Universidade Estadual de Campinas

Faculdade de Odontologia de Piracicaba

Marcia Diaz Serra

- Cirurgiã Dentista -

"EFEITO DA REABILITAÇÃO PROTÉTICA REMOVÍVEL BUCAL NA ESPESSURA MUSCULAR E FORÇA DE MORDIDA EM CRIANÇAS NA DENTIÇÃO MISTA"

Dissertação apresentada à Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas para como requisito para obtenção do título de Mestre em Odontologia, Área de Odontopediatria.

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Orientadora: Profa. Dra. Maria Beatriz Duarte Gavião

Banca examinadora:
Profa. Dra. Maria Beatriz Duarte Gavião
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Profa. Dra. Marinês Nobre dos Santos Uchôa

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"Bom é render graças ao Senhor e cantar louvores ao teu nome, ó Altíssimo, anunciar de manhã a tua misericórdia e, durante as noites, a tua fidelidade, com instrumentos de dez cordas, com saltério e com a solenidade da harpa. Pois me alegraste, Senhor, com os teus feitos; exultarei nas obras das tuas mãos. Quão grandes, Senhor, são as tuas obras! Os teus pensamentos, que profundos! O inepto não compreende, o estulto não percebe isto: ainda que os ímpios brotam como a erva, e florescem todos os que praticam a iniqüidade, nada obstante, serão destruídos para sempre; tu, porém, Senhor, és o Altíssimo, eternamente. Assim, ao Rei eterno, imortal, invisível, Deus único, honra e glória pelos séculos dos séculos. Amém!"

Salmo 92:1-8; I Tim 1:17

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“Ainda que eu fale as línguas dos homens e dos anjos, se não tiver amor, serei como o bronze que soa ou como o címbalo que retine.
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SUMÁRIO

RESUMO

O objetivo deste estudo foi avaliar a força de mordida e a espessura dos músculos mastigatórios em 25 crianças com perda precoce de dentes decíduos posteriores antes e após reabilitação bucal com prótese parcial removível. Para tanto, o estudo é composto de três capítulos. No capítulo 1, intitulado *Maximum bite force – a review of the literature*, realizou-se a revisão de literatura sobre força de mordida e discorreu-se sobre as variáveis influenciadoras. A revisão mostrou que a força de mordida tem sido amplamente avaliada e associada às variáveis morfológicas e funcionais do sistema mastigatório. No capítulo 2 intitulado *A six-month evaluation of maximum bite force in wearing a removable dental prosthesis* avaliou-se a força de mordida das crianças, e no capítulo 3, intitulado *Masseter and temporalis muscle thickness of children wearing removable dental prosthesis – a six-month evaluation* avaliou-se a espessura dos músculos masseter e porção anterior temporal através da ultra-sonografia. Avaliou-se também as variáveis corporais, representadas por proporções faciais, peso e altura nos capítulos 2 e 3. A força de mordida foi obtida utilizando-se um transmissor constituído de um tubo de fibra reforçada, pressurizado, conectado ao sensor de pressão (MPX 5700 Motorola). A espessura dos músculos foi avaliada nas posições mandibulares de máxima contração e repouso, com o equipamento digital Just Vision 200 (Toshiba Corporation, Japão), com transdutor linear de 56 mm, banda-larga de 10 MHz. As proporções faciais foram determinadas através de mensurações da face em fotografias padronizadas. Na análise dos dados do segundo e terceiro capítulo utilizou-se o teste de Shapiro-Wilk para verificação da normalidade da distribuição dos dados. Os testes *t* pareado e *t* independente, Wilcoxon, Mann-Whitney, Correlação de Pearson ou de Spearman e modelos de regressão ajustados foram aplicados quando indicados, com nível de significância de 5%. Os resultados mostraram que não houve diferenças estatísticas entre os sexos para nenhuma das variáveis ($p>0,05$). Houve aumento significativo de espessura muscular entre contração e repouso; entre força de mordida e espessura do masseter (relaxado e contraído) após 6 meses da instalação do aparelho protético; o músculo temporal relaxado mostrou-se maior antes da instalação do aparelho protético ($p<0,05$), o que não aconteceu para o temporal contraído ($p>0,05$). Não foram encontradas correlações entre proporções faciais e espessura muscular ou força de mordida

($p>0,05$). Considerando as variáveis corporais, houve correlação significativa entre espessura do masseter relaxado e altura corpórea na primeira sessão de exames, e entre espessura do masseter (contraído e relaxado) e todas as variáveis corporais na segunda sessão ($p<0,05$); com relação ao temporal, foi encontrada correlação significativa entre o músculo contraído e altura corpórea na primeira sessão e entre o músculo relaxado e peso corpóreo na segunda sessão de exames ($p<0,05$). Com relação à força de mordida foi encontrada correlação com altura corpórea somente segunda sessão de exames ($p<0,05$). Dentro dos limites deste estudo podemos concluir que a prótese parcial removível influenciou os aspectos morfológicos dos músculos, determinado aumento da espessura muscular, e o aspecto funcional, aumentando a força de mordida.

