *Student* e Mann-Whitney foram aplicados para comparar os pacientes com maloclusão de Classe I e Classe II divisão 1, e ANOVA e Kruskal-Wallis para comparar os tipos faciais quanto à frequência de defeitos ósseos baseado nos achados do observador 2. Para o tratamento estatístico dos dados, foi utilizado o pacote computacional *SPSS for Windows* (versão 16.0), adotando-se um nível de significância de 5%.

5. PUBLICAÇÃO

Título da publicação:

ASSESSMENT OF DEHISCENCE AND FENESTRATION IN PATIENTS WITH CLASS I AND CLASS II DIVISION 1 MALOCCLUSION USING CONE BEAM COMPUTED TOMOGRAPHY

Formatação da publicação seguindo as normas da revista American Journal of Orthodontics and Dentofacial Orthopedics (APÊNDICE C-pág. 59)

Assessment of dehiscence and fenestration in patients with Class I and Class II division 1 malocclusion using cone beam computed tomography

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Abstract

Introduction: The aim of this study was to compare the presence of alveolar defects (dehiscence and fenestration) in patients with Class I and Class II, division 1 malocclusions and in different facial types. **Methods:** Sectional exams performed by cone beam computed tomography (CBCT) of 79 Class I and 80 Class II division I malocclusion in patients with no previous orthodontic treatment were evaluated. A total of 4319 teeth comprised the sample. All the teeth were analyzed by two examiners using sectional images in axial and cross-sectional views to check for the presence or absence of dehiscence and fenestration in the buccal and lingual surfaces. **Results:** The results showed that 155 patients (96.9%) presented some type of alveolar defect. The Class I malocclusion patients presented a greater prevalence of dehiscence, which was 35% higher than those with Class II, division 1 malocclusion. There was no statistically significant difference between the facial types. **Conclusion:** This study showed that CBCT is a valuable tool for orthodontic treatment planning aimed at maintaining healthy periodontal structures, since there is a great prevalence of dehiscence and fenestration in patients with no previous orthodontic treatment, even in those with minor skeletal or occlusal discrepancies.

Key-words: Class I, Class II division 1, dehiscence, fenestration, tomography.

Orthodontic movement is achieved by biological events in bone remodeling (resorption and apposition) of the alveolar process which gives support to the teeth through the involvement of the roots.[1] Since bone resorption occurs in the direction of tooth movement, the reduced volume of the alveolar bone, sometimes with minimal thickness, sometimes even non-existent, is a complicating factor for orthodontic treatment.[2]

Earlier studies and case reports have observed that as the roots are displaced and move away from the center of the alveolar bone, there is an increased risk of creating or exacerbating alveolar defects[3,4] and producing consequent mucogingival changes, such as gingival recessions.[5-7] These alveolar defects, when characterized by a lack of the facial or lingual cortical plate which expose the underlying root surface, affecting the marginal bone, is called dehiscence. When there is still a portion of bone in the cervical region, the defect is called fenestration.[8] The occurrence of dehiscence and fenestration during orthodontic treatment will depend on several factors such as the direction of movement, frequency and magnitude of the orthodontic force applied and the volume and anatomical integrity of the periodontal support tissues.[1,4] To avoid these problems, the alveolar morphology must be diagnosed prior to orthodontic treatment through imaging, which shows the bone topography and anatomy. Currently, cone beam computed tomography (CBCT) is the option chosen for most clinical dental situations, including the alveolar process, when a cross-sectional examination is indicated, due a lower dose of radiation,[9,10] a better image resolution[11] and lower costs when compared to Multislice CT.

To date no study has been undertaken to compare the presence of alveolar defects in different malocclusions, although the hypothesis that there is no difference in terms of bone covering between the different malocclusions was tested. The aim of this study was to compare the presence of dehiscence and fenestration between patients with Class I and Class II, division 1 malocclusions in different facial types using CBCT.

Material and methods

This research was approved to the Research Ethics Committee of Charitè – Universitätsmedizin, Berlin- Germany.

Tomographic exam

This study was performed using pretreatment sectional exams of orthodontic patients from the radiological files of the Mesantis private orthodontic clinic in Berlin, Germany. The images were obtained using i-CAT tomography (Imaging Sciences International, PA, USA), with 47.7mA, 120kV, 40 s exposure time and isotropic voxel size of 0.4 x 0.4 x 0.4mm. The imaging protocol was performed with a 12-in field of view so as to include the entire facial anatomy. The files were exported to 512 *x* 512 pixels matrix in DICOM 3 format and processed using the InVivoDental software (Anatomage,CA-USA).The head of the patient was oriented locating the occlusal plane parallel to horizontal plane and in centric occlusion.

