SIMEI ANDRÉ DA SILVA RODRIGUES FREIRE

TRATAMENTO DE FRATURAS DE MANDÍBULAS ATRÓFICAS:
Estudo Epidemiológico, Mecânico e Análises de Elementos Finitos.

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UNIVERSIDADE ESTADUAL DE CAMPINAS
FACULDADE DE ODONTOLOGIA DE PIRACICABA

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Estudo Epidemiológico, Mecânico e Análises de Elementos Finitos.

Orientador: Profa. Dra. Luciana Asprino

TESE DE DOUTORADO APRESENTADA A FACULDADE DE ODONTOLOGIA DE PIRACICABA DA UNICAMP PARA OBTENÇÃO DE TÍTULO DE DOUTOR EM CLÍNICA ODONTOLÓGICA NA ÁREA DE CIRURGIA E TRAUMATOLOGIA BUCO-MAXILO-FACIAIS

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Este exemplar corresponde à versão final da Tese defendida pelo aluno, e orientado pelo Profa. Dra. Luciana Asprino

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A Comissão Julgadora dos trabalhos de Defesa de Tese de Doutorado, em sessão pública realizada em 03 de Julho de 2012, considerou o candidato SIMEI ANDRÉ DA SILVA RODRIGUES FREIRE aprovado.

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todos esses anos e pelo incentivo
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RESUMO

O objetivo desse trabalho foi avaliar a epidemiologia e características do tratamento de fraturas de mandíbula atrófica; comparar a resistência mecânica e a distribuição de tensões de três técnicas de fixação interna aplicadas em fraturas de mandíbulas atróficas. **CAPÍTULO I:** Dados foram coletados de pacientes vítimas de fraturas em mandíbulas atróficas em um período de dez anos (1999-2009). Os dados analisados continham informações demográficas e socioeconômicas, etiologia dos traumas, diagnóstico, tipos de traumas, deslocamento das fraturas, o método de fixação utilizado, região das fraturas, traumas associados, tempo decorrido entre o trauma e tratamento. A principal causa das fraturas em mandíbulas atróficas foi a queda da própria altura, acometendo principalmente pacientes do gênero masculino desempregados. A faixa etária mais acometida foi a de trinta a sessenta anos ocorrendo predominantemente fraturas bilaterais na região de corpo mandibular. **CAPÍTULO II:** Avaliou-se a resistência, *in vitro,* por meio de testes de carregamento linear a fixação de fraturas de mandíbulas atróficas com defeito de continuidade por meio de três sistemas de fixação. Foram utilizadas réplicas de mandíbulas humanas atróficas de poliuretano submetidas a simulação de fratura com defeito de continuidade de 15mm em corpo direito, fixadas pelos seguintes sistemas: Grupo 1 - sistema 2,4mm conventional, Grupo 2 - sistema 2,4 mm com travamento e Grupo 3 - sistema 2,0mm com travamento. Pelos resultados obtidos o sistema com travamento aumentou a resistência da fixação pela melhor e mais favorável distribuição de cargas, os sistemas 2,4mm de fixação interna estável testados apresentaram adequada resistência mecânica para tratamento de fraturas de mandíbulas atróficas com defeito de continuidade. **CAPÍTULO III:** Avaliou-se, *in sílico,* pelo método de elementos finitos a fixação de fraturas de mandíbulas atróficas por meio de três sistemas de fixação submetidas a testes de carregamento linear. Os modelos criados em elementos finitos de fratura de mandíbula atrófica foram fixados pelos seguintes sistemas, sistema 2,4mm convencional, sistema 2,4mm com travamento e sistema 2,0mm com travamento.

Pelos resultados obtidos o sistema 2,4mm convencional demonstrou suportar toda carga aplicada nesta simulação, os sistemas com travamento apresentaram dissipação das tensões para região anterior e posterior da mandíbula e no sistema de fixação convencional as tensões se localizaram na porção entre os furos do sistema de fixação assim como no sistema com travamento, porém este ainda apresentou dissipação para os parafusos, com concentração crescente para região apical dos parafusos próximos a simulação do traço de fratura.

Palavras-chave: Trauma de Face, Mandíbula Atrófica, Fixação Interna Estável.

ABSTRACT

The aim of this study was to evaluate the epidemiology and treatment characteristics of atrophic mandibular fractures; to compare the mechanical strength and stress distribution of three internal fixation techniques applied in atrophic mandibles fractures treatment. **CHAPTER I**: Data were collected from patients suffering from atrophic mandibles fractures in a period of ten years (1999-2009). The data analyzed contained demographic and socioeconomic characteristics, etiology of trauma, diagnosis, types of trauma, displacement of the fractures, the region of fracture, associated trauma, time elapsed between trauma and treatment. The main cause of fractures in atrophic mandibles was fall accidents, affecting mainly male unemployed patients. The age group most affected was between thirty to sixty years occurring bilateral fractures predominantly in the mandibular body region. **CHAPTER II**: Resistance was evaluated *in vitro* by linear loading test in the atrophic mandible fracture simulation with continuity defect by three stable internal fixation systems. It was used replicas of human atrophic polyurethane mandible subjected to simulated fracture defect continuity of 15mm in right body region, fixed by the following systems: Group 1 - 2.4mm conventional system, Group 2 - 2.4 mm *locking* system and Group 3 - 2.0mm *locking* system. The results obtained with the *locking* system increased the resistance setting for the better and more favorable load distribution, the 2.4mm stable internal fixation systems tested had adequate mechanical strength for the treatment of fractures of atrophic mandibles with continuity defects. **CHAPTER III:** It was evaluated ,*in silico,* by the method of finite elements with linear force three stable internal fixation systems for the treatment of atrophic mandible fractures. The finite element models created in the atrophic mandible fracture were fixed by the following systems, the conventional system 2.4mm, 2.4mm *locking* system and 2.0mm *locking* system. The results obtained demonstrated that the *locking* system increased the resistance by a favorable and better distribution of the stresses during the loading test when applied in atrophic mandible fractures with continuity defects. The three internal fixation systems tested in this study showed adequate

mechanical efficiency to be applied in atrophic mandible fractures with continuity defects treatment.

Keywords: Facial Trauma, Atrophic Mandible, Stable Internal Fixation.

SUMÁRIO

1. INTRODUÇÃO

A mandíbula edêntula sofre atrofia óssea que leva à diminuição da altura e espessura óssea, tornando-a mais susceptível à fraturas. O edentulismo tem reduzido nos Estados Unidos desde 1950 (Oliver, 1993) e atualmente aproximadamente 8% da população adulta americana é completamente edêntula. Porém os avanços nos tratamentos em saúde, com a eliminação das epidemias que provocam doenças infecciosas e as vantagens gerais de se viver em uma ascendente sociedade moderna têm favorecido o aumento da expectativa de vida em vários locais do mundo, tornando a população demograficamente mais velha. Segundo o IBGE (Instituto Brasileiro de Geografia e Estatística), entre 2000 e 2009, a expectativa de vida do brasileiro cresceu 2 anos, 8 meses e 15 dias, e em relação a 1980, aumentou 10 anos, 7 meses e 6 dias, aumentando pouco mais de 3 meses entre 2008 e 2009, passando para 73,17 anos ante 72,86 anos no ano anterior. As mulheres continuam vivendo mais que os homens e têm expectativa de vida ao nascer de 77 anos, ao passo que os homens têm uma expectativa de vida de 69,4 anos.

Complicações, incluindo infecções, má união, fratura das placas, e a não união, têm incidência muito maior em mandíbulas atróficas edêntulas do que em dentadas (Haug, 1993). Isto possivelmente se deve à reduzida área de secção na linha de fratura, resultando em insuficiente contato ósseo na mandíbula e a presença de osso denso, esclerótico e pouco vascularizado. A diminuição das forças funcionais geradas nos pacientes desdentados podem levar a considerar o uso de fixação menos estável, o que possibilitaria a realização de cirurgias menos invasivas nesses pacientes. Infelizmente, as técnicas menos estáveis, como as miniplacas, historicamente resultaram em falhas como a união fibrosa, má união, falha dos parafusos, e fraturas de placas (Spiessl, 1989).

Uma das primeiras formas de se tratar fraturas em mandíbulas atróficas foi por meio da fixação funcionalmente não estável, ou seja, pela utilização de fios de aço, dentaduras e bloqueio maxilomandibular. Porém com o advento da fixação interna estável e devido ao alto índice de complicações pós-operatórias, uma abordagem mais agressiva por meio da utilização de placas de reconstrução do sistema 2,7mm e 2,4mm passaram a ser utilizadas.

Novas complicações surgiram com o uso destas placas como maior índice de exposição no pós-operatório, impossibilidade de reabilitação protética além de desvantagens como a necessidade da realização de grandes incisões, maior tempo cirúrgico e dificuldade para adaptar a placa.

Sistema de placas e parafusos com travamento dos parafusos na placa se tornaram disponíveis na década de 80 (Raveh *et al.,* , 1980, 1982), inicialmente com um sistema chamado Thorp® (Titanium-coated Hollow Screw and Reconstruction Plate System), no qual havia uma perfuração na cabeça do parafuso que recebia um segundo parafuso menor para fixar o parafuso principal na placa. Na década de 90 outro sistema com rosqueamento da própria cabeça do parafuso na placa, chamado UniLock®, substituiu o sistema Thorp®, atualmente chamado de sistema com travamento ou bloqueio ou mesmo Locking. Este sistema tem vantagem significativa na estabilidade independente do contato da placa com o osso, tornando a adaptação da placa mais fácil ao osso, uma vez que pequenos espaços são permitidos entre a placa e osso. Haug *et al.,* (2002) demonstraram que a estabilidade da redução da fratura não é reduzida quando placas de reconstrução com travamento estão até 4mm acima da superfície óssea. Além disso, a não compressão da placa contra o periósteo possibilita melhor revascularização da cortical óssea (Sutter and Raveh, 1988; Vuillemin *et al.,* 1988; Söderholm *et al.,* 1991).

Pelo fato das fraturas em mandíbulas atróficas edêntulas serem relativamente incomuns, a maioria dos cirurgiões possuem experiência limitada com esse tipo de tratamento. Mugino *et al.,* (2005) trataram 335 pacientes com fraturas mandibulares entre 1980 e 2004, 11 desses pacientes (3%) tinham fraturas em mandíbula edêntula, e somente 8 (2,3%) eram atróficas. Em meio a condições não favoráveis do tratamento de fraturas em mandíbulas atróficas começou-se a realizar tratamentos mais agressivos, aplicando-se placas ósseas de reconstrução por meio de abordagem extra-oral. Porém com o surgimento de novos sistemas de fixação, outras opções de tratamento cirúrgico se tornaram viáveis (Ellis & Price , 2008).

Diante desta tendência torna-se importante a realização de testes *in vitro* para avaliação da distribuição de tensão e resistência mecânica das placas de reconstrução 2,0mm com travamento, comparando-as com o sistema 2.4mm com travamento e 2,4mm conventional, de uso já consagrado para tal indicação.

Essa tese foi desenvolvida em formato alternativo, de acordo com informação CCPG 002/06, os objetivos gerais foram de avaliar a epidemiologia (anexo 1) e características do tratamento de fraturas de mandíbula atrófica; comparar, *in vitro*, a resistência mecânica e a distribuição de tensões de três técnicas de fixação interna aplicadas em fraturas de mandíbulas atróficas, por meio de testes mecânicos e de elementos finitos.

CAPÍTULO 1

A 10-year Retrospective Study of Atrophic Mandible Fractures: Incidence and Patterns

ABSTRACT

Purpose: The aim of this study was to retrospectively evaluate the epidemiological characteristics of prevalence, type and treatment modalities of fractures in atrophic mandibles.

Patients and Methods: Data was collected from patients with fractures in atrophic mandibles during a ten year period (1999-2009). The data recorded included demographic data, etiology, diagnosis, type, dislocation, associated facial trauma, methods of treatment, time interval between trauma and treatment. Data analysis involved a descriptive analysis, Qui-Square Test, Fisher Exact Test, t-test and Kruskall-Wallis.

Results: From a total of 976 mandible fractures there were 40 atrophic mandible fractures with a male: female ratio of 2:1 and a mean age of 54.5 years. Men were statistically associated with fractures in atrophic mandibles, when compared to women ($p<0,05$). The most common cause of fractures in atrophic mandibles were falls (47.5%). The social occupation of the victims were unemployed (40%) followed by economically active (37.5%). There were 2 symphysis fractures, 10 parasymphysis fractures, and 38 mandible body fractures, 5 angle fractures and 2 condyle fractures in a total of 57 lines of fractures diagnosticated. One fracture was classified as comminuted and 56 were classified as no comminuted, 19 fractures were not displaced, 19 had less than 5 mm of displacement and others 19 fractures more than 5 mm of displacement. Fractures treated with surgery represented 75.4% (34 bilateral and 9 unilateral) of the patients, while 24.6% (0 bilateral and 14 unilateral) of the patients received nonsurgical treatment ($p<0,05$). The distribution of facial traumas according to the number of atrophic mandible fractures showed that most patients presented a unilateral trauma associated with atrophic mandible fracture (55%).

<u>Conclusions</u>: Fall accidents are the main cause of atrophic mandible fractures in both genders in the evaluated region. There was a higher prevalence of atrophic mandible fractures in patients between thirty and sixty years old and a clear predominance of men in the whole sample. Most of the atrophic mandible fractures occurred in the body region and were bilateral. Not displaced or minimally displaced can be treated by nonsurgical methods. Open versus closed treatment should be judged individually. The evaluation of the aged patient in the treatment of face trauma is up to the oral and maxillofacial surgeon.

Keywords: Atrophic Mandible, Elderly Patient, Facial Trauma.

INTRODUCTION

Maxillofacial trauma has been investigated worldwide because it affects a significant percentage of trauma patients[1,2,3]. Traumatic injury has been identified as the leading cause of reduced productivity, accounting for the loss of more working years than heart disease and cancer combined[3]. A direct relationship exists between the severity of a facial injury and a patient's reporting of an occupational disability[4]. The most common fractured bone of the face is the mandible[1,2,5,6].

The atrophy of the jaw, the final stage of edentulism, leads to decreased bone mass, making the bone more vulnerable to fractures. Edentulous people have reduced in the United States since 1950 and currently about 8% of the adult American population is completely edentulous[6,7]. But advances in health treatment, with the elimination of epidemics that cause infectious diseases and the general advantages of living in a modern society has favored the increase in life expectancy in several locations around the world, making the population demographically older. In 1990, life expectancy in the United States was of 67 years, in 2004 however, the expectation rose to 77.8 years. In 2030, 1 in every 5 people in the United States will be over 65 years old. Part of that population is the fastest growing segment of people with 85 years or more, in 2050 the projection is for approximately 20 million elderly people in this age group[8].

The atrophic mandible fracture occurs mainly in the elderly[9,10]. There are several factors that may contribute to the weakening of the jaw in that age group. One of these is the reduction of vascularization or the decrease of blood flow in the elderly[10,11,12]. Furthermore, with the loss of teeth, which in many elderly patients may have occurred in previous seasons, we have a subsequent loss of bone mass. This loss of bone mass and decreased vascularization reduces the resistance of the jaw which makes it more vulnerable to fractures during traumatic events[12,13].