Palavras-chave: força de mordida, espessura muscular, ultra-sonografia, morfologia facial, masseter, temporal, criança, dentição mista, prótese parcial removível

ABSTRACT

The aim of this study was to evaluate the maximum bite force and the thickness of the masseter and anterior portion of the temporalis muscles in twenty-five children with early loss of primary teeth, before and six months after oral rehabilitation with removable dental prosthesis. Three chapters compose the study. In chapter 1, entitled *Maximum bite force – a review of the literature*, a review of the pertinent literature about maximum bite force was done, and the influencing variables were discussed. The review showed that bite force has been widely evaluated and associated to the morphological and functional variables of the masticatory system. The second chapter, entitled *A six-month evaluation of maximum bite force in wearing a removable dental prosthesis* it was evaluated the bite force of the children; and in chapter 3, entitled *Masseter and temporalis muscle thickness of children wearing removable dental prosthesis – a six-month evaluation* evaluated the thickness of the masseter and anterior portion of the temporalis muscles by means of ultrasonography. Also, it was evaluated the body variables, represented by facial proportions, weight and height in chapters 2 and 3. Bite force was determined with a pressurized transducer, which consisted of a pressurized rubber tube connected to a sensor element (MPX 5700, Motorola SPS, Austin, TX, USA). Muscle thickness was measured during relaxation and maximum clenching, using the Just-vision 200 digital ultrasonography system (Toshiba Corporation, Japan) with a high-resolution real-time 56 mm/10-MHz linear-array transducer. Facial proportions were determined through measurements of the face in standard photographs. For data analysis in the second and third chapters, the normality of the distributions was assessed by the Shapiro-Wilks *W*-test. The *t* paired or unpaired tests, Wilcoxon, Mann-Whitney, Pearson's or Spearman's Correlations and linear regression were applied as indicated, with significance level of 5%. The results showed no statistical differences between genders for any of the variables ($p>0.05$). There was statistical significant increase in muscle thickness from relaxation to clenching; between bite force and masseter muscle thickness both during clenching and relaxation from the first to the second evaluation; the temporalis muscle was thicker in before the placement of the prosthetic device ($p<0.05$), which did not happen for the contracted temporalis. There were not correlations between facial proportions and muscle thickness or bite force ($p>0.05$). Considering the body variables, there was a significant correlation between masseter muscle thickness during relaxation and body height in the first evaluation, and between masseter muscle thickness (both contracted and relaxed) and all the body variables in the second evaluation ($p<0.05$). In relation to the temporalis muscle, it was found a significant correlation between the contracted muscle and height in the first evaluation, and between the relaxed muscle and weight in the second evaluation ($p<0.05$). In relation to the bite force, there was only a correlation with body height in the second evaluation ($p<0.05$). Within the limitations of this study, it can be concluded that the removable dental prosthesis influenced the morphology of the muscles, determining an increase in muscle thickness, and the function, increasing the bite force.

Key words: bite force, muscle thickness, ultrasonography, facial morphology, masseter, temporalis, children, mixed dentition, removable dental prosthesis

I. INTRODUÇÃO GERAL

A Odontopediatria tem como meta proporcionar aos pacientes, além do tratamento odontológico convencional, informações sobre condutas que enfatizem a prevenção de problemas do sistema mastigatório como um todo, possibilitando crescimento e desenvolvimento adequados das estruturas componentes. A manutenção da integridade dos arcos dentários decíduos e mistos, tanto do ponto de vista morfológico quanto funcional, constitui fator de influência no desenvolvimento da dentição permanente, mantendo o comprimento dos arcos dentários, conservando espaço para os dentes sucessores, estabelecendo hábitos bucais saudáveis e proporcionando desenvolvimento adequado da musculatura, da parte esquelética e da articulação temporomandibular (ATM). Os padrões funcionais básicos da oclusão são determinados antes do estabelecimento da dentadura permanente, fazendo com que estes primeiros estágios de desenvolvimento oclusal sejam de extrema importância (Thurow, 1977).