Sample

Selection of the sample was carried out by observer 1, trained in the use of sectional images, but who did not participate in the study. The following inclusion criteria were considered: CBCT exams of patients over 18, with no history of orthodontic treatment prior to the exam; males and females with Class I or Class II division 1 malocclusion in different facial types. Class I samples were confirmed by the bilateral Class I molar and canine relationship, ANB between 2° and 4° and overjet between 1 and 4mm. The criteria for selecting Class II division 1 samples were the bilateral Class II molar and canine relationship, ANB ≥ 4° and overjet > 4mm. The facial types were divided according to the NS.GoGn proposed by Reidel[12], with mesofacial group measuring from 27° to 37°, brachyfacial group < 27° and dolichofacial group ≥ 37°.

The exclusion criteria covered: patients with tooth loss, agenesis and images suggesting the presence of periodontal disease such as horizontal and vertical proximal bone loss, furcal involvement and calculus. Partial and low resolution images were also excluded from the evaluation, as well 133 teeth with extensive restorations involving the cementoenamel junction (CEJ).

A total of 79 Class I and 80 Class II division 1 malocclusion patients matched the inclusion criteria, giving a total of 4319 teeth to be evaluated. The power analysis determined that sample size with 139 patients would be sufficient to detect 5% difference between malocclusion groups. The distribution of different malocclusion and facial type groups for all subjects is shown in Table I. Tables II and III show the sample characteristic according to malocclusion and facial type.

Imaging evaluation

Two calibrated examiners (an orthodontist-observer 2 and a dentist- observer 3) performed a visual analysis of all the sectional images in a dark room, using a 24.1" LCD monitor with 1920 *x* 1200 pixels resolution. Both observers evaluated the same tomography views, in a blind study without knowing either the malocclusion or facial type groups or even each other's results. First, the mesio-distal and buccal-lingual axes of each tooth were placed perpendicular to the horizontal plane. The total length of the root was evaluated in axial and cross-sectional slices at the buccal and lingual surfaces.

Images that showed the absence of cortical bone surrounding the root in at least three consecutive views were registered as having an alveolar defect. This lack of bone was classified as dehiscence when the alveolar bone height was more than 2mm away from the CEJ, based on the value for normal alveolar height.[13] It was classified as fenestration when the defect did not involve the alveolar crest (Figure 1).The root length was divided into three equal parts, from CEJ to apex, in order to locate in which third of the root the alveolar defect was present.

After 20 days, the observer 2 repeated the analysis of 25% of the exams, randomly selected, to certify the reproducibility of the method.

Statistical analysis

The level of interobserver and intraobserver agreement was assessed by kappa statistics. Student t and Mann-Whitney tests was applied to compare the malocclusion groups. Analysis of Variance (ANOVA) and Kruskal-Wallis tests were used to compare the facial types. The statistical analysis was performed using an SPSS package (version 16.0, Chicago III) at a 0.05 significance level.

Results

Kappa values for interobserver and intraobserver agreement varied from 0.7 to 1.00, which represented a good agreement of this method.

There was at least one type of alveolar defect in 96.9% of the patients. The hypothesis tested wasn’t confirmed. Table IV shows the difference between Class I and Class II division 1 and facial types. Class I malocclusion showed a greater prevalence of alveolar defects, specifically of dehiscence, which was 35% higher in patients with Class II division 1 malocclusion. No difference was observed between facial types.

There were more occurrences of alveolar defects (75.65%) in the buccal root surfaces. Dehiscence was associated with 51.09% of all teeth, more prevalent in the mandible (57.35%) and the teeth most affected were the lower incisors (24%), lower canine (9.82%) and lower first premolar (9.5%). In maxilla, canine (7.98%) and first premolar (7.86%) were the teeth with more occurrences. Dehiscence was also more predominant in the buccal root surface (69.43%), with the exception of the lower central incisors, which had an equal distribution in the buccal and lingual surfaces. Large dehiscence involving the apical root third represented 10.43% of dehiscence defects and was more related to the lower incisors (32.19%), upper (14.77%) and lower (14.39%) canines and upper first premolars (8.33%). Figure 2 shows axial and cross-sectional views of dehiscence in the lower jaw occurring in a Class I malocclusion patient.