Complications, including infection, poor union, fracture of the plates, and non-union, have a much greater incidence in atrophic edentulous mandibles than in dentate mandible fractures[14]. This is possibly due to the reduced area section of the line of fracture, resulting in insufficient jaw bone contact in the presence of a dense and sclerotic bone, which is poorly vascularized[14, 15]. The low functional forces generated in edentulous patients can lead us to consider the use of less stable fixation, which would enable less invasive surgery in these patients. Unfortunately, the techniques of less rigid plates, which are used less, often result in failure. This may manifest as a fibrous non-union, bad union, failure of the screws and plate fracture. Based on clinical data, this seems particularly true when the jaw is 20mm or less in vertical dimension[15]. Many advantages in the screw-*locking* system have been published in recent literature because it seeks to combine the advantages of fixing at internal and external forces created between screw and plate [11,16].

Due to the fact that atrophic edentulous mandibles fractures are relatively uncommon, the majority of surgeons have limited experience in the treatment of patients with this problem. Mugino *et al.,*[17] treated 335 patients with mandible fractures between 1980 and 2004, 11 of these patients (3%) had fractures in edentulous mandibles, and only 8 (2.3%) were atrophic. Among non-favorable conditions, atrophic mandible treatment began to perform more aggressive fixation, applying stronger bone plates through an extra-oral approach and making immediate bone graft when indicated[18].

With the emergence of new systems for setting, there were more options for surgical treatment. Ellis and Price[18] published indicating the use of reconstruction plates with 2.0mm *locking* system for the treatment of fractures in atrophic mandibles. The results showed that the setting during this period went through changes and that their main choice for treatment of fractures in atrophic mandibles from 2000 was the use of the system of fixation with reconstruction plates with *locking* 2.0mm called "*locking* reconstructive plates". Such plates offer better stability of fracture segments, as they have a system of *locking* between the screw and the plate to prevent the forced displacement of the reduction.

Understanding maxillofacial trauma of atrophic mandible gives support to prevention policies and evaluation of the treatment modalities. Few reports have been published about this type of fractures epidemiology[19,20,21]. The following study was developed to evaluate the epidemiological characteristics of prevalence and treatment modalities of atrophic mandible fractures from 1999 to 2009 in Piracicaba Dental School, State University of Campinas-UNICAMP Piracicaba, SP, Brazil.

PATIENTS AND METHODS

Data was collected from patients who attended the division of Oral and Maxillofacial Surgery at the University of Campinas - Unicamp, Brazil, from 1 April 1999 to 01 February 2009. Information was obtained retrospectively from clinical notes and surgical records from each patient using a standardized data collection form that was specifically developed to investigate the epidemiological features of maxillofacial trauma. The data recorded included patient gender, age, occupation, etiology, diagnosis, type of atrophic mandible fracture, dislocation of the fractures, associated facial trauma, methods of treatment, time interval between trauma and treatment. Exclusion criteria were charts that did not have complete information about the trauma.

Patients were divided in ten years groups according to their ages. Occupation activities were divided in economic active patients, students, unemployed, dependents and retired patients. Etiology of the atrophic mandible fractures included car, motorcycle, bicycle, pedestrian motor vehicle accidents, work-related and sports related accidents, falls, individual violence and others that did not fit any of the categories above. The atrophic mandible fractures were diagnosed as unilateral or bilateral. The classifications of the fractures were based on panoramic and computed tomography exams. Atrophic mandible fractures were also classified as non-displaced, displaced less than five millimeters or displaced more than five millimeters. They were also classified as simple and comminuted fractures. Treatment of atrophic mandible fractures was divided into nonsurgical treatment (arch bars used in prothethic fixation) and surgical treatment (open reduction and internal fixation). The atrophic mandible fractures were classified according to its region as symphysis, parasymphysis, body, angle and condyle fractures.

Data analysis involved a descriptive analysis which was made for each variable. The Qui-square test was used to compare the counts of categorical response between two independent variables. If the expected values were less than 5 in the contingency table, the Fisher's exact test was used. T-test and Kruskal-Wallis test were used to compare two or more independent variables, respectively. The association between the variables had been considered significant when the p-value was less than 0.05 ($p<0.05$).

RESULTS

A total of 3148 trauma patients were evaluated from 1 April 1999 to 1 February 2009 at the division of oral and maxillofacial surgery of University of Campinas - Unicamp. From these patients, a total of 2035 sustained maxilla facial fractures, 976 sustained mandible fractures and 40 were diagnosed with atrophic mandible fractures. These numbers show that 1.9% of the patients victims of maxillofacial trauma sustained at least one atrophic mandible fracture. There were 27 males and 13 females with atrophic mandible fractures, with a male: female ratio of 2:1. T-test revealed a significant difference between atrophic mandible fractures between men and women ($p<0.05$).

There were 23 unilateral, 17 bilateral atrophic mandible fractures, presenting a total of 40 atrophic mandible fractures. Considering the gender and the diagnosis, 14 men and 9 women were diagnosed with unilateral atrophic mandible fractures, 13 men and 4 women sustained bilateral atrophic mandible fractures. Qui-square test did not show a statistical difference between gender and the distribution of unilateral and bilateral condyle fractures. The age of the patients at the time of injury ranged from 26 to 83 years, with a mean age of 54.5 years. According to the age 7.5% of the patients were between 10 and 30 years old, 52.5% percent were between thirty and sixty years old and 40% of the patients were older than sixty years. Table 1 lists the number of atrophic mandible fractures according to gender, age and etiology. There was a higher prevalence of atrophic mandible fractures in patients between thirty and sixty years old and a clear predominance of men in the whole sample. Kruskal-Wallis test showed a statistical significant association between the age and cause of maxillofacial fractures ($p<0.05$). Falls were the most frequent causes of atrophic mandible fractures. Particularly for women, the most common causes of atrophic mandible fractures were falls (53.8%) followed by bicycle accidents and violence (8.69% each type). According to the social activity, 37.5% percent of the patients were economically active and 40% unemployed, as listed in table 2. T-test did not showed statistical association between gender and the distribution of occupational activities.

The diagnosis and classification of atrophic mandible fractures is shown in table 3 and figure 1. There were 2 symphysis fractures, 10 parasymphysis fractures, and 38 mandible body fractures, 5 angle fractures and 2 condyle fractures in a total of 57 lines of fractures diagnosticated. Fifty six fractures were classified as noncomminuted fractures, and 19 fractures were not displaced, 19 had less than 5 mm of displacement and other 19 fractures more than 5 mm of displacement. Fractures treated with surgery represented 75.4% (34 bilateral and 9 unilateral) of the patients, while 24.6% (0 bilateral and 14 unilateral) of the patients received nonsurgical treatment, no treatment complication were observed. Kruskal-Wallis test revealed a statistical significant association between atrophic mandible fractures and surgical treatment and between the simple and non displaced fractures and closed treatment ($p<0.05$). Table 4 lists the diagnosis of atrophic mandible fractures versus age groups and etiology. According to the results 76.4% percent of bilateral fractures were caused by falls with a peak incidence of 60 and older years. The oral health was evaluated regarding tooth loss. All patients were edentulous. The mean time interval between trauma and surgery was 11.2 days.

DISCUSSION

The data presented in this study was retrospectively collected from a population of 800,000 inhabitants, composed by the cities of Limeira, Rio Claro and Piracicaba, Brazil, which is young, has a great mobility, lives in urban areas and is economically active. A temporal study of atrophic mandible fracture indicates the most common age groups involved, shows the prevalence of different etiologic factors and reveals the effectiveness of surgical and nonsurgical treatments.

Atrophic mandible fractures are relatively uncommon, the majority of the surgeons possess limited experience in the treatment of the patients with this problem. The number of cases necessary for evaluation of the treatment methods is not available to surgeons. Mugino *et al.*,[17] treated 335 patients with mandible fractures between 1980 and 2004, 11 of these patients (3%) had fractures in edentulous jaws, and 8 (2.3%) were atrophic only.

This investigation revealed that 1.9% of the maxillofacial trauma patients sustained at least one atrophic mandible fracture. Mandible fractures represented 47.9% of the injuries. The frequency of atrophic edentulous mandible fractures is low and is considered to be less than 1% of all facial fractures. While low, the frequency of all facial fractures in the geriatric population is thought to be on the rise because of the increased life expectancy of older individuals, the enhanced popularity of their leisure activities, and increased physical mobility of the older population. This trend is supported by the census data reported by the US Department of Commerce[8] that indicates that there will be an expansion of the elderly population by 50% by the year 2050. Thus, this problem will not decrease in occurrence, but is more likely to become more problematic.

The incidence of atrophic mandible fracture ranged patients from 26 to 83 years old, with a mean of 54.5 years. According to the results, 7.5% percent of the patients were between 10 and 30 years old, 52.5% percent were between thirty and sixty years and 40% of the patients were older than sixty years. This is due to lower motor coordination of the older patients, which results in more limited mobility and greater occurrence of falls, moreover the edentulous mandible is more susceptible to fractures during the traumatic episodes.

Atrophic mandible fracture occurs mainly in the aged population[9,10]. Some factors exist that can contribute for the weakness of the jaw in this group. One of the factors is the reduction of the vascularization or the decrease of the sanguineous flow in aged people [11,12]. Moreover, with the loss of teeth, in which in many of the aged patients it may happened at previous times, we have a subsequent loss of bone mass[9,13]. This loss of bone mass and the reduction of the vascularization reduces the resistance of the jaw that becomes more vulnerable to fractures during traumatic events mainly in the mandibular body where it occurs with greater incidence[7,21].

In the study 1.9% of the patients victims of maxillofacial trauma sustained at least one atrophic mandible fracture. There were 27 males and 13 females with atrophic mandible fractures, with a male: female ratio of 2:1. This indicates that men are more vulnerable to atrophic mandible fractures. The ratio may be justified by the economical social activity, given that men possess greater participation in the economically active market than women. One other interesting fact that we observed in our result is the high index of atrophic mandible fracture in unemployed aged people, victims vulnerable to the high index of violence present in a class less favored by the governmental assistance.

A higher prevalence of atrophic mandible fractures in patients between thirty and sixty years old and a clear predominance of men in the whole sample were observed in the results. Falls were the most frequent causes of atrophic mandible fractures. Particularly for women, the most common causes of atrophic mandible fractures were falls (53.8%) followed by bicycle accidents and violence (8.69% each type). According to the social activity, 375% of the patients were economically active and 40% unemployed, as listed in table 2. Represented 76.4% of bilateral fractures were caused by falls with a peak incidence of 60 years old and older years.

The etiology of maxillofacial fractures is commonplace, which includes bicycle, motorcycle and car accidents, falls, interpersonal violence, and activity related accidents. The high occurrence of atrophic mandible fracture by falls with 52,5% in aged people is explained by their difficult in locomotion and shorter walking ability.

Zachariades[22] agreed that bilateral fractures are the result of excessive force. According to Huelke[23], a force applied to the mandible is distributed and seeks out the weakest point of the mandible arch and causes extreme bending and stress failure at that point.

Fractures treated with surgery represented 75.4% (17 bilateral and 9 unilateral) of the patients, while 24.6% (0 bilateral and 14 unilateral) of the patients received nonsurgical treatment.

There were 65 facial fractures associated with atrophic mandible fractures in 40 patients of the sample. As shown in table 5, where 55% of the victims had only the broken atrophic mandible, followed by 32.5% of the patients who additionally had a fracture of face associated with atrophic mandible fracture. In the great majority of the accesses, adding the unilateral and bilateral fractures of atrophic mandible, were carried through an extraoral approach, resulting in a total of 76.9% of surgical treatments. Other factors should be taken into consideration when indicating open or closed treatment of the atrophic mandible fractures. These include the position of the fracture, displacement, patients function, if the vascular supply of the mandible is preserved or not, systemic conditions and the age of the patient [24].

Some patients were treated by nonsurgical therapy. Open reduction may be the patient's or surgeons' preference considering that the most important advantage of using stable internal fixation is to avoid or shorten the period of maxillo-mandible fixation and improved functional results but it is dependent of the patient's resources and socioeconomic status. In cases of associated mandible fractures, occlusal instability, in fractures which were passive to stable fixation, open reduction was performed in 65% of the fractures in this sample. Surgery was indicated in authors` institution for patients with unilateral or bilateral atrophic mandible fractures, with large displacement and loss of functions [25].

Controversies in the treatment of atrophic mandible fractures exist[26,27]. Some schools defend that, in the majority of the circumstances, these fractures must be opened and be fixed. Others defend that these fractures can be treated successfully by means of the technique of anatomical reduction.

However, with the sprouting of new systems of setting, some options of surgical treatment have appeared[28,29]. This fact makes it more difficult to establish a protocol for treatment of fractures of atrophic mandibles. In the last 30 years, it has many debates regarding the size and the number of bone plates necessary to treat fractures in dentate mandible successfully [29,30]. The oral health was evaluated regarding tooth loss. All patients were edentulous. The mean time interval between trauma and surgery was 11.2 days.

CONCLUSION

Considering the causes of atrophic mandible fracture and the distribution between genders, men are predominant. Falls are the main cause of atrophic mandible fractures in both genders in the region analyzed.

The age groups which sustained a prevalence atrophic mandible fractures were in patients between thirty and sixty years old and a clear predominance of men in the whole sample. Most of the atrophic mandible fractures occurred in the body region and were bilateral, not displaced or minimally displaced and can be treated by nonsurgical means.

Open versus closed treatment should be judged individually. The evaluation of the elderly patient in the handling of face trauma is of responsibility of the oral and maxillofacial surgeon, who must have knowledge on the current physiological alterations of aging, as well as on attention for the pathologies most frequent of this age band.