A mastigação proporciona força e estímulo indispensáveis para o desenvolvimento normal da maxila e mandíbula e relaciona-se com a manutenção dos arcos dentários, com a estabilidade da oclusão e com o estímulo funcional sobre o periodonto, músculos e articulações (Molina, 1989). A força de mordida é um dos componentes da função mastigatória e é exercida pelos músculos elevadores da mandíbula e regulada pelos sistemas nervoso, muscular, esquelético e dental (Sheikholeslam, Moller & Lous, 1980; Ow, Carlsson & Jemt, 1989). Conseqüentemente, as condições destes sistemas influenciarão a habilidade mastigatória (Ono *et al.*, 1992) e o padrão de mastigação (Yamashita, Hatch & Rugh, 1999). A força dos músculos mastigatórios determina a quantidade de força disponível para cortar e triturar os alimentos. Várias técnicas têm sido usadas para avaliar clinicamente as características fisiológicas dos músculos da mastigação (Tsai & Sun, 2004) como a mensuração da força de mordida (Kiliaridis *et al.*, 1993; Rentes *et al.,* 2002), quantificando a força total dos músculos elevadores da mandíbula (Kiliaridis *et al.,* 1995; Tortopidis *et al.,* 1998). Acredita-se que quanto maior a força de mordida, melhor é o sistema mastigatório (Ow, Carlsson & Jemt, 1989; Helkimo, Carlsson & Carmeli, 1975; Carlsson, 1973).

Em estudos de forças oclusais, os resultados freqüentemente mostram grande variação. Estrutura facial, força muscular geral e diferenças entre sexos são somente alguns dos fatores que podem influenciar os resultados (Kiliaridis *et al.,* 1995b). Outros como estado da dentição, localização do transdutor dentro do arco dentário, estado mental do sujeito durante o experimento, atitude do investigador e sujeito, maloclusões, sinais e sintomas de disfunção temporomandibular (DTM), assim como a extensão da separação vertical dos arcos, causada pelo transdutor de força, podem influenciar os valores encontrados de força de mordida (Fields *et al.,* 1986, Bakke *et al.,* 1990).

A determinação dos níveis individuais de força de mordida tem sido amplamente utilizada em Odontologia com o objetivo de entender os mecanismos da mastigação (Ahlgren & Öwall, 1970; Carlsson, 1974; Bakke, 1993), para a avalição dos efeitos terapêuticos de aparelhos protéticos (Haraldsson, Karlsson & Carlsson, 1979; Haraldsson, Carlsson, Ingervall, 1979; Lundgren & Laurel, 1984; Lundqvist, Carlsson & Hedegård, 1986) e para fornecer valores de referência para estudos da biomecânica destes aparelhos (Fernandes *et al.*, 2003). A reabilitação bucal, substituindo dentes ausentes, adicionada ao aprimoramento da retenção e estabilidade de próteses, melhora a função bucal e, conseqüentemente, a força de mordida (Muller *et al*., 2001; van Kampen *et al*. 2002; Jacinto-Gonçalves, 2003).

Atualmente a ultra-sonografia permite acesso fácil e reprodutível aos parâmetros da função muscular e sua interação com o sistema crânio-mandibular (Kiliaridis and Kälebo, 1991; Raadsheer *et al.*, 1994; Kubota *et al.,* 1998; Bertram *et al.,* 2003; Emshoff *et al.,* 2002; Bakke *et al.*, 1992). Adiciona informação valiosa aos exames convencionais da função dos músculos da mastigação e da interação dentro do sistema crânio-mandibular (Bakke *et al.,* 1992) e permite estudos longitudinais em larga escala de mudanças da espessura muscular durante o crescimento em relação à mudanças nas propriedades biomecânicas dos músculos mastigatórios (Raadsheer *et al.*, 1994, 1996).

Imagens precisas podem ser obtidas por outras técnicas, mas os fatores de segurança e econômicos da ultra-sonografia a tornam mais vantajosa para a avaliação dos músculos peribucais (Henriksson-Larsen *et al.*, 1992) para propósito de reabilitação (Close *et al.* 1995). Em relação à tomografia computadorizada, a ultra-sonografia tem a vantagem de não permitir efeitos biológicos cumulativos (Raadsheer *et al.* 1994; Baum, 1975; Stweart & Moore, 1984; Emshoff *et al.*, 2003). Quanto à ressonância magnética, esta requer sedação em crianças menores de 10 anos de idade. Desta forma, a ultra-sonografia torna-se um método mais viável para estudos em idades precoces, pois a técnica é indolor e tem sido utilizada em exames pré-natais, o que assegura sua efetividade e inocuidade, além da aparelhagem poder ser facilmente manuseada e transportada, possuindo custo relativamente menor que os outros métodos.

É amplamente aceito que existe interação entre a função dos músculos mastigatórios e o crescimento craniofacial. Em adultos, foram encontradas correlações entre dimensões faciais e a espessura do músculo masseter. A ultra-sonografia é um dos métodos mais utilizados para verificação da espessura dos músculos da mastigação, permitindo visualização estática e dinâmica dos músculos da cabeça e pescoço (Raadsheer *et al.*, 1994; Bertran *et al.*, 2003), permitindo correlacionar os achados à morfologia facial, força de mordida e fatores oclusais (Raadsheer *et al.*, 1996; Bakke *et al.*, 1992).

A manutenção da integridade dos arcos na dentadura decídua, dentição mista e início da dentadura permanente é importante para o desenvolvimento