Fenestration was present in 36.51% of the sample. Different from dehiscence, this type of alveolar defect occurred with greater frequency in the maxilla (68.4%). The teeth most affected were the upper lateral incisors (12.47%), upper first premolars (12.35%) and upper canines (12.22%). In mandible, lateral incisors (8.01%), canines (7.06%) and central incisors (6.65%) were the teeth with more occurrences of fenestration. The results showed that medium root third is the most associated with fenestration (56.34%). Figure 3 shows axial and cross-sectional views of fenestration in the upper jaw occurring in a Class I malocclusion patient.

The panoramic distribution of dehiscence and fenestration is demonstrated in Figure 4.

Discussion

The results of this study would suggest that the presence of such alveolar defects as dehiscence and fenestration is a common finding in the dental arches, data also found by Rupprecht et al.[14] In this sample, 96.9% of the patients had some type of defect with the predominance of dehiscence (51.09%) over fenestration (36.51%). Published studies have shown different results with regard to the prevalence of dehiscence and fenestrations among various ethnic groups, ranging respectively from 0.99% to 13.4% and from 0.23% to 16.9% in the teeth which were analyzed.[14-23] It is difficult to make a correlation with these studies because of the different methods used, usually based on analyses of skulls, a method quite different from that used in this study, which was based on volumetric CT images of live patients.

Access to the alveolar bone covering is more reliable if done through the surgical removal of the gingival tissues. However, this invasive method is not applicable in an epidemiological study, since the risks involved in the procedure outweigh the benefits accrued. This study used images from a database of patients who had already been exposed to CBCT for orthodontic purposes. The use of CBCT is justified firstly by the fact that the radiation dose received by the patients is markedly lower when compared to that of the CT[24] or Multislice CT,[9,11] and secondly by its ability to detect alveolar defects.[25] In addition to these advantages, this imaging method is extremely accurate in linear measurements of dentofacial regions[26] and in high resolution for dental and periodontal structures.[27]

The imaging diagnosis of alveolar defects such as dehiscence and fenestrations depends on its length, the thickness of the alveolar cortical as well as the visualization of the periodontal ligament space,[25] which requires high definition images. The high resolution of the CBCT is related to low voxel size[26] and higher values of mA and kV. The voxel size of 0.4mm used in this study could have contributed to a worse image resolution when compared to a dimension of 0.2mm.[26] This problem could compromise the diagnosis and has contributed to limitations in the analysis of the alveolar region in this study. However, 0.4mm is the voxel size recommended for orthodontic purposes by the tomography manufacturer.

Fuhrmann et al[28] observed that when cortical thickness is less than 0.5mm, the CT scan has shown relative accuracy. Özmeric[29] also reported that the visualization of the periodontal ligament space when less than 200μm is not detectable with the CBCT. These factors can contribute to false-positive results. Undoubtedly, these were also limiting factors in this study, since in certain regions of the root, the alveolar bone and periodontal ligament are extremely thin. In this study, this limitation may have been responsible for a certain overestimation of the prevalence of defects, a fact also reported by Fuhrman,[25] Fuhrmann et al[28] and Nauert & Berg[30] in studies of the alveolar bone supporting the lower incisors. At the same time, in orthodontics an alveolar thickness of less than 0.5mm represents a condition of "a quasi defect," because it is extremely thin and should be considered as defect as well. This strongly indicates caution in orthodontic movement[2] and does not invalidate the results.

In the analysis of the presence of alveolar defects in skulls performed by Rupprecht et al[14] and Davies et al,[19] they defined as dehiscence an alveolar height greater than 4mm for the proximal alveolar crest. Similar to Ezawa et al,[22] this study used the CEJ as a reference point, which is a stable mark and also easily identifiable in tomography images. The literature differs as to what is the normal value that should be adopted for alveolar height in relation to the CEJ, ranging from between 1mm to 3mm.[31] In this study a 2mm value for normal CEJ distance was used as it is the value most frequently adopted in studies of patients with no periodontal disease. In young adults (15-25 year-olds), the average height of the alveolar bone in relation to the CEJ is 1.4mm (± 0.7) and in the over forty-fives this average is extended to 3mm (± 1.5).[13] As our sample was between 18-34 year-olds the 2mm value for CEJ was not underestimated.