References

1. Lida S, Kogo M, Sugiura T, Mima T, Matsuya T: Retrospective analysis of 1502 patients with facial fractures. Int J Oral Maxillofac Surg 30:286, 2001

2. Brasileiro BF, Passeri LA: Epidemiological analysis of maxillofacial fractures in Brazil: a Five-year propective study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 102: 28, 2006

3. Gassner R, Tuli T, Hach O, Rudisch A, Ulmer H: Cranio-maxillofacial trauma: a 10 year review of 9543 cases with 21 067 injuries. Journal of Cranio-Maxillofacial Surgery 31: 51, 2003

4. Girotto JA, MacKenzie E, Fowler C, Redett R, Robertson B, Manson PN: Long-term physical impairment and functional outcomes after complex facial fractures. Plast Reconstr Surg 108: 312, 2001

5. Fasola AO, Obiechina AE, Arotiba JT: Incidence and pattern of maxillofacial fractures in the elderly. Int J Oral Maxillofac Surg 32: 206, 2003

6. Fasola AO, Nyako EA, Obiechina AE, Arotiba JT: Trends in the characteristics of maxillofacial fractures in Nigeria. J Oral Maxillofac Surg 61: 1140, 2003

7. Oliver RC, Brown LJ: Periodontal diseases and tooth loss. Periodontology 2:117, 1993

8. US Census Bureau: Profile of general demographic characteristics, 2005. Available at http://factfinder.census.gov/servlet/ACSSAFFFacts?_submenuId_factsheet_1&_sse_onSo. Accessed November 16, 2007

9. Bruce RA, Strachan DS: Fractures of the edentulous mandible:The Chalmers J. Lyons Academy Study. J Oral Surg 34:973,1976

10. Friedman CD, Constantino PD: Facial fractures and bone healing in the geriatric patient. Otolaryngol Clin North Am 25:1109, 1996

11. Scott RF: Oral and maxillofacial trauma in the geriatric patient,*in* Fonseca RJ, Walker RV, Betts NJ, *et al.,* (eds): Oral and Maxillofacial Trauma, vol 2. Philadelphia, PA, Saunders, 1997,pp 1045-1072

12. Bradley JC: A radiological investigation into the age changes of the inferior dental artery. Br J Oral Surg 13:82, 1975

13. Ellis E, Moos KF, El-Attar A: Ten years of mandibular fractures: An analysis of 2,137 cases. Oral Surg 59:120, 1985

14. Haug RH: Effect of screw nwnber on reconstruction plating. Oral Surg Oral Med Oral Path01 75:664, 1993

15. Spiessl B: Universal plate system, central angle fractures, use of the EDCP and reconstruction plate internal fixation of the mandible, in Spiessel 8: Internal Fixation of the Mandible. New York, NY, Springer-Verlag, 1989, pp 19-35,292-294

16. Frost D, Tucker M, White R: Small plate fixation for fixation of mandibular fractures, *in* Tucker MR, Terry BC White RP, *et al.,.,* (eds): Rigid Fixation in Maxillofacial Surgery. Philadelphia, PA, Lippincott, 1991, p 104

17. Mugino H, Takagi S, Oya R, *et al.,.,*: Miniplate osteosythesis of fractures of the edentulous mandible. Clin Oral Invest 9:266, 2005

18. Ellis E, Price C:Treatment Protocol for fractures of the Atrophic Mandible.J Oral Maxillofac Surg 66:421-435,2008

19. Buchbinder D: Treatment of fractures of the edentulous mandible, 1943 to 1993: A review of the literature. J Oral Maxillofac Surg 51:1174, 1993

20. Iatrou I, Samaras C, Lygidakis NT: Miniplate osteosynthesis for fractures of the edentulous mandible: A clinical study, 1989–1996. J Craniomaxillofac Surg 26:400, 1998

21. Luhr HG, Reidick T, Merten HA: Results of treatment of fractures of the atrophic dentulous mandible by compression plating. J Oral Maxillofac Surg 54:250, 1996

22. Zachariades N, Koumoura F, Konsolaki-Agouridaki E: Facial trauma in women resulting from violence by men. J Oral Maxillofac Surg 48: 1250, 1990

23. Huelke DF, Harger JH: Maxillofacial injuries: their nature and mechanism of production. J Oral Surg 27: 451, 1969

24. Schilli W, Stoll P, Bähr W, *et al.*,., Mandibular fractures, *in* Prein J (ed): Manual of Internal Fixation in the Cranio-Facial Skeleton: Techniques Recommended by the AO/ASIF Maxillofacial Group. New York, Springer, 1998, p 87

25. Tucker MR: An in vitro study of the effect of bony buttressing on fixation strength of a fractured atrophic edentulous mandible model. J Oral Maxillofac Surg 58:62, 2000

26. Thaller SR: Fractures of the edentulous mandible: A retrospective review. J Craniofac Surg 4:491,1993

27. Bruce RA, Ellis E: The second Chalmers J. Lyons Academy Study of fractures of the edentulous mandible. J Oral Maxillofac Surg 51:904, 1993

28. Raveh J, Sutter F, Hellem S: Surgical procedures for reconstruction of the lower jaw using the titanium-coated hollow-screw reconstruction plate system: Bridging of defects. Otolaryngol Clin North Am 20:535, 1987 Solve H, Olofson J: Titanium coated

29. Sikes JW, Smith BR, Mukherjee DP: An in vitro study of the effect of bony buttressing on fixation strength of a fractured atrophic edentulous mandible model. J Oral Maxillofac Surg 58:56, 2000

30. Tate GS, Ellis E, Throckmorton GS: Bite forces in patients treated for mandibular angle fractures: Implications for fixation recommendations. J Oral Maxillofac Surg 52:734, 1994

Table 1. Distribution of patients with mandibular atrophic fractures by gender, age and etiology.

	Bicycle		Falls		Car		Motorcycle		Violence		Sports		Work		Pedestrian		Others		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
0-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-30	-	-	-	-	-	1	1	-	1	-	-	-	-	-	-	-	-	-	2	1
31-40	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	1	-	-	2	1
41-50	-	2	4	-	1	-	-	-	1	-	1	-	-	-	-	-	-	-	7	2
51-60	1	-	4	-	-	-	-	-	2	1	-	-	-	-	-	-	-	1	7	2
60 or +	-	-	4	7	2	-	-	-	3	-	-	-	-	-	-	-	-	-	9	7
Total	1	2	12	7	3	1	2	-	7	1	1	-	1	-	-	1	-	1	27	13

(Key: Pedestrian, pedestrian motor vehicle accident. F, female. M, Male)

Table 2. Distribution of social occupation of 40 patients with mandibular atrophic fractures.

	Number of patients		
Occupation	Men	Women	Total
Economically active	12(30%)	3(7,5%)	15(37,5%)
Student	-	-	-
Unemployed	9(22,5%)	7(17,5%)	16(40%)
Dependent	-	3(7,5%)	3(7,5%)
Retired	6(15%)	-	6(15%)

Table 3. Distribution of mandibular atrophic fractures according to the treatment modality, diagnosis, classification, displacement and comminution.

		Classification						Displacement				Comminution		
Treatment		Symphysis	Parasymphysis	Body	Angle	Condyle	Total	0 mm	Less than 5 mm	More than 5 mm	Total	Noncomminuted	Comminuted	Total
Surgical	Unilateral	1	1	6	1	-	9	-	6	3	9	9	-	9
	Bilateral	-	4	11	2	-	17	12	6	16	34	34	-	34
Nonsurgical	Unilateral	1	1	10	-	2	14	7	7	-	14	13	1	14
	Bilateral	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 4. Distribution of patients with mandibular atrophic fractures according to etiology,diagnosis and age.

	Bicycle		**Falls**		**Car**		**Motorcycle**		**Violence**		**Sports**		**Work**		**Pedestrian**		**Others**		**Total**	
Age	B	U	B	U	B	U	B	U	B	U	B	U	B	U	B	U	B	U	B	U
0-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-30	-	-	-	-	-	1	-	1	-	1	-	-	-	-	-	-	-	-	-	3
31-40	-	-	-	-	-	-	-	1	-	-	-	-	-	1	1	-	-	-	1	3
41-50	-	2	2	2	1	-	-	-	-	1	1	-	-	-	-	-	-	-	4	4
51-60	1	-	2	2	-	-	-	-	-	3	-	-	-	-	-	-	-	1	3	6
60 or +	-	-	9	2	-	2	-	-	-	3	-	-	-	-	-	-	-	-	9	7
Total	1	2	13	6	1	3	-	2	-	8	1	-	-	1	1	-	-	1	17	23

Key: Pedestrian, pedestrian motor vehicle. B, bilateral; U, unilateral.

Table 5. Distribution of facial fractures according to the number of atrophic mandible fractures.

	Atrophic Mandible Fracture	
Number of Facial Fractures	Unilateral	Bilateral
01	12	10
02	8	5
03	2	1
04	1	1
05	-	-
Total	23	17

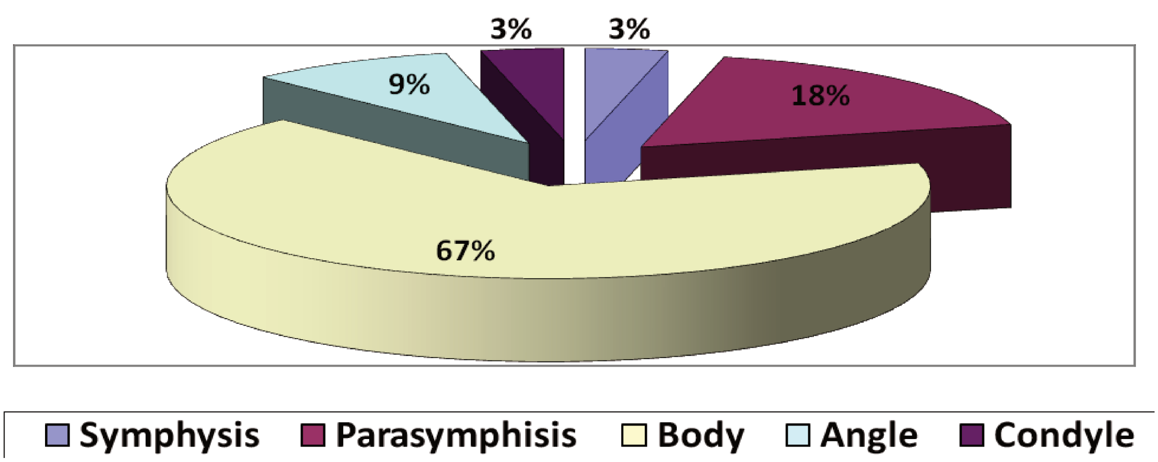


Figure1. Distribuition of Atrophic Mandible Fractures

CAPÍTULO 2

A Mechanical Evaluation Of Stable Internal Fixation of Atrophic Mandible Fractures with Continuity Defects

ABSTRACT

<u>Purpose</u>: The aim of the present study was to comparatively evaluate the resistance and failure areas created after load incidence in different varieties of stable internal fixation in atrophic mandible fractures with continuity defect.

<u>Materials and Methods</u>: Twenty synthetic polyurethane atrophic mandible replicas were subjected to flextorsional loading tests to evaluate 3 fixation techniques of the atrophic mandible fractures. A control group without fixation and three groups of stable internal fixation formed by 2.4mm conventional system, 2.4 *locking* systems and 2.0 *locking* systems with 8-hole plates were contoured to each of the edentulous mandibles with gap fractures measuring 15mm. Each group was subjected to flextorsional loading using an Instron 4411 servohydraulic mechanical testing unit. The load value with a 10mm displacement were measured.

<u>Results</u>: The mean and standard deviation of the peak load indicated that the group with 2.4mm *locking* was the one that presented the highest resistance, followed in descending order by the control group, standard 2.4mm group and 2.0mm *locking* group showing no statistically significant difference between the 2.4mm and control groups when compared to the others.

<u>Conclusion</u>: Under the conditions tested, the *locking* system increased the resistance by a favorable and better distribution of the tension forces during the loading test when applied in atrophic mandible fractures with continuity defects. The two 2.4mm internal fixation systems tested in this research showed adequate mechanical efficiency to be applied in atrophic mandible fractures with continuity defects.

Keywords: Atrophic Mandible, Stable Internal Fixation, Facial Trauma

INTRODUCTION

The management of the atrophic edentulous mandible fractures remains a surgical challenge despite many of the recent advances in fracture management. This is due to a number of factors, not the least of them which is the relative low frequency of this form of injury, the relative inexperience of all maxillofacial surgeons, as well as the insufficiency of information on this topic in the surgical literature. The frequency of atrophic edentulous mandible fractures is low and is considered to be less than 1% of all facial fractures[1]. Yet while low, the frequency of all facial fractures in the geriatric population is thought to be on the rise because of the increased life expectancy of older individuals, the enhanced popularity of their leisure activities, better medical management and increased physical mobility of the older population[2]. This trend is supported by census data reported by the US Department of Commerce that indicates that there will be an expansion of the elderly population by 50% by the year 2050[3]. Thus, this problem will not decrease in occurrence, but is more likely to become more problematic.

Management of this type of injury in prior decades has included wire osteosynthesis, the use of dentures, Gunning stents, external pin fixators, and even avoidance of treatment. With the introduction of stable internal fixation into the surgeon's options, this technology has brought with it the potential for the increased stability during the repair of this type of fracture. Yet despite these improvements, complications still occur; they include infection, nonunion, masticatory disability, neurosensory deficits, and both high direct costs as well as high indirect social costs[4]. The reasons for these types of complications have been considered to be both biologic and biomechanical[5].

The biologic problems associated with this patient population include the systemic diseases associated with advancing age[5-7], reduction in local blood flow, osteoporosis, and change in bone quality[8-10]. The biomechanical considerations include the loss of the buttressing effects associated with diminished bone height of the atrophic edentulous mandible, as well as the stability associated with the specific form of fixation[11-13]. While medical management can alter many of the biologic effects, there are some (such as bone quality and blood supply) that cannot be altered. Thus, the fixation modality may be the only variable that can be reliably improved upon to enhance healing of the fractured atrophic edentulous mandible. While conventional wisdom has taught us that the application of a bone plate to the lateral border of the edentulous jaw, just as for the dentate mandible, should be advantageous, this application for the severely atrophic mandible may not be the best alternative. Numerous inadequacies are associated with this type of application to the atrophic edentulous mandible. The type and quality of soft tissue coverage of the atrophic edentulous mandible, when reconstructed by the traditional lateral border plate, often results in wound dehiscence and can then be compounded by infection and non-union[13].

Moreover, the application of a 2.4 mm outer thread diameter screw requiring 5 mm of bone between the fracture site or the inferior or superior border requires a minimum of 12.5 mm of bone. This is not available in the severely atrophic edentulous mandible (Class 3, <10 mm) and thus subjects the reconstruction failure on a biomechanical basis. The argument that a bone graft will be helpful does not eliminate the potential for biomechanical failure, but only adds second site surgical morbidity to the list of potential problems in the management of this already complex injury. Over the past years some surgeons group has reconsidered lateral border reconstruction plate management for atrophic edentulous mandibular fractures, and have placed the plate at the inferior border, much as one would place a transmandibular implant[14].

With these clinical observations in mind, the question that remains is therefore, the purpose of this investigation was to comparatively evaluate the resistance after load incidence in different varieties of stable intern fixation in atrophic mandible fractures with continuity defects, using atrophic polyurethane synthetic mandible replicas under bench top conditions that resembled clinical function. These synthetic replicas were chosen to eliminate many of the variables associated with human cadaveric and animal mandibles and have previously been used for biomechanical research[15-20]. The polyurethane replicas have been created from exactly matched human anatomy in all dimensions and proportions[15,16]. The uniformity of these synthetic replicas provides more consistent sampling than cadaver bone, with a similar modulus of elasticity[15-20]. Their use as human bone substitutes has been evaluated for these types of biomechanical investigations and has been verified as being acceptable alternatives. While direct inference to *in vivo* function cannot be made when using human bone substitutes, experimental trends can be identified. [21]

The parameters evaluated in this investigation were maximum load value, with a displacement of 10mm for the mechanical test. Each of these parameters was evaluated under conditions that simulated function: body region loading (flextorsional loads).

MATERIALS AND METHODS

We used identical synthetic polyurethane atrophic mandible replicas confectioned specifically for this research (Nacional Ossos, Jaú-São Paulo, Brazil). Synthetic replicas were chosen to eliminate many of the variables associated with human cadaveric mandibles and bone from animal sources. Moreover, such replicas are readily available, have uniform mechanical properties, and have a hard foam cortex that reasonably reproduces the qualities of mandibular bone.

SAMPLE PREPARATION

All 20 atrophic mandibles in the study for the mechanical test were made from one single model confectioned by one investigator. For the choice of the resistance in mechanical test of the polyurethane jaw offered by (Nacional Ossos, Jaú-São Paulo, Brazil), that could be normal or extra hard, linear shipment test was carried through in bodies of test (2X2 cm) in the machine for universal essay Servohidraulic Instron, model 4411 (Instron Corp, Norwood, ME). In such a way the modulus of elasticity of the body test was that closed to the human bone. The atrophic mandible models were reduced to a consistent height and length of 10 mm at the body and synphysis region. The alveolar ridge reductions and the 15mm gap fracture in the right body mandible were made using a Stryker TPS reciprocation saw (Stryker Instruments, Kalamazoo, MI). Five unfractured synthetic mandible replicas without rigid fixation system were reserved as control models (for body region [flextorsional] loading). Fifteen more replicas were selected for the experimental groups. Following verification of a consistent 10 mm mandible height and length, three groups of stable internal fixation formed by 2.4mm conventional system, 2.4mm *locking* system and 2.0mm *locking* system with 8-hole plates fabricated from titanium (Tóride Ind. Com. Ltda. EPP) were contoured to each of the edentulous mandibles in the experimental groups. The experimental groups (Figure 1) were contoured and fixed to the lateral border of the atrophic mandibles by a guide made of acrylic resin that was used for the attachment of the plates and bicortical screws, being 14mm screws for the 2.4mm systems and 12mm screws for the 2.0mm stable internal fixation systems.

Figure1 – Guide made of acrylic resin used for the attachment of the plate and bicortical screws.

All *locking* plates were contoured using bending inserts to maintain plate integrity. Five mandibles from each of the experimental groups were reserved for body region (flextorsional) loading. The 15 plates and 120 screws were placed by a single investigator.

The atrophic mandibles were attached to a custom made test platform, at which the proximal segment was rigidly stabilized in the right condyle, allowing free movement of the distal segment while the loads were applied (Figure 2).

Figure 2 – Custom made test platform with rigid stabilized right condyle, allowing free movement of the distal segment by flextorsional loading forces.

LOADING TEST

The 3 sample groups and the control group were subjected to flextorsional loading from the upper part to the lower part, in the left first molar region, using the Instron 4411 (Instron, Norwood, MA) Servohydraulic material testing unit. The material testing unit produced linear displacement at a rate of 1 mm/minute, and the loading was continued until 10mm distance. The peak load data in kilogram-force (kgf) were obtained.

The peak load is the load at which the system begins to permanently deform. The mean and standard deviation values were derived and compared for statistical significance within the attachment categories and tested using analysis of variance. A P value of less than 0.05 was considered significant, and the mean values were compared using the Tukey test.

RESULTS

From the 20 synthetic mandibles, 15 plates, and 120 screws used in this investigation, some very exciting information was obtained and observations made. For body region loading, no statistically significant differences were noted between the control group and the 2.4mm conventional system when compared to the other groups for peak load.

For each experimental group, load was resisted logarithmically along a straight slope until the 10mm of dislocation was reached. Lastly, some interesting observations were made regarding the fixation systems when no failure was reached with no screw shattered or bend.

LOADING TEST

A summary of the results of the statistical analysis is presented in Table 1. The 2.4mm *locking* system were the most resistant to the linear flextorsional loading test with 1.888 kgf load resistence, followed by the 2.4mm conventional system with 1.608 kgf load resistance and the 2.0mm *locking* system with 1.522 kgf load resistance, which presented the lower resistance.

DISCUSSION

The studies that evaluate the forces involving the gnathic chew and bones are very complex, since we have in one same bone some muscular insertions, each one exerting vector forces in distinct directions. This model becomes more complex when we add an atrophic mandible fracture simulation with internal stable fixation.

Initially the application of flextorsional forces in unfractured atrophic polyurethane mandible had been of great importance to demonstrate that the substratum had resistance enough to test the fixation system applied. Another important information is related to the total immobility of the support used to system test (complete atrophic mandible installed to the support and submitted the linear flextorsional test), allowing to infer that the point of application of loads, as well as the standardization of the inclusion and apprehension of the models, was correct.

They have had many debates regarding the size and of the number of bone plates necessary to treat the atrophic mandible fractures successfully. The general trend has been the reduction of the profile of the system. The introduction of stable internal fixation by miniplates for treatment of mandible fractures with monocortical screws generated a true revolution in the treatment of these fractures. Nowadays, the great majority of these fractures are treated by means of this technique, exceptions including cominutives fractures, and possibly atrophic mandible fractures[22,23].

The referring results to the fixation system averages and shunting line standard of loads had shown significance statistics for bigger resistance in the groups treated by 2.4mm locking system with 14mm screws, followed by the group 2.4mm conventional system with 14mm screws and 2.0mm locking system with 12mm screws. When evaluated in qualitative way the fixation system in the displacement/peak load, it is possible to verify that in the cases of the plates and screws, imperfection of the setting material did not occur, remaining itself all the screws in the interior of the substratum and occurring the bending of the plate.

In this study, the statistical significant difference was not evidenced between the groups 2.4mm conventional system and control group when compared to the others. A possible explanation for the inferior resistance of the groups fixed by the 2.0mm *locking* system is exactly a lesser thickness and consequently inferior resistance of the fixation material, however it was sufficiently near by the resistance presented by the substratum. Although this lower resistance, is important to be observed that probably it is not clinically significant, being also similar to the resistance presented by the 2.4mm conventional, who is accepted as a classically method and widely used, also praised by the AO/ASIF.

The fixation by the 2.4mm *locking* system with bicortical 16mm screws and 2.0mm *locking* system with 14mm screws, a compression between the segments, that could cause damages to the alveolar inferior nerve, as well as the biggest torque to the condyles does not exist. Moreover, the introduction of the 2.0mm *locking* system few years behind placed in doubts the indication for the choice of the 2.4mm reconstruction plates. The company Synthes®, created 2.0mm locking plates with three different thicknesses and bigger thickness (1.5mm), the 2.0mm *locking* system is called reconstructive plate.

The thickest plate come in some lengths, including some so long as the 2.4-mm reconstruction plates. From now on it was started to use these plates, whose thickness is of 1,5mm, for the treatment of atrophic mandible fractures soon after its introduction[24], and today this is the trend for treatment of atrophic mandible fractures, but still it has distrust in indicating it due the lower resistance. Still valley the penalty to stand out the average thickness of the plates used in this study was of 2,95mm, in the conventional 2.4-mm system; 2.0-mm in the 2.4-mm *locking* system; and 1,5mm in the system 2.0mm *locking* system. That demonstrates that the *locking* system increased the resistance to loads, therefore exactly the 2.4mm *locking* plate having only 2/3 of the thickness of the plates of the 2.4mm conventional group. This fact also favors the indication for the clinical use of the reconstructive 2.0mm *locking* plates, therefore although presenting only 50.8% of the thickness of the 2.4mm conventional plate system, which is widely accepted for clinical use, it had presented 69,8% of resistance presented for this last system. This is much more resistant of what the conventional 2.0mm *locking* system, and a plate applied in the inferior rim of the buccal cortex with bicortical screws is the sufficient to supply adequate stability for these fractures. At least three screws in each side of the fractures must be used.

The use of 2.0mm *locking* bone plate in atrophic mandible fractures possess great advantages. Because this plate is thinner than the 2.4-mm system it is less palpable by the patient and offers less risk of intra oral exposure. This plate also is much easier to bend and adapted than the 2.4-mm reconstruction plate, saving time. The low profile of the plate also diminishes the interference risk during the use of prosthesis.

Differently of what it was found previously in literature, with the advent of the *locking* system and its advantages as a reconstructive plate system has been developed which possess expansive screw heads that, when activated, stop the screw in the plate. The constraint between the plate and the screw respects the necessities for compression between the plate and the screw, as it occurs in a conventional system of plate and screw. In an open reduction, the stable internal setting makes possible better stability and faster mobilization. A potential advantage of the *locking* system is that little screws are necessary to reach a maximum load resistance. Such fact would make possible the use of smaller incisions or settings of lesser bone parts and still would allow functional load[25].

The use of *locking* system improves the resistance of the system therefore thinner plates are applied with a good clinical performance. This clinical performance with a lesser rigidity occurs because the masticatory forces in the first six postoperative weeks are reduced, a *locking* system with less rigidity will present a good clinical performance with satisfactory stabilization during the initial phase of the bone repair.

The limitation of the masticatory forces in the first postoperative weeks had mainly edema involving the region of the masticatory muscles reducing the bite force for less than 300N, when in normal condition it should be 700N, and that the monocortical setting with plates and screws offer to sufficient postoperative stability for the bone repairing[26,27]. Such information makes possible the use of *locking* system 2.0mm for atrophic mandible fractures treatment.

Clinically it is still very difficult to measure the real impact of these differences of resistance of the setting systems on the bone repair, as well as the mechanics resistance necessary to promote an adequate and previsible bone repair[28,29,30]. However, also we know that the correct positioning betweem the segments can influence the degree of bone contact and the quality of the surface that will be able to receive the fixation material.

In this way, we can affirm that in clinical conditions where a good bone contact exists, theoretically any one of the studied techniques of setting in this work can be used. Already in the cases where the bone contact is lesser and is necessary an immediate mandibular function, in a patient with expected bigger masticatory force, perhaps the most recommendable it is the use of more rigid techniques of setting, as the 2.4-mm *locking* systems and 2.4-mm conventional system with bicortical screws. Valley stand out that the choice of the atrophic mandible fracture Luhr class III[31] was propositál, therefore represents the clinical situation of bigger challenge, therefore it is less favorable to the repair from the mechanical and biological points of view.

The professionals must have greater care in relation to the positioning and stability supplied by the stable internal fixation system in order to prevent possible imperfections in the fixation systems in its clinical use. Immediate bone grafting should be considered when formulating a treatment plan for atrophic fractured mandibles with continuity defects. More investigations should be done to evaluate the 2.0-mm reconstructive bone plate in association with bone grafts.

CONCLUSION

Under the conditions tested, the *locking* system increased during the loading test when applied in atrophic mandible fractures with continuity defect. Despite the relative resistance of the 2.0mm *locking* system during the mechanical tests, the two 2.4mm internal fixation systems tested in this research showed adequate mechanical efficiency to be applied in atrophic mandible fractures with continuity defect.

REFERENCES

1. Newman I: The role of autogenous primary rib grafts in treating fractures of the atrophic edentulous mandible. Br J Oral Maxillofac Surg 33:381, 1995

2. Seper L, Piffko J, Joos U, *et al.,.,*: Treatment of the atrophic mandible in the elderly. J Am Geriatr Soc 52:1583, 2004

3. US Bureau of the Census. Current Population Reports, series P-25, no. 952. Projections of the Population of the United States, by Age, Sex, and Race: 1988 to 2080. Washington, DC, US Department of Commerce, 1989

4. Assael L: Discussion: Results of treatment of fractures of the atrophic edentulous mandible by compression plating: A retrospective evaluation of 84 consecutive cases. J Oral Maxillofac Surg 54:254, 1996

5. Bruce RA, Strachan DS: Fractures of the edentulous mandible: The Chalmers J. Lyons Academy Study. J Oral Surg 34:973, 1976

6. Xie Q, Ainamo A: Association of edentulousness with systemic factors in elderly people living at home. Community Dent Oral Epidemiol 27:202, 1999

7. Bruce RA, Ellis E: The second Chalmers J. Academy Study of fractures of the edentulous mandible. J Maxillofac Surg 51:904, 1993

8. McGregor AD, MacDonald DG: Age changes in the human inferior alveolar artery-A histological study. Br J Oral Maxillofac Surg 27:371, 1989

9. Friedman CD, Constantino PD: Facial fractures and bone healing in the geriatric patient. Otolaryngol Clin North Am 25:1109, 1996

10. Bradley JC: A radiological investigation into the age changes of the inferior dental artery. Br J Oral Surg 13:82, 1975

11. Sikes JW, Smith BR, Mukherjee DP: An in vitro study of the effect of bony buttressing on fixation strength of a fractured atrophic edentulous mandible model. J Oral Maxillofac Surg 58:56, 2000

12. Luhr HG, Reidick T, Merten HA: Results of treatment of fractures of the atrophic edentulous mandible by compression plating. J Oral Maxillofac Surg 54:250, 1996

13. Marciani RD: Invasive management of the fractured atrophic edentulous mandible. J Oral Maxillofac Surg 59:792, 2001

14. Powers MP, Bosker H, Van Pelt H, *et al.,*: The transmandibular implant: From progressive bone loss to controlled bone growth. J Oral Maxillofac Surg 52:904, 1994

15. Haug RH, Fattahi TT, Goltz M: A biomechanical evaluation of mandibular angle fracture plating techniques. J Oral Maxillofac Surg 10:1199, 2001

16. Haug RH, Nuveen EJ, Barber JE, *et al.,*: An in vitro evaluation of distractors used for osteogenesis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 86:648, 1998

17. Haug RH, Barber JE, Reifeis R: A comparison of mandibular angle fracture techniques. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 82:257, 1996

18. Dichard A, Klotch D: Testing biomechanical strength of repairs for the mandibular angle fracture. Laryngoscope 104:201, 1994

19. Kroon F, Mathison M, Cordes JR, *et al.,*: The use of miniplates in mandibular fractures. An in vitro study. J Craniomaxillofac Surg 19:199, 1991

20. Schmoker R: The eccentric dynamic compression plate: An experimental study as to its contribution to the functionally stable internal fixation of fracture of the lower jaw. AO Bulletin, pp 1-31,1976

21. Bredbenner TL, Haug RH: Substitutes for human cadaveric bone in maxillofacial rigid fixation research. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 90:574, 2000

22. Iatrou I, Samaras C, Lygidakis NT: Miniplate osteosynthesis for fractures of the edentulous mandible: A clinical study, 1989–1996. J Craniomaxillofac Surg 26:400, 1998

23. Mugino H, Takagi S, Oya R, *et al.,*: Miniplate osteosythesis of fractures of the edentulous mandible. Clin Oral Invest 9:266, 2005

24. Ellis E, Price C:Treatment Protocol for fractures of the Atrophic Mandible.J Oral Maxillofac Surg 66:421-435,2008

25. Raveh J, Sutter F, Hellem S: Surgical procedures for reconstruction of the lower jaw using the titanium-coated hollow-screw reconstruction plate system: Bridging of defects. Otolaryngol Clin North Am 20:535, 1987 Solve H, Olofson J: Titanium coated, 1998

26. Stoelinga PJW, Borstlap WA. The fixation of sagittal split osteotomias with miniplates: The versatility of a technique. J Oral Maxillofac Surg 61(12):1471-6, 2003

27. Ellis E, Throckmorton G: Bite forces in patients treated for mandibular angle fractures. J Oral Maxillofac Surg 52:734, 1994

28. Harada K, Watanabe M, Ohkura K, *et al.;*: Measure of bite force and occlusal contact area before and after bilateral sagittal split ramus osteotomy of the mandible using a new pressure-sensitive device: A preliminary report. J Oral Maxillofac Surg 58:370, 2000

29. Van der Braber W, Van der Glas H, Van der Bilt A, Bosman F. Masticatory function in retrognatic patients, before and after mandibular advancement surgery. J Oral Maxillofac Surg 62 (5): 549-54, 2004

30. Nakata Y, Ueda HM, Kato M, Tabe H. Chances in stomatognatic function induced by orthognatic surgery in patients with mandibular prognatism. J Oral Maxillofac Surg 65(3):444-51, 2007

31. Luhr HG, Reidick T, Merten HA: Results of treatment of fractures of the atrophic edentulous mandible by compression plating. J Oral Maxillofac Surg 54:250, 1996

Table 01: Groups analyzed according to load (mean and standard deviation).