The literature has not as yet presented any studies comparing the presence of alveolar defects in different malocclusion, specifically between Class I and Class II division 1 malocclusion. The study reporting an alveolar analysis comparing malocclusions, focused on thickness.[2] Handelman[2] compared the alveolar bone of these malocclusions by measuring the thickness in the anterior and apical region using cephalometry radiographs and found no statistical differences between Class I and Class II malocclusion. This study is consistent with these findings in that the apical region of the roots presented no statistical difference in terms of the distribution of alveolar defects between Class I and Class II malocclusion.

These differences in relation to dehiscence and fenestration between Class I and Class II division 1 malocclusion constitute new data. It is thought that tooth inclination may justify these differences, since the alveolar growth is defined by the axial tilt of the tooth in eruption, which influences the spatial orientation as well the buccolingual thickness of the alveolar process.[8] This theory is supported by the identification of shorter alveolar bases in Class II malocclusion patients in the canine, premolar and upper molar regions[32,33] when compared to patients with Class I malocclusion and normal occlusion. This transversal shortness has greater dental inclination influence than skeletal reduction due to the lingual orientation of these teeth,[32,33] a condition that allows for thicker bone in the buccal region compared to teeth with a more perpendicular position in their alveolus.

In addition to dental inclinations, it is also thought that the presence of crowding may be an influential factor in the differences found between the malocclusion. In Class I malocclusion, crowding is a common feature, resulting in the misalignment of crowns and roots. This study did not set out to detect the influence of crowding in alveolar defects. Other studies using this methodological approach on patients with normal occlusion may confirm this assumption.

Some studies have reported that dolichofacial patients have thinner alveolar bone than in other facial type patients.[2,4] So in this study, the expectation of finding dolichofacial types with a higher prevalence of alveolar defects, was not confirmed, since there were no statistically significant differences between facial types. This data suggests that the great prevalence of dehiscence and fenestration is a common anatomical finding, affecting different types of face, and that the vertical position of the jaws does not influence the presence of dehiscence or fenestration.

The clinical relevance of the results of this study is to alert orthodontic specialists about orthodontic movement in Class I malocclusion patients. In fact, the orthodontic treatment of these patients requires less extensive tooth movement when compared with those with Class II malocclusion. However, the magnitude of tooth movement should be just as well planned in Class I patients, as in other malocclusions. At the same time, the results of this study guarantee greater reliability in the treatment planning of patients with Class II malocclusion because of the need for further extensions of the dental displacement.

Another clinical importance shown is related to the direction of orthodontic movement and the groups of teeth with higher risk of dehiscence and fenestration. According to the literature, dehiscence is more frequently found in the mandible, while fenestration is more frequently related to the maxilla.[14-23] Many studies have also found alveolar defects in the buccal surfaces,[14,16,20,21] a feature also recognized by the results of this research. This happens because the bone at the buccal surface narrows, where the amount of marrow bone is less dense than in the lingual region.[25] This data suggests greater caution about tooth proclination in the lower arch, especially in the incisor region, a fact greatly emphasized by other authors.[4-7,34,35] In addition, this study showed a large number of alveolar defects in the lingual face of lower incisors, which involves greater care in treatment planning for cases which need the extraction of lower premolars and retraction of incisors. Upper canines and first premolars also showed a great prevalence of dehiscence in this study. This feature offers an important clue to procedures involving rapid expansion of the maxilla, since the first premolars, and sometimes the canines, are the support teeth for orthopedic devices. Because of the considerable force needed to break the median palatine suture, an evaluation of the periodontal structures, including alveolar bone and gingival biotype, is a secure approach for the procedure. This is so because an increase in alveolar bone height associated[36] with gingival recession, caused by the effects of dental inclination,[37] has been observed.[38]

The prevalence of alveolar defects is an interesting data for orthodontists, who can alert patients to the fact that dehiscence and fenestration are probably common findings in the population and are not caused by orthodontic movement alone. At the same time, the great prevalence of alveolar defects cannot explain the prevalence, which does not seem proportional, of gingival recession before orthodontic treatment. In the literature, the occurrence of gingival recession associated with orthodontic treatment is a controversial issue. Studies about the role of the gingival phenotype as a protective factor in gingival recession have found that where there is a thickness of more than 0.5mm in the attached gingival, the risk of gingival recession is reduced.[7] A thicker attached gingiva probably plays a decisive role in preventing gingival recession even when the alveolar bone is reduced or absent. Thus, for patients with a thin attached gingiva, a correct diagnosis of bone support in the periodontal evaluation should be undertaken jointly with a diagnosis of the relationship of the craniofacial structures in order to moderate the tooth movement and consequently reduce the risk of gingival changes.