Group	Load (kgf)	
	Average	**DP**
Control	1.608 b	0.049
2.0Locking	1.061 c	0.318
2.4 Control	1.522 b	0.186
2.4 Locking	1.888 a	0.156

Means followed by different letters differ ($p \leq 0.05$)

CAPÍTULO 3

Comparison Of Three Different Fixation Techniques Of Atrophic Mandible Fractures Using Three-Dimensional Finite Elements Analysis

ABSTRACT

Purpose: The aim of this study was to comparatively evaluate the mechanical stress over atrophic mandible fractures and hardware fixed with three different stable internal fixation systems using three-dimensional finite element analysis.

Materials and Methods: A three-dimensional finite element model of an atrophic mandible fracture at the right body region was simulated on a computer model. The model was fixed with three different types of stable internal fixation: the 2.4mm conventional system, the 2.4mm *locking* system and the 2.0mm *locking* system with 8-hole plates with bicortical screws. Load was applied until a displacement of 1 mm occurred and the results obtained were compared with previous mechanical and photoelastic tests, analyzing the mechanical stresses developed in the proximity of miniplates and screws and within the fixation system themselves.

Results: The results obtained demonstrated that the conventional system support most of the load applied in this experiment, the *locking* systems presented dissipation of the tensions to the anterior and posterior mandible and conventional systems presented tensions located in the portion between the holes of the fixation system plate as well as *locking* system, but it still showed dissipation for the screws, with increasing concentration in the apical region of the screws near the fracture simulation.

Conclusions: Under the conditions tested, the conventional system retained most of the torcional forces, dissipating shorter stress to them to the mandible, the *locking* system presented a better stress distribution among the atrophic mandible increasing the resistance by a favorable distribution of the stress forces during the loading test when applied in atrophic mandible fractures. The three stable internal fixation systems tested in this research showed adequate mechanical efficiency to be applied in atrophic mandible fractures.

Keywords: Finite Element Analysis, Atrophic Mandible, Stable Internal Fixation.

INTRODUCTION

Maxillofacial trauma has been investigated worldwide because it affects a significant percentage of trauma patients[1]. Traumatic injury has been identified as the leading cause of reduced productivity, accounting for the loss of more working years than heart disease and cancer combined[3]. A direct relationship exists between the severity of a facial injury and a patient's reporting of an occupational disability[4].

The most common fractured bone of the face is the mandible[1]Management of patients with atrophic mandible fractures has been a challenge for maxillofacial surgeons for years[1-6]. Techniques that have been used are splints, external pins, split ribs, wire osteosynthesis, and stable fixation[1-7]. Results with each of these techniques have had variable success depending on the amount of atrophy that the patient showed before injury. There has been an evolution of treatment over the years in which closed techniques have been gradually replaced by open techniques[1-6,8,9].

In 1976, Bruce and Strachan suggested that closed reductions should be tried first and that if an open reduction was required, wire mesh was preferable to a bone plate[10].

In 1979, Marciani and Hill, after reviewing 33 well documented cases, recommended a closed reduction of fractures of the atrophic mandibular body[11]. In the second Chalmers J. Lyons Academy study, published in 1993, Bruce and Ellis 3 noted that 81.5% of the 104 patents had an open reduction and internal fixation with a bone plate[12]. In 1996, Luhr *et al.,* presented their results in 84 patients with atrophic edentulous mandible fractures treated with compression bone plates[13]. In

2006, Wittwer *et al.,* reviewed their outcomes of the treatment of 30 patients treated with different plating systems[14]. They concluded that the more atrophic a fractured mandible is, the more stable the fixation of the fracture needed to be. Tiwana *et al.,*in 2009, suggested that for ideal healing of edentulous, atrophic mandible fractures, bone grafting is needed in addition to a large reconstruction plate and a bone graft. [15]

The patient population with atrophic mandible individuals who present for management of traumatic injuries presents generally physiological alteration[1,3-5,9]. In general, they are an older population with concomitant medical issues. Bruce and Ellis noted that their patients had an assortment of medical illnesses including cardiovascular disease and chronic respiratory disease[3]. Injuries tend to be more evenly distributed between genders, and falls tend to account for a higher percentage of the cause of these injuries[1,3,9]. Long periods of edentulism lead to atrophy of the mandible in height and width, particularly in the body region of the mandible[10].

As a consequence, there is an increased incidence of unilateral and bilateral body fractures, as this area of the mandible becomes more susceptible to fracture[3,11]. Eyrich *et al.,* had 34 patients with atrophic mandible fractures ranging in age from 38 to 89 years with a mean age of 70.5 years. Of their patients, 26% were female and 74% were male[16]. Wittwer *et al.,* noted that the cause of the injury in 23 of their 30 patients was a fall.[14] Their age group was 42 to 91 years with a mean of 72 years. Bruce and Strachan noted that falls accounted for 30% of the injuries that they saw[2]. Nonunion and fibrous unions were and are a well recognized complication when treating these patients[1,3,5].

Bruce and Strachan stated that there was a 20% incidence of nonunion after treatment of these types of fractures[2]. Later studies with more aggressive techniques have shown the incidence of nonunion and malunion to be approximately 10%[8,9]. Luhr *et al.,* developed a classification of atrophy based on the height of the mandible in the body region, with a Class I atrophy being 16 to 20 mm, a Class II atrophy 11 to 15 mm, and a Class III atrophy being 10 mm or less. The patients with Class III atrophy have the greatest incidence of nonunion.[13]

Over the past years some surgeons has reconsidered lateral border reconstruction plate management for atrophic edentulous mandibular fractures, and placed the plate at the inferior border, much as one would place a transmandibular implant[14]. With these clinical observations in mind, the purpose of this investigation was to comparatively evaluate the tension areas created after load incidence in different varieties of stable internal fixation in atrophic mandible fractures.

MATERIAL AND METHODS

CONSTRUCTION OF THE GEOMETRIC STRUCTURES

To create the finite element model, it was necessary to construct the geometric structures of the atrophic mandible and the screws and miniplates. The atrophic mandible was constructed from a DICOM file of a mandible taken from CTI (Center for Information Technology Renato Archer, Campinas, SP, Brazil) data bank, that was previously obtained from a dry atrophic mandible submitted to a helical CT scan with thickness of 1 mm.

The computer model of the titanium miniplates and screws (conventional and *locking*) were developed based on physical specimens from Tóride Ind. Com. Ltda. EPP Mogi-Mirim-São Paulo, Brazil.

The atrophic mandible fractures were fixed with three different types of stable internal fixation: the 2.4mm conventional system, the 2.4mm *locking* system and the 2.0mm *locking* system with 8-hole plates fabricated from titanium (Tóride Ind. Com. Ltda. EPP) were contoured to each of the edentulous mandibles in the experimental groups. Finite element models of bicortical screws were used, being 14mm screws to the 2.4-mm systems and 12-mm screws to the 2.0-mm stable internal fixation system.

Each reconstruction miniplate and screws was determined to be in perfect contact with the bone, the tridimensional geometry of both mandible and miniplate/screws were created by the software Rhinoceros 4.0 (McNeel North America, Seattle, WA).

FINITE ELEMENT MODEL DEVELOPMENT AND PROPERTIES

The geometry was imported to the software Femap v.10.1 (Siemens PLM Software Inc., Plano, TX) for the preprocessing of the finite element (FE) model development. All the materials were considered to be homogenous, isotropic and with linear elastic properties.

As the results of the finite elements analyses were going to be validated with previous tests, it was choosen to model the bone as one phase and homogeneous. The properties from polyurethane mandibular substratum were obtained from a compression test at Instron 4411 and the properties from the titanium alloy provided by the manufacturers, with an isotropic Young´s modulus of 624.42 MPa for the mandibular substratum and 116,000 MPa for the titanium alloy, and a Poisson´s ratio of 0.2817 and 0.34, respectively.

A fracture in the right body region of the atrophic mandible was simulated. The two bone fragments were tightly fixed together after the bone was cut, therefore only allowing the displacement in the direction of the chewing force. The mandible was constrained to flextorsional loading from the upper part to the lower part, in the left first molar region until a displacement of 1 mm was reached.

A mechanical statical analysis was done in the software NEi Nastran v.9.2.3 (NEi Software, Westminister, CA). Stress contours were computed and plotted in the bone tissue and in the fixation appliances. The stability of a three-dimensional stress state was evaluated according to the stress hypothesis of Maximum Principal Stress whose stress scale measures the general effective stress in a material. All stress values are given in MPa (N/mm2). A color scale with 16 stress values served to evaluate quantitatively the stress distribution, varying between -3 to 20 MPa for the atrophic mandible fracture and -3 to 500 MPa for the miniplates/screws.

The graphical visualization of the results were exported again to the software FEMAP v.10.1 a quantitative analysis was carried out considering the load performed by the model in the standardized 1 mm displacement.

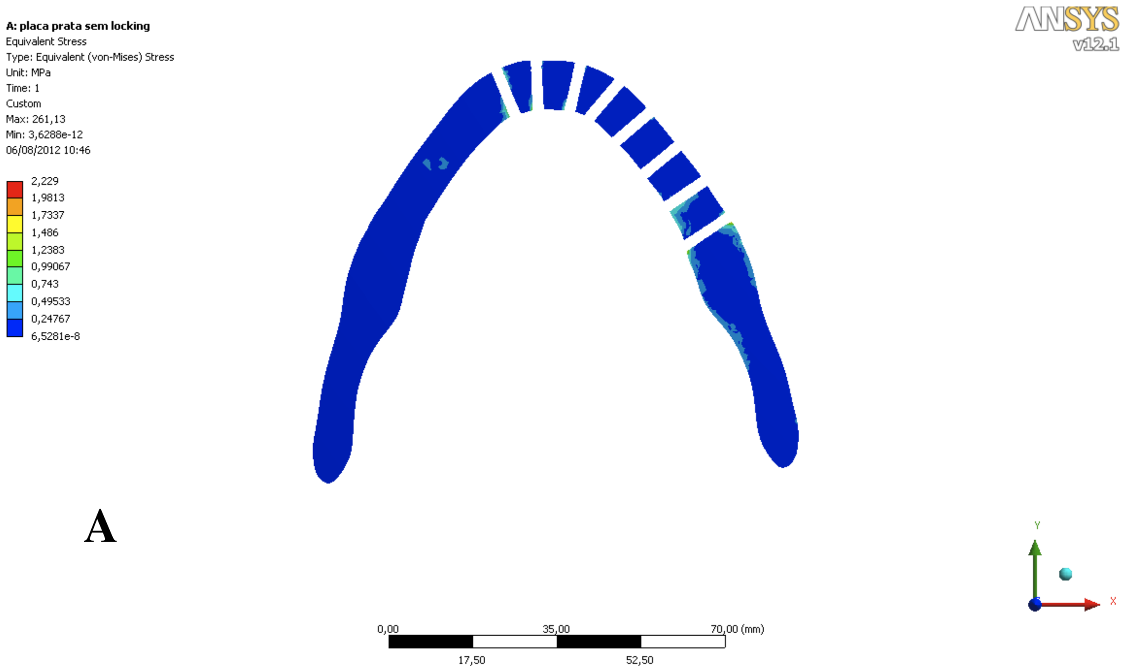
RESULTS

VALIDATION OF THE FEA MODELS

The results obtained by finite element analysis were compared in a qualitative manner with the photoelastic analysis results from Freire S.A.S.R, 2010,[17] with similar stress pattern between group samples, what validates the FEA models.

2.4mm Conventional System

Von Mises stress was observed and measured around the section across the atrophic mandible model when subjected to flextorsional force concentrating stress in the anterior portion and posterior body region of the atrophic mandible model. In this tests a concentration of stress at the interior portion of the atrophic mandible model were observed also, with all those stresses presenting low intensity. In the 2.4mm conventional system we can observe areas of stress in the system fixation, mainly in the plate and around the screws. When the fixation system is analyzed individually we can observe higher stress in the region of screw and plate contact. The forces are very similar in all the eight screws with incidence at the neck region. If taken in consideration the whole set, the distal screws were submitted to a higher stress. (Figures 1A,1B,1C).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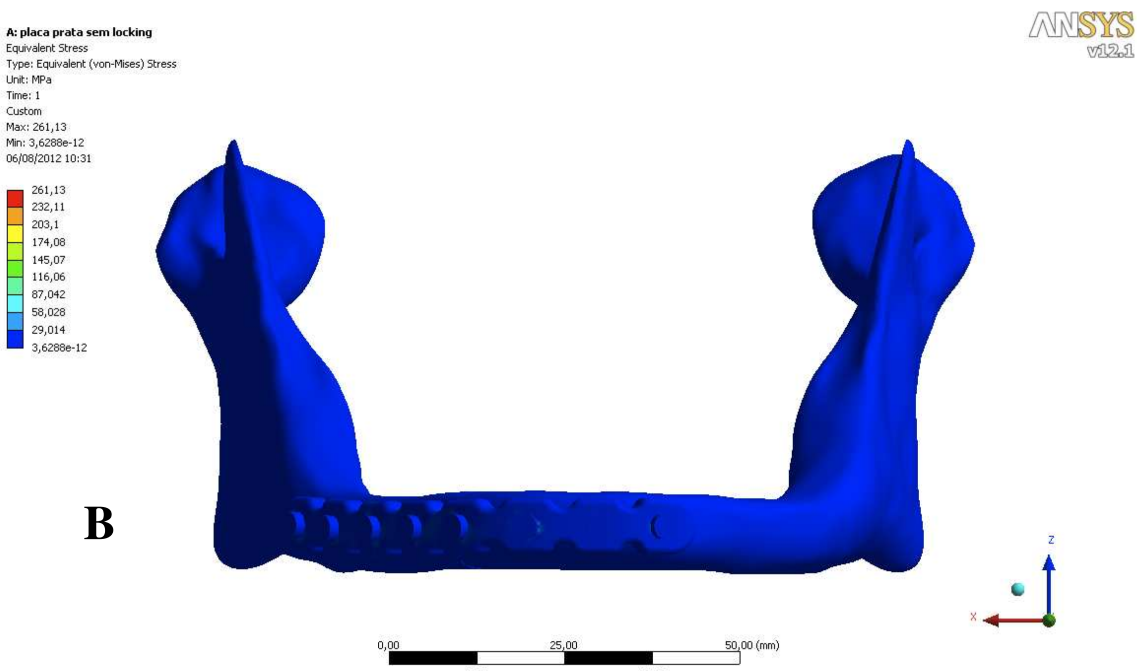
35,00
70,00 (mm)
17,50
52,50

A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37,50

B

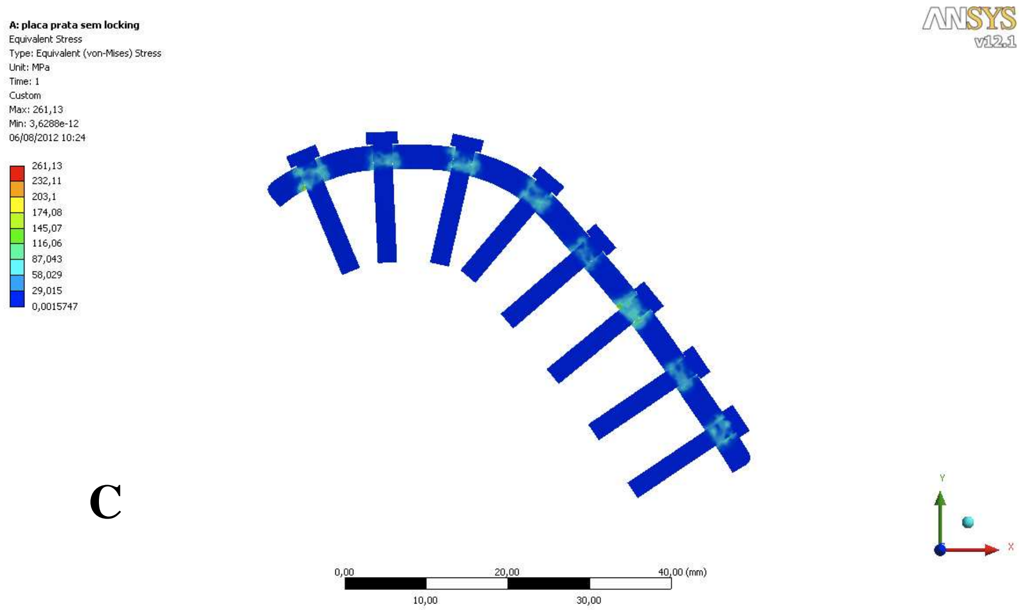
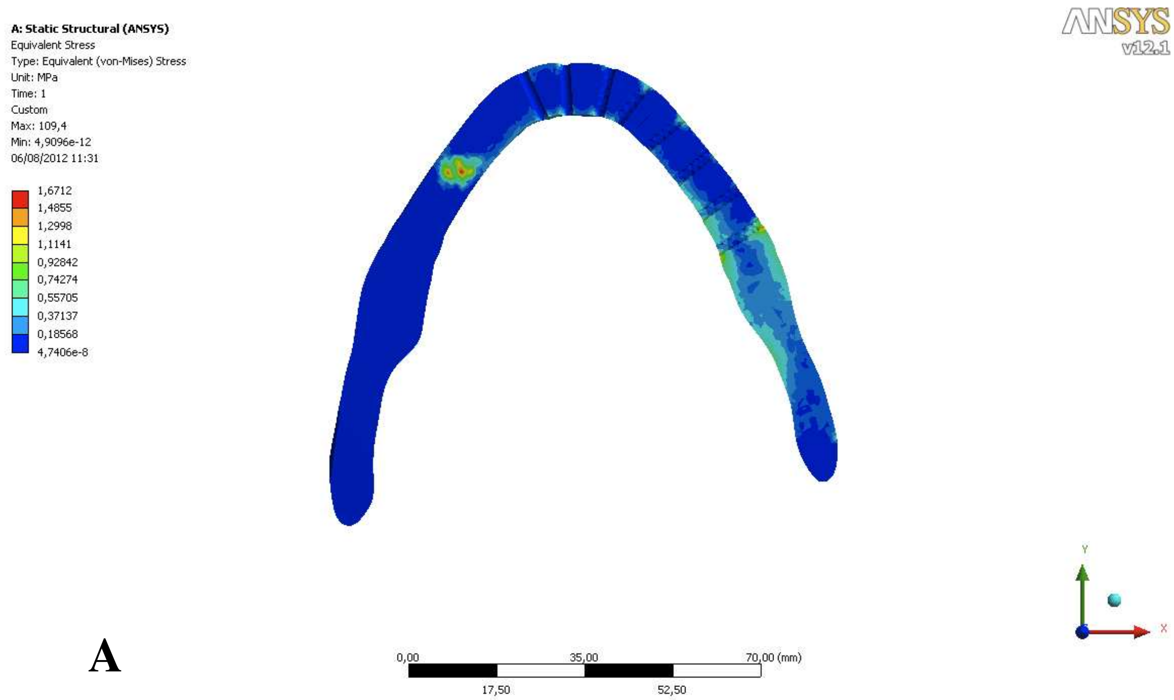


Figure 1 – von Mises stress values of FEA of 2.4mm Convenctional System: a) inferior view of the atrophic mandible model b) frontal view of the atrophic mandible model c) 2.4mm Conventional internal stable fixation system view of the atrophic mandible model.

2.4mm *Locking* System

A highest von Mises stress was observed and measured around the section across the atrophic mandible model when subjected to this flextorsional force concentrating stress in the anterior portion and posterior body region of the atrophic mandible model. In this tests a concentration of stress at the interior portion of the atrophic mandible model were observed also. Areas of stress in the fixation system, mainly in the plate and around the middles screws are noted. When the fixation system is analyzed individually we can observe higher stress in the region of between the middles screws dissipating to apical portion. The stress were similar in all the eight screws but more intense in the middle ones. If taken in consideration the whole set, the head and neck portion of the screws were submitted to a higher stress. (Figures 2A,2B,2C).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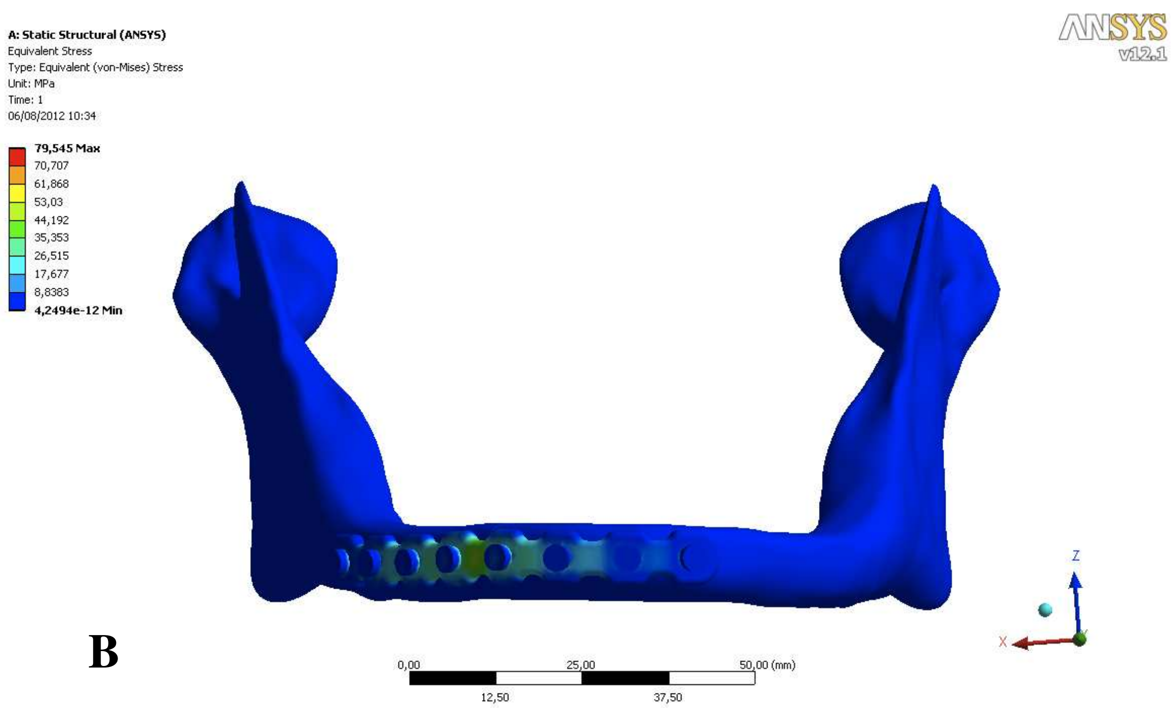
X

A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Z
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B

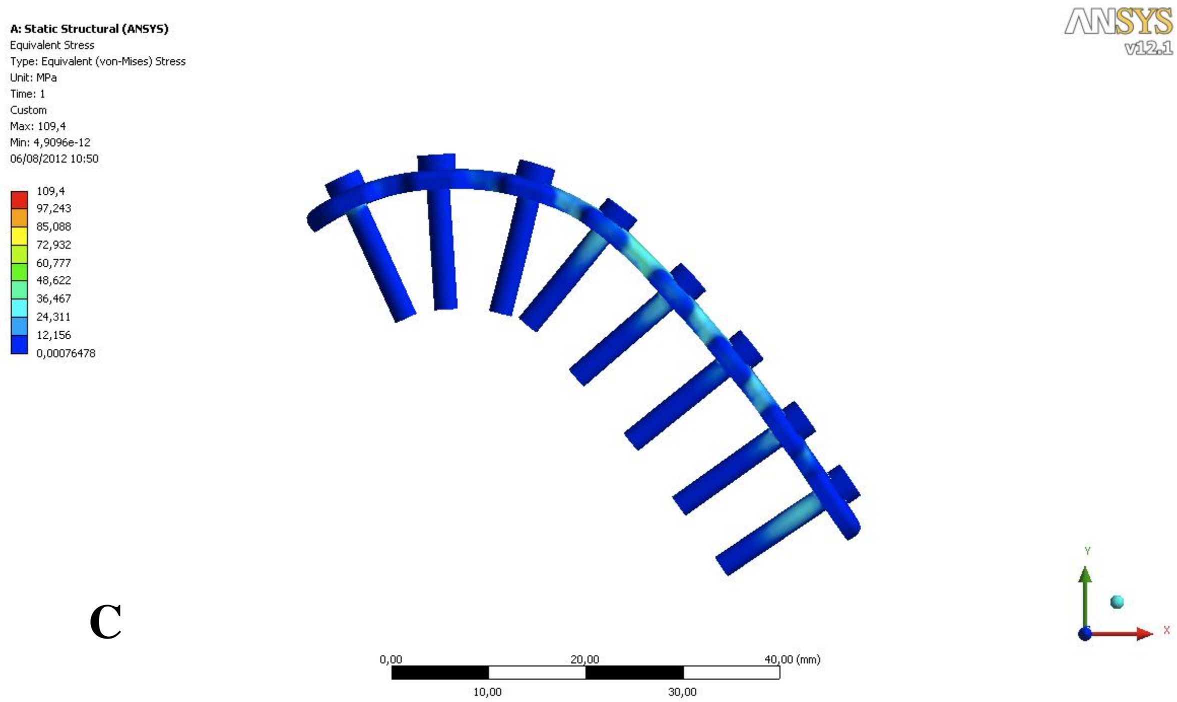
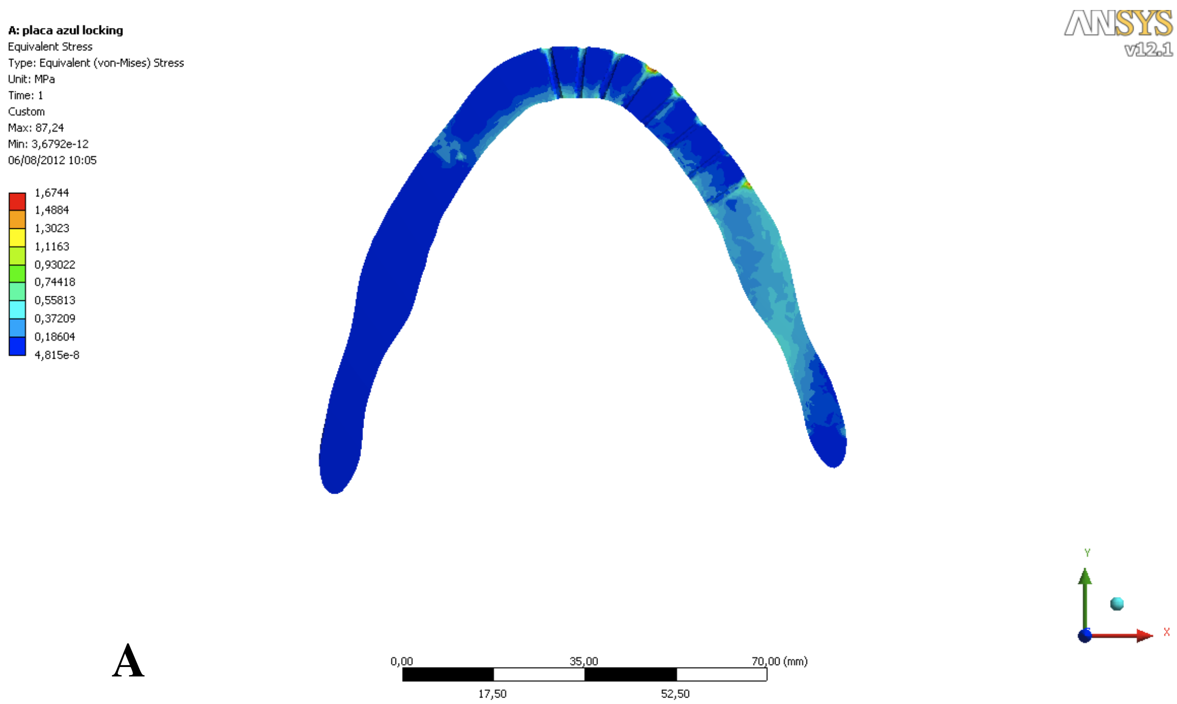


Figure 2 – von Mises stress values of FEA of 2.4mm *Locking* System: 2A) inferior view of the atrophic mandible model 2B) frontal view of the atrophic mandible model 2C) 2.4mm *Locking* internal stable fixation system view of the atrophic mandible model.

2.0mm *Locking* System

A highest von Mises stress was observed and measured around the section across the atrophic mandible model when subjected to this flextorsional force concentrating stress in the anterior portion and posterior body region of the atrophic mandible model. In this tests a concentrations of stress at the interior portion of the atrophic mandible model were observed also. Areas of stress in the fixation system, mainly in the plate and around the middles screws were noted with high intensity. When the fixation system is analyzed individually we could observe higher stress in the region of between the middle screws dissipating to apical portion with more intensity to the ones exactly next to the fracture simulation. The stress occur in all the eight screws but more intensive in the middle ones. If taken in consideration the whole set, the head and neck portion of the screws were submitted to a higher stress, mainly the ones next to the fracture simulation. (Figures 3A,3B,3C).