With this in mind, the indication of tomography images should be considered for orthodontic patients. In some countries, it is common to start orthodontic treatment in Class I malocclusion using only panoramic radiographs. Considering the ALARA principle, the indication of an imaging method should be based on the clinical needs of the patient, getting maximum image quality while maintaining a lower radiation dose. This is worth considering, since orthodontic patients are being more and more exposed to radiation.[39] However, in cases involving more extensive orthodontic movements, and patients who have a less favorable gingival biotype such as thin attached gingiva, a three-dimensional diagnosis of alveolar bone is recommended so as to preserve their periodontal health during and after treatment.

Conclusions

According to the results, CBCT is a valuable tool for orthodontic treatment planning where maintaining healthy periodontal structures is the aim, since there is a great prevalence of dehiscence and fenestration in patients with no previous orthodontic treatment, even in those with minor skeletal or occlusal discrepancies.

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Table I-Distribution of malocclusion and facial types groups

Facial type / **Malocclusion**	Brachyfacial	Mesofacial	Dolichofacial	Total
Class I	32	29	18	79
Class II division 1	27	30	23	80
Total	59	59	41	159

Table II – Mean values (± standard deviation) for age, ANB, overjet and NS.GoGn in Class I and Class II division 1 malocclusion.

	Class I	Class II division1
Age (years)	27.09 (7.46)	26.48 (8.18)
ANB (°)	2.52 (1.96)	6.66 (1.96)
Overjet (mm)	2.61 (0.86)	5.72 (1.13)
NS.GoGn (°)	29.32 (6.48)	30.98 (6.63)

Table III - Mean values (± standard deviation) for NS.GoGn in different facial types

	Brachyfacial	Mesofacial	Dolichofacial
NS.GoGn(°)	23.41 (3.28)	31.07 (1.74)	38.77 (2.86)

Table IV – Mean values (± standard deviation) for alveolar defects in Class I and Class II division 1 malocclusion and in facial types.

	Alveolar defect		Dehiscence		Fenestration	
	Number of surfaces	p*	Number of surfaces	p**	Number of surfaces	p*
Malocclusion						
Class I	30.01 (9.45)	<0.01	22.36 (12.26)	< 0.01	11.08 (5.62)	N.S.
Class II division 1	21.78 (10.34)		14.43 (10.63)		9.41 (5.52)	
Facial type						
Brachyfacial	26.84 (10.78)	N.S.	19.52 (12.19)	N.S.	10.16 (5.49)	N.S.
Mesofacial	24.90 (10.82)		17.31 (12.33)		10.45 (5.91)	
Dolichofacial	25.85 (10.56)		18.27 (11.78)		10.05 (5.49)	

* Student test and ANOVA
**Mann-Whitney and Kruskal-Wallis tests

Figure 1-Dehiscence (A) and fenestration (B) in a skull. (from:Rateitschak KH, ed. Farbatlanten der Zahnmedizin. Stuttgart: Thieme, 1984)