A

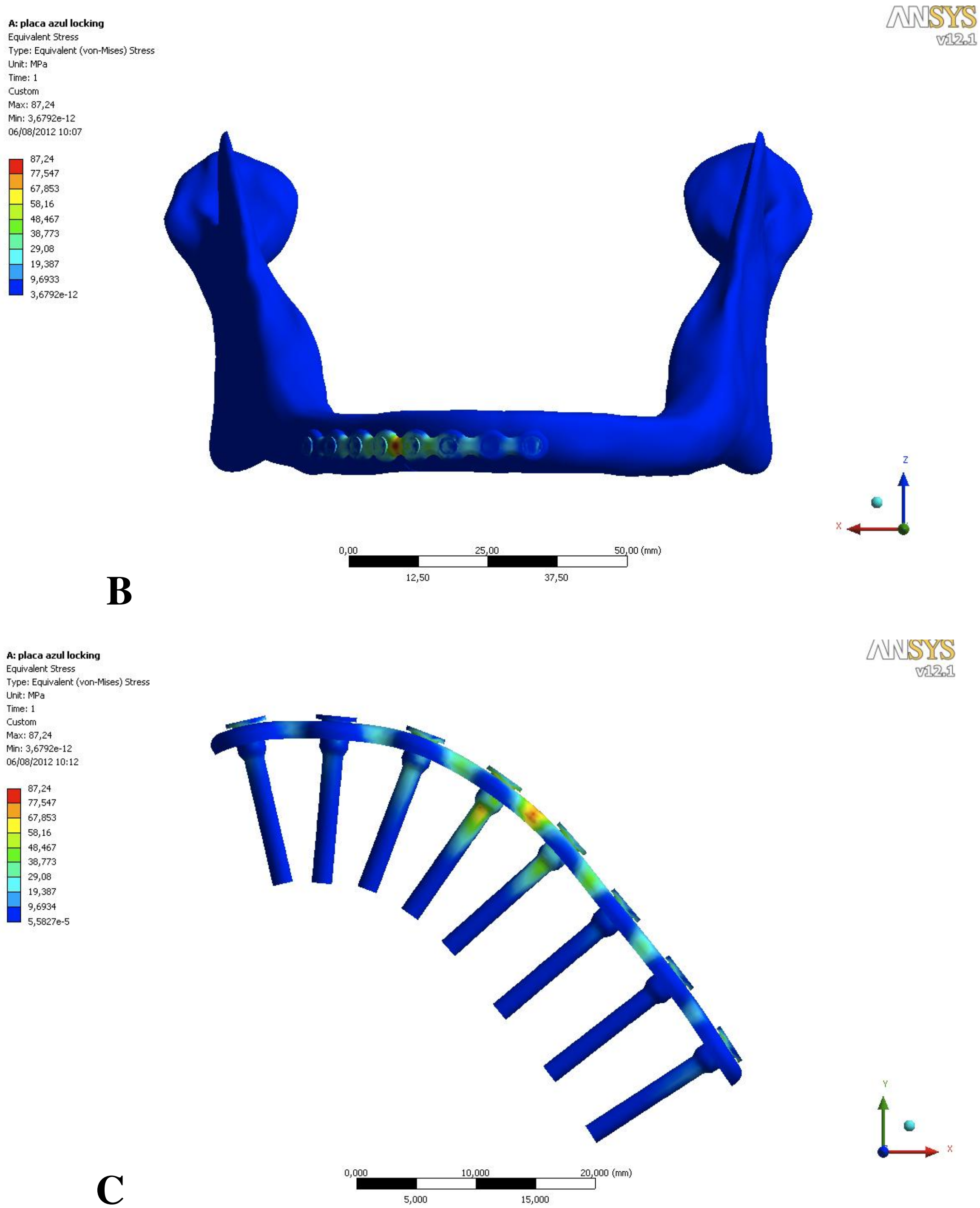


Figure 3 – von Mises stress values of FEA of 2.0mm *Locking* System: 3A) inferior view of the atrophic mandible model 3B) frontal view of the atrophic mandible model 3C) 2.0mm *Locking* internal stable fixation system view of the atrophic mandible model.

DISCUSSION

The fixation method is one of the factors that influences the clinical outcome. Some authors believed that miniplate fixation for atrophic mandible fracture is insufficient and have recommended using a reconstruction plate.[4-6] Although a large reconstruction plate has stronger mechanical strength than small plates, a large reconstruction plate requires wider stripping of the periosteum for placement and decreases periosteal contact with bone after placement.[7] In addition, large bicortical screws may violate the inferior alveolar nerve or be an instrument of further jaw fracture[8]; therefore, other surgeons prefer miniplate osteosynthesis.[9-11]

Only few biomechanical investigations have been reported regarding the fixation of atrophic mandible fracture. Sikes *et al.,*[6] biomechanically tested various fixation methods and recommended the use of a reconstruction plate. On the other hand, carried out biomechanical tests on various miniplate fixation techniques and showed that a double miniplate can achieve sufficient stability to treat fractures of the atrophic mandible[9].

These mechanical tests focused on the strength of the fixation devices; however, other biomechanical factors affecting bone healing have not been well investigated. Biomechanical problems causing failure of fracture treatment include: *1*) miniplate fracture; *2*) screw loosening; and *3*) excessive displacement between bone gap. Miniplate fracture may be related closely to the mechanical strength of the miniplate. Screw loosening is attributed to excessive stress on the bone around the screws.

The thickest plates come in some lengths, including some so long as the 2.4mm reconstruction plates. From now on it was started to use these plates, whose thickness is of 1,5mm, for the treatment of atrophic mandible fractures soon after its introduction[18], and today this is the trend for treatment of atrophic mandible fractures, but still it has distrust in indicating it due the lesser resistance. Still valley the penalty to stand out the average thickness of the plates used in this study was of 2,95mm, in the conventional 2.4mm system; 2mm in the 2.4mm *locking* system;

and 1,5mm in the system 2.0mm *locking* system. What it demonstrates that the *locking* system increased the resistance to loads, therefore exactly the 2.4mm *locking* plate having only 2/3 of the thickness of the plates of the 2.4mm conventional group. This fact also favors the indication for the clinical use of the reconstructive 2.0mm *locking* plates, although presenting only 50.8% of the thickness of the 2.4mm conventional plate system, which is widely accepted for clinical use, it had presented 78.5% of resistance presented for this last system. This is much more resistant of what the conventional 2.0mm *locking* system, and a plate applied in the inferior rim of the buccal cortex with bicortical screws is the sufficient to supply adequate stability for these fractures. At least three screws in each side of the fractures must be used.[17]

The use of 2.0.mm *locking* bone plate in atrophic mandible fractures possess great advantages. The *locking* miniplate presented better maximum principal stress distribution in comparison with conventional miniplates. There was an important stress concentration with high values neighboring the screw near the fracture simulation, however, values were lower than in the conventional miniplate, with higher values in the others screws´ periphery. In relation to the fixation system, the highest stress region was in the gaps of the miniplates between the holes, with stress concentration in the middle area at the fracture simulation getting weaker to its extremities.

The stress in the screws were much high in the ones located next to the fracture simulation, this fact were observed in all stable intern system, but with higher intensity to the thinner plate, this is probably due to smaller plate thickness, which makes it more prone to torsion and occurrence of stress. The smaller thickness of the 2.0-mm *Locking* system, makes its less palpable by the patient and offers less risk of intra oral exposure. This plate also is much easier of being adapted than the 2.4-mm reconstruction plate, and this saves time. The low profile of the plate also diminishes the interference risk during the use of protheses.

Differently of what it was found previously in literature, currently with the advent of the *locking* system and its advantages as told for Sutter & Raveh[19] in its article that a system of reconstruction plate has been developed in which possess expansive heads of screws that, when activated, they stop the screw in the plate. The constraint between the plate and the screw respects the necessities for compression between the plate and the screw, as it occurs in a conventional system of plate and screw. It tells that in a reduction opened in stable internal setting it makes possible stability better and a faster mobilization. A potential advantage of the *locking* system is that little screws can be necessary to reach a maximum load of resistance. Such fact would make possible the use of lesser incisions or settings of lesser bone parts and still would allow functional load.[19]

In such a way the use of *locking* system has a great trend lesser and with same resistance. This happens because clinically this type of this stable internal fixation presents a good performance. This same performance with a lesser rigidity if must to the fact of the masticatory forces in first the six postoperative weeks be reduced, and systems, with exactly of lesser resistance, obtain to exert satisfactory stabilization during the initial phase of the bone repair[20]. Authors as Stoelinga & Borstlap[21] and Throckmorton & Ellis III[22] had demonstrated the limitation of the masticatory forces in the first postoperative weeks had mainly edema involving the region of the masticatory muscles reducing the bite force for less than 300N,when in normal condition it should be 700N, and that the monocortical setting with plates and screws offer to sufficient postoperative stability for the bone repairing. Such fact becomes possible the use of the *locking* system 2.0mm for atrophic mandible fractures treatment.

Clinically it is still very difficult to measure the real impact of these differences of resistance of the setting systems on the bone repair, as well as the mechanics resistance necessary to promote an adequate and previsible bone repair[23-25]. However, also we know that the correct positioning enters the segments can influence the degree of bone contact and the quality of the surface that will be able to receive the material from setting.

Of this form, we can affirm that in clinical conditions where a good bone contact exists, theoretically any one of the studied techniques of setting in this work can be used. Already in the cases where the bone contact is lesser and is necessary an immediate mandibular function, in a patient of the bigger masticatory force, perhaps most recommendable it is the use of more rigid techniques of setting, as they are the cases of the 2.4mm *locking* systems and 2.4mm conventional system with bicortical screws. It's important to stand out that the choice of the atrophic mandible fracture Luhr class III[5] was propositional, therefore represents the clinical situation of bigger challenge, therefore it is less favorable to the repair of the mechanical and biological points of view.

The professionals must have well-taken care of greater in relation to the positioning and stability supplied for the stable internal fixation system in order to prevent possible imperfections in the systems of setting in its clinical use.

CONCLUSIONS

Under the conditions simulated, the conventional system retained most of the flexoflextorsional forces dissipating shorter stress to the mandible portion, the *locking* system presented a better stress distribution among the atrophic mandible increased the resistance by a favorable distribution of the stress forces during the loading test when applied in atrophic mandible fractures. The three internal fixation systems tested in this research showed adequate mechanical efficiency to be applied in atrophic mandible fractures.

REFERENCES

1. Marciani RD: Invasive management of the fractured atrophic edentulous mandible. J Oral Maxillofac Surg 59:792, 2001

2. Bruce RA, Strachan DS: Fractures of the edentulous mandible: The Chalmers J. Lyons Academy study. J Oral Surg 34:973, 1976

3. Buchbinder D: Treatment of fractures of the edentulous mandible, 1943 to 1993: A review of the literature. J Oral Maxillofac Surg 51:1174, 1993

4. Bruce RA, Ellis E: The second Chalmers J. Lyons Academy study of fractures of the edentulous mandible. J Oral Maxillofac Surg 51:904, 1993

5. Luhr HG, Reidick T, Merten HA: Results of treatment of fractures of the atrophic edentulous mandible by compression plating. J Oral Maxillofac Surg 54:250, 1996

6. Sikes JW, Smith BR, Mukherjee DP: An in vitro study of the effect of bony buttressing on fixation strength of a fractured atrophic edentulous mandible model. J Oral Maxillofac Surg 58:56, 2000

7. Tucker MR: An in vitro study of the effect of bony buttressing on fixation strength of a fractured atrophic edentulous mandible model. J Oral Maxillofac Surg 58:62, 2000

8. Iizuka T, Lindqvist C: Sensory disturbances associated with rigid internal fixation of mandibular fractures. J Oral Maxillofac Surg 9:1264, 1991

9. Choi BH, Huh JY, Suh CH, *et al.,*: An in vitro evaluation of miniplate fixation techniques for fractures of the atrophic edentulous mandible. Int J Oral Maxillofac Surg 34:174, 2005

10. Bruce RA, Strachan DS: Fractures of the edentulous mandible: The Chambers J. Lyons Academy study. J Oral Surg 34:393, 1976

11. Marciani RD, Hill O: Treatment of the fractured edentulous mandible. J Oral Surg 37:569, 1979

12. Bruce RA, Ellis E III: The second Chalmers J. Lyons Academy study of fractures of the edentulous mandible. J Oral Maxillofac Surg 51:904-11, 1993

13. Luhr HG, Reidick T, Merten HA: Results of treatment of fractures of the atrophic edentulous mandible by compression plating: A retrospective evaluation of 84 cases. J Oral Maxillofac Surg 54:250, 1996

14. Wittwer G, Adeyemo WL, Turbani D, *et al.,*: Treatment of atrophic mandibular fractures based on the degree of atrophy— Experience with different plating systems: A retrospective study. J Oral Maxillofac Surg 64:230, 2006

15. Tiwana PS, Abraham MS, Kushner GM, *et al.,*: Management of atrophic edentulous mandibular fractures: The case for primary reconstruction with immediate bone grafting. J Oral Maxillofac Surg 67:882, 2009

16. Eyrich GKH, Grantz KW, Sailer HF: Surgical treatment of fractures of the edentulous mandible. J Oral Maxillofac Surg 55: 1081, 1997

17- Freire A.S.R.F. Avaliação mecânica e fotoelástica de sistemas de fixação interna estável utilizados no tratamento de fraturas de mandíbulas atróficas. Estudo *in vitro*, em mandíbulas de poliuretano.[Tese]. Piracicaba:Unicamp/FOP, 2010

18.Ellis E 3rd, Price C: Treatment protocol for fractures of the atrophic mandible. J Oral Maxillofac Surg. Mar;66(3):421-35, 2008

19. Raveh J, Sutter F, Hellem S: Surgical procedures for reconstruction of the lower jaw using the titanium-coated hollow-screw reconstruction plate system: Bridging of defects. Otolaryngol Clin North Am 20:535, 1987 Solve H, Olofson J: Titanium coated

20.Haug RH, Street CC, Goltz M: Does plate adaptation affect stability? A biomechanical comparison of *locking* and non*locking* plates. J Oral Maxillofac Surg.; 60:1319, 2006

21. Stoelinga PJW, Borstlap WA. The fixation of sagittal split osteotomias with miniplates: The versatility of a technique. J Oral Maxillofac Surg; 61(12):1471-6, 2003

22. Throckmorton GS, Buschang PH, Ellis E. Improvement of maximum occlusal forces after orthognatic surgery. J Oral Maxillofac Surg. 54: 1080-1086, 1996

23. Harada K, Watanabe M, Ohkura K, *et al.,*: Measure of bite force and occlusal contact area before and after bilateral sagittal split ramus osteotomy of the mandible using a new pressure-sensitive device: A preliminary report. J Oral Maxillofac Surg 58:370, 2000

24. Van der Braber W, Van der Glas H, Van der Bilt A, Bosman F. Masticatory function in retrognatic patients, before and after mandibular advancement surgery. J Oral Maxillofac Surg; 62 (5): 549-54, 2004

25. Nakata Y, Ueda HM, Kato M, Tabe H. Chances in stomatognatic function induced by orthognatic surgery in patients with mandibular prognatism. J Oral Maxillofac Surg; 65(3):444-51, 2007

DISCUSSÃO

A fratura em mandíbula atrófica ocorre principalmente na população idosa (Bruce,1976; Friedman, 1996). Além da própria atrofia óssea subsequente ao edentulismo, existem vários fatores que podem contribuir para o enfraquecimento da mandíbula nesse grupo etário. Um destes é a redução da vascularização ou o decréscimo do fluxo sanguíneo nos idosos (Scott, 1997; Bradley, 1975).

Esta perda de massa óssea e a diminuição da vascularização reduzem a resistência da mandíbula o que a torna mais predisposta a fraturas durante eventos traumáticos. Tal fato foi observado nos resultados, onde a grande maioria dos pacientes acometidos por fraturas de mandíbulas atrófica eram do gênero masculino no qual a faixa etária de maior incidência foi justamente pacientes com sessenta anos ou mais, vítimas principalmente de queda da própria altura. Tal fato é justificado pela redução da coordenação motora, maior dificuldade de locomoção que resulta em maior ocorrência de fraturas durante a ocorrência em eventos traumáticos.