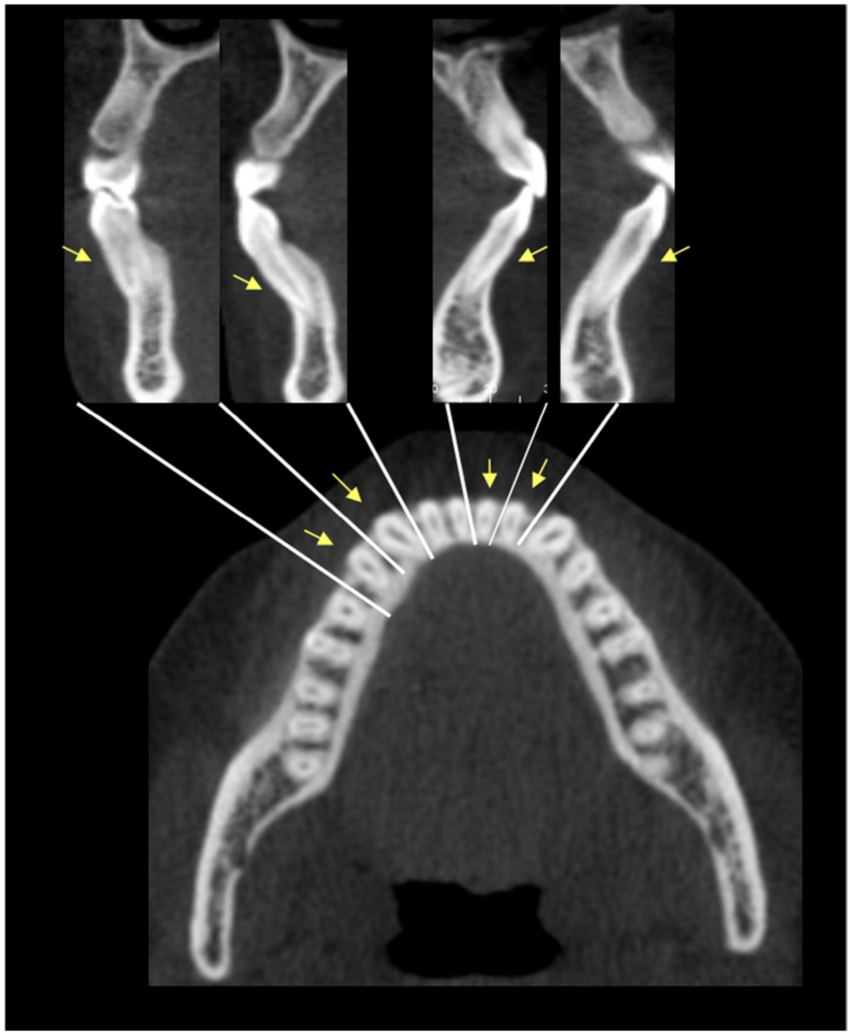

Figure 2. Axial and cross-sectional views of dehiscence in mandible of patient with Class I malocclusion.

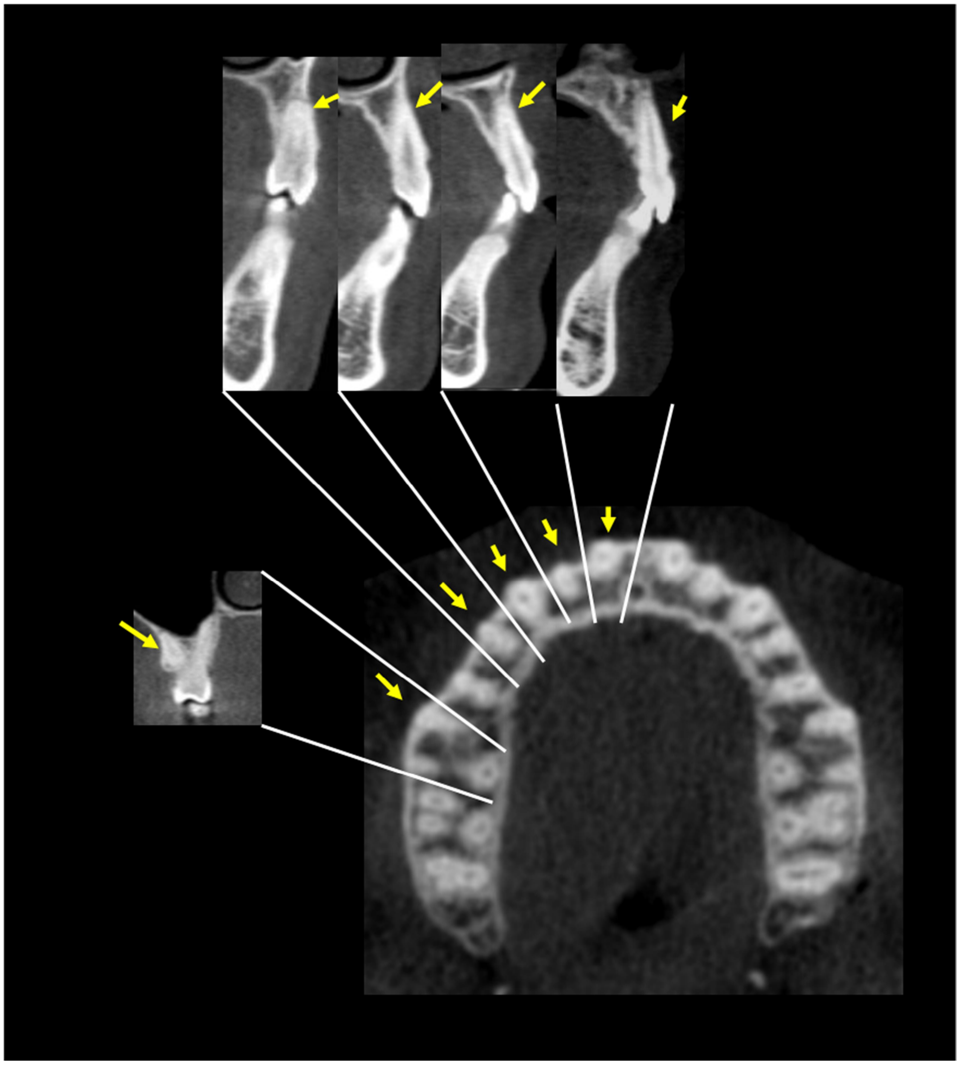

Figure 3. Axial and cross-sectional views of fenestration in maxilla of patient with Class I malocclusion.

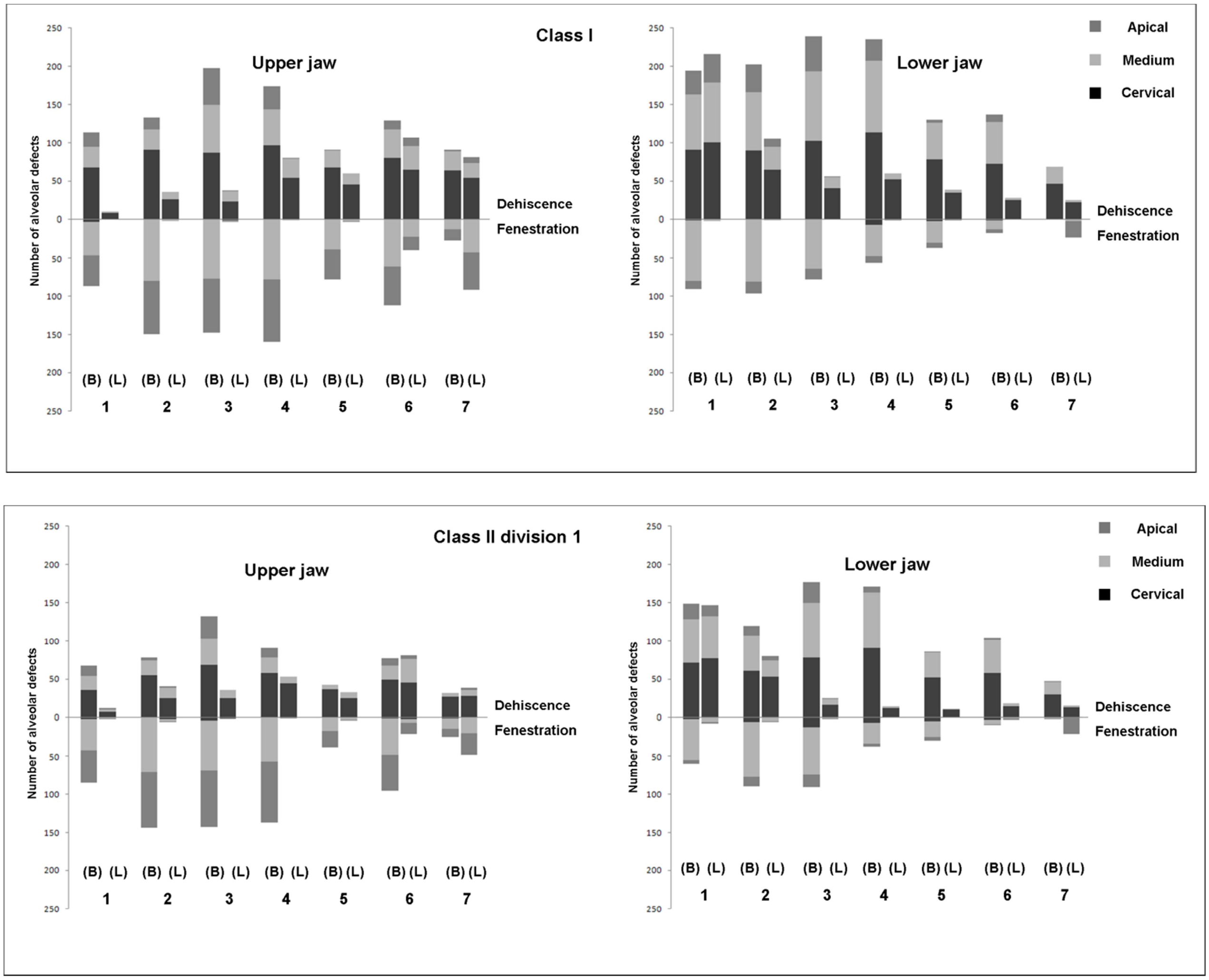

Figure 4- Graph distribution of dehiscence and fenestration in Class I and Class II division 1 malocclusion (B: buccal surface; L: lingual surface).