Uma vez que os pacientes idosos atualmente se encontram mais economicamente ativos, estes também estão mais suscetíveis a fraturas. Nos resultados significativa parte das ocorrências se deram com pacientes que exerciam atividades trabalhistas. A própria fisiologia óssea causa, mediante o passar dos anos e a ocorrência do edentulismo associado ao uso de próteses removíveis, a atrofia dos rebordos alveolares. Nos resultados observamos a maior incidência de fraturas na região de corpo mandibular onde temos uma maior redução tanto de altura quanto de espessura resultando assim em maior fragilidade e consequentemente maior incidência de fraturas de mandíbulas atróficas durante episódios traumáticos.

Um considerável índice de complicações, incluindo infecções, má união, fratura das placas, e a não união, têm incidência muito maior em mandíbulas atróficas edêntulas do que em dentadas (Haug, 1993). Isto é explicado pelas próprias características fisiológicas da estrutura óssea da mandíbula atrófica fraturada, onde temos uma reduzida área de secção na linha de fratura, resultando em insuficiente contato ósseo na mandíbula e a presença de osso denso, esclerótico e pobremente vascularizado. A relativa redução das forças funcionais geradas nos pacientes desdentados podem nos levar a considerar o uso de fixação menos estável, o que possibilitaria a realização de cirurgias menos invasivas nesses pacientes. Infelizmente, as fixações menos estáveis, como as miniplacas, historicamente resultaram em falhas como a união fibrosa, má união, falha dos parafusos, e fraturas de placas (Spiessl, 1989).

A AO/ASIF (Arbeitsgemeinschaft fuer Osteosynthesefragen - Association for the Study of Internal Fixation) Maxillofacial Group (Spiessl,1989; Schilli *et al.,* 1998) têm recomendado a aplicação de placas *load-bearing* (cargas suportada pela placa no local da fratura), uma vez que placas *load sharing* (compartilhamento de carga entre placas e estruturas da terminação óssea fraturada) não seria possível em mandíbulas atróficas. Portanto estaria indicada a utilização de placa de reconstrução óssea, formando um pequeno intervalo na área da fratura e se fixando nas áreas da mandíbula nas quais o osso está mais estável e saudável. Tal fato significa que em fraturas no corpo de mandíbulas atróficas, uma placa de reconstrução óssea é fixada com parafusos localizados no ramo e na sínfise.

Estudos mecânicos mostraram que à medida que a mandíbula se torna mais atrófica, a ancoragem da placa é diminuída significantemente (Choi *et al.,*2005; Sikes *et al*,2000). Isto significa que a fixação aplicada ao osso ao longo da linha de fratura numa mandíbula atrófica deve suportar e não compartilhar cargas. Assim a placa de fixação óssea deveria sustentar toda a carga aplicada na fratura. Um estudo de 40 fraturas em 25 pacientes com mandíbula atrófica tratados desta maneira obtiveram alto índice de sucesso (95%), com somente um caso de não união e um caso de reparo tardio (Schilli *et al.,*1998).

Mugino *et al.,* (2005) relataram que nos últimos 30 anos, têm havido muitos debates a respeito do tamanho e do número de placas ósseas necessárias para tratar com sucesso fraturas em mandíbulas desdentadas. A tendência geral tem sido a diminuição, ou mesmo até a não utilização de placas de reconstrução. A introdução da fixação interna rígida gerou modificações no tratamento das fraturas de mandíbula. Hoje em dia, a maioria das fraturas de mandíbula são tratadas por meio desta técnica, exceções incluem as fraturas cominutivas, e possivelmente fraturas em mandíbulas atróficas.

Em um estudo *in vitro* de Gutwald *et al.,*(1999) demonstraram que o sistema de placas e parafusos com travamento fornece melhor estabilidade em fraturas de mandíbulas simuladas do que placas convencionais quando os parafusos não travam nas placas. Assim, é possível usarmos placas menores em fraturas com sistema com travamento do que é necessário para sistemas convencionais. Outro estudo de Sikes *et al.,* (1998) demonstrou que quando somente dois parafusos pudessem ser usados em cada lado do defeito, parafusos com travamento possibilitaram estabilidade significativamente maior que os sem travamento quando colocados em placas de reconstrução óssea.

Desde a década de 90 indica-se o uso do sistema de placas e parafusos ósseos de reconstrução 2.4mm com travamento para fraturas em mandíbulas atróficas. Em fraturas de mandíbulas atróficas, esta placa funciona bem, aplica o conceito de carga suportada e é o sistema de fixação atualmente recomendado pela AO/ASIF para fraturas em mandíbulas atróficas (Schilli *et al.,* 1998).

Ellis & Price (2008) publicaram a indicação do uso de placas de reconstrução do sistema 2.0mm com travamento para tratamento de fraturas em mandíbulas atróficas. Os resultados mostraram que a fixação ao longo deste período passou por mudanças e que sua principal escolha para tratamento de fraturas em mandíbulas atróficas a partir do ano 2000 foi a utilização do sistema de fixação com placas de reconstrução do sistema 2.0mm com travamento. Estas placas são mais grossas do que as placas 2.0mm anteriores por serem reconstrutivas. O uso da placa óssea de reconstrução 2.0mm com travamento no tratamento de fraturas em mandíbulas atróficas possui grandes vantagens. Primeiramente é um sistema menos espesso que as placas do sistema 2.4mm conventional, sendo assim menos provável ser palpável ou exposta nos tecidos moles, além de mais fácil adaptação e reabilitação protética do paciente.

Nos testes mecânicos realizados neste trabalho observamos uma maior resistência das placas e parafusos *Locking*, mesmo com o defeito de continuidade. Isto devido a estas placas mesmo com menor espessura apresentarem resultados semelhantes ou até mesmo superiores quando comparados a resistência do substrato e as placas convencionais nos testes mecânicos como observamos nos resultados obtidos pelo sistema 2.4mm *Locking*. Temos assim que as vantagens das placas do sistema *Locking* além do aumento da resistência mecânica apresentam como vantagens: melhor estabilidade independente do contato da placa com o osso, tornando a adaptação da placa mais fácil, uma vez que pequenos espaços são permitidos entre a placa e osso onde Haug *et al.,* (2002) demonstraram que a estabilidade da redução da fratura não é reduzida quando placas de reconstrução com travamento estão até 4mm acima da superfície óssea.

Além disso, a não compressão da placa contra o periósteo possibilita melhor revascularização da cortical óssea (Sutter and Raveh, 1988; Söderholm *et al.,*1991). O fato do sistema *Locking* ser menos espesso que as placas do sistema 2.4mm conventional, faz com que esta seja menos provável de ser palpável ou exposta nos tecidos moles. Esta placa também é mais fácil de ser adaptada quando comparada a placa de reconstrução 2.4mm, que é mais grossa, economizando assim tempo cirúrgico. Além do fato da baixa espessura e altura a placa também diminui o risco de interferência durante o uso de próteses favorecendo a reabilitação do paciente tratado por fratura de mandíbula atrófica.

Nas simulações computacionais realizadas observou-se que as placas *Locking* dissiparam tensões para regiões distantes do traço de fratura, região anterior e posterior ao sistema de fixação, o que favorece o reparo ósseo. Além disso o sistema foi capaz de suportar as tensões atuando como um corpo único, ou seja, sem grande concentrações em regiões específicas como observamos a ocorrência na região do colo dos parafusos do sistema conventional, isto devido a uma melhor distribuição das tensões tanto no plano interno quanto no plano externo.

Autores como Stoelinga & Borstlap (2003), Throckmorton & Ellis III (2003), realizaram pesquisas nas quais mostram a redução do esforço mastigatório existente nas seis primeiras semanas do pós-operatório que aliada às recomendações, orientação e motivação do paciente por parte do cirurgião, no qual o paciente deve exercer esforço mastigatório mínimo tendo apenas uma alimentação líquida e pastosa faz com que a resistência mecânica exigida do sistema de fixação seja também reduzido, possibilitando assim o tratamento de fraturas de mandíbulas atróficas por meio de sistemas de fixação interna estável mais delicados como os sistemas 2.4mm e 2.0mm *Locking* quando bem indicados.

CONCLUSÃO

Tendo em vista o aumento da expectativa de vida, maior atividade social, limitações motoras adquiridas com o avançar da idade e a maior incidência de fraturas de mandíbulas atróficas em paciente idosos em eventos traumáticos dos quais a queda da própria altura foi a principal causa, temos que a acessibilidade, a necessidade de acompanhantes além da manutenção das atividades motoras por meio de exercícios e acompanhamento médico devem ser disponibilizados aos pacientes idosos.

Placas do sistema *Locking* apresentaram nos testes aos quais foram submetida no presente trabalho melhor eficiência mecânica. Mesmo com relevante valor de resistência apresentado pelo sistema 2.0mm *Locking*, os sistemas 2.4mm de fixação interna estável apresentaram adequada eficiência mecânica para utilização no tratamento de fraturas de mandíbulas atrófica com defeito de continuidade. Já para os testes de elementos finitos dos sistemas de fixação de fraturas de mandíbulas atróficas sem defeito de continuidade, os três sistemas apresentaram adequada eficiência mecânica.

É extremamente válido ressaltar que a experiência profissional, a colaboração do paciente por meio de orientação e motivação assim como elaboração de adequado plano de tratamento por meio de individualização dos casos são de fundamentais importância para o sucesso de paciente acometidos por fraturas de mandíbulas atróficas.

REFERÊNCIAS

1. Bruce RA, Strachan DS: Fractures of the edentulous mandible:The Chalmers J. Lyons Academy Study. J Oral Surg. 1976; 34:973.

2. Friedman CD, Constantino PD: Facial fractures and bone healing in the geriatric patient. Otolaryngol Clin North Am. 1996; 25:1109.

3. Scott RF: Oral and maxillofacial trauma in the geriatric patient,*in* Fonseca RJ, Walker RV, Betts NJ, *et al.,* (eds): Oral and Maxillofacial Trauma, vol 2. Philadelphia, PA, Saunders, 1997,pp 1045-1072.

4. Bradley JC: A radiological investigation into the age changes of the inferior dental artery. Br J Oral Surg. 1975; 13:82.

5. Haug RH: Effect of screw number on reconstruction plating. Oral Surg Oral Med Oral Path. 1993; 75:664.

6. Spiessl B: Universal plate system, central angle fractures, use of the EDCP and reconstruction plate internal fixation of the mandible, in Spiessel 8: Internal Fixation of the Mandible. New York, NY, Springer-Verlag. 1989; pp 19-35,292-294.

7. Schilli W, Stoll P, Bähr W, *et al.,*: Mandibular fractures, *in* Prein J (ed): Manual of Internal Fixation in the Cranio-Facial Skeleton: Techniques Recommended by the AO/ASIF Maxillofacial Group. New York, Springer. 1998; p 87.

8. Choi BH, Huh JY, Suh CH, *et al.,*: An in vitro evaluation of miniplate fixation techniques for fractures of the atrophic edentulous mandible. Int J Oral Maxillofac Surg. 2005; 34:174.

9. Sikes JW, Smith BR, Mukherjee DP: An in vitro study of the effect of bony buttressing on fixation strength of a fractured atrophic edentulous mandible model. J Oral Maxillofac Surg. 2000; 58:56.

10. Mugino H, Takagi S, Oya R, *et al.,*: Miniplate osteosythesis of fractures of the edentulous mandible. Clin Oral Invest. 2005; 9:266.

11. Gutwald R, Büscher P, Schramm A, *et al.,*: Biomechanical stability of an internal mini- fixation system in maxillofacial osteosynthesis. Med Biol Eng Comp. 1999; 37(Suppl 2):280.

12. Sikes JW, Smith BR, Mukherjee DP, *et al.,*: Comparison of fixation strengths of *locking* head and conventional screws. J Oral Maxillofac Surg. 1998; 56:468.

13. Ellis E 3rd, Price C: Treatment protocol for fractures of the atrophic mandible. J Oral Maxillofac Surg. 2008; Mar;66(3):421-35.

14. Haug RH, Peterson GP, Goltz M: A biomechanical Evaluation of mandibular condyle fracture plating techniques. J Oral Maxillofac Surg. 2002; 60:71-80.

15. Sutter F, Raveh J: Titanium-coated hollow screw and reconstruction plate system for bridging lower jaw defects: Biomechanical aspects. Int J Oral Maxillofac Surg.1988; 17:267.

16. Soderholm A, Lindqvist C, Skutnabb K, *et al.,*: Bridging of mandibular defects with two different reconstruction systems. J Oral Maxillofac Surg.1991; 49:1098.

17. Stoelinga PJW, Borstlap WA. The fixation of sagittal split osteotomias with miniplates: The versatility of a technique. J Oral Maxillofac Surg 2003; 61(12):1471-6.

18. Tate GS, Ellis E, Throckmorton GS: Bite forces in patients treated for mandibular angle fractures: Implications for fixation recommendations. J Oral Maxillofac Surg.1994; 52:734. 104.Thaller SR: Fractures of the edentulous mandible: A retrospective review. J Craniofac Surg.1993; 4:491.

COMITÊ DE ÉTICA EM PESQUISA

FACULDADE DE ODONTOLOGIA DE PIRACICABA
UNIVERSIDADE ESTADUAL DE CAMPINAS

CERTIFICADO

O Comitê de Ética em Pesquisa da FOP-UNICAMP certifica que o projeto de pesquisa **"Estudo epidemiológico retrospectivo da incidência de trauma facial dos pacientes atendidos na área de Cirurgia e Traumatologia Buco-maxilo-faciais da Faculdade de Odontologia de Piracicaba - UNICAMP no período de 1999 a 2009"**, protocolo nº 131/2008, dos pesquisadores Roger William Fernandes Moreira, Jose Luis MuÑante Cardenas, Luciana Asprino, Márcia Socorro da Costa Borba, Marcio de Moraes, Paulo Maria Santos Rabêlo Júnior, Raul Seabra Guimarães Neto, Renato Sawazaki, Sergio Monteiro Lima Junior e Simei Andre da Silva Rodrigues Freire, satisfaz as exigências do Conselho Nacional de Saúde - Ministério da Saúde para as pesquisas em seres humanos e foi aprovado por este comitê em 25/02/2011.

The Ethics Committee in Research of the School of Dentistry of Piracicaba - State University of Campinas, certify that the project **"Retrospective epidemiologic study of facial trauma treated by the Oral and Maxillofacial Surgery department of Piracicaba Dental School - State University of Campinas from 1999 to 2009"**, register number 131/2008, of Roger William Fernandes Moreira, Jose Luis MuÑante Cardenas, Luciana Asprino, Márcia Socorro da Costa Borba, Marcio de Moraes, Paulo Maria Santos Rabêlo Júnior, Raul Seabra Guimarães Neto, Renato Sawazaki, Sergio Monteiro Lima Junior and Simei Andre da Silva Rodrigues Freire, comply with the recommendations of the National Health Council - Ministry of Health of Brazil for research in human subjects and therefore was approved by this committee at 02/25/2011.

Profa. Dra. Lívia Maria Andaló Tenuta
Secretária
CEP/FOP/UNICAMP

Prof. Dr. Jacks Jorge Junior
Coordenador
CEP/FOP/UNICAMP

Nota: O título do protocolo aparece como fornecido pelos pesquisadores, sem qualquer edição.
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