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APÊNDICE A

CHARITÉ

EINGANG
23. Juni 2008

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16.06.08

The role of the CBCT in Class II orthodontic planning
Antragsnummer: EA1/112/08
Vorgang vom 12.06.08 per E-Mail

Sehr geehrter Professor Bumann,

hiermit bestätigen wir Ihnen den Eingang Ihres Schreibens vom 12.06.08 mit folgender Anlage:

- Studienprotokoll

Sie beantragten die Stellungnahme der Ethikkommission zur Verwendung von anonymisierten Röntgenbildern für das o.g. Forschungsvorhaben, welche aufgrund von medizinisch indizierter Diagnostik angefertigt wurden.

Unter den von Ihnen beschriebenen Voraussetzungen (keine zusätzlichen studienbedingten Röbtgenuntersuchungen, Auswertung in anonymer Form ohne die Möglichkeit der Zuordnung zum Patienten) erhebt die Ethikkommission keine ethischen und rechtlichen Bedenken gegen das Vorhaben.

Mit freundlichen Grüßen

Prof. Dr. med. R. Morgenstern
Stellvertretender Vorsitzender

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APÊNDICE B

ANDREA JOSEFINE HIRTENSTEIN FAIRMAN
Tradutora Pública e Intérprete Comercial
Matrícula na Junta Comercial no. 0615 - Portaria 68/ 2000, de 12 de Julho de 2000
Idiomas: Alemão/ Espanhol/ Inglês/ Português
RG: 5.372.855-5 - CPF: 818.364.498/ 87 - INSS: 11.716.557.768 - CCM: 9.533.408-4

REPÚBLICA FEDERATIVA DO BRASIL
15 de Novembro de 1889

TRADUÇÃO No. 1048 LIVRO NO.08 FOLHA NO.348-349

CERTIFICO e DOU FÉ, para os devidos fins, que nesta data me foi apresentado um documento em idioma alemão, o qual traduzo para o vernáculo no seguinte teor:

[Cabeçalho:]
CHARITÉ
Comissão de Ética; sede; gerente geral: Sra. Katja Orzechowski, médica
ethikkommission@charité.de
endereço para correspondência: Charitéplatz 1, 10117 Berlin, Tel. 030/450-517222, Fax: 030/450-517952; www.charité.de/ethikkommission/
Consta um carimbo com o seguinte teor: Entrada 23 de junho de 2008.
.
Carta endereçada ao Sr. Professor Dr. Axel Bumann, Instituto para Tomografia de Volume Craniofacial; Rua Georgenstrasse 25 – 10117 Berlin.

Data: 16.06.08;
Referência: O papel da CBCT no planejamento ortodôntico Classe II
No. solicitação: EA1/112/08
Processo de 12.06.08 por e-mail

Prezado Professor Bumann,

Acusamos o recebimento da sua carta de 12.06.08 com o seguinte anexo:

- protocolo de estudo

solicitando o posicionamento da comissão de ética para o uso de imagens radiológicas anônimas, para o projeto de pesquisa acima mencionado, que foram realizadas devido ao diagnóstico por indicação médica.

Nas condições descritas por V.Sa. (nenhum exame radiológico adicional no âmbito do estudo, avaliação de forma anônima sem a possibilidade de identificar o paciente), a Comissão de Ética não tem nenhuma objeção ética ou jurídica contra o projeto.

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Andrea J. H. Fairman – Tradutora Pública

R. Batataes, 460 - CEP 01423-010 - São Paulo - SP - Brasil
Fone/Fax: + 55 11 **3059 8250**
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ANDREA JOSEFINE HIRTENSTEIN FAIRMAN
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Atenciosamente

(assinatura de) Prof. Dr. med. R. Morgenstern
Vice-Presidente

[Rodapé:]
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NADA MAIS consta do documento acima que devolvo com esta tradução, segundo o meu melhor entender o qual conferi, achei conforme e assino.

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APÊNDICE C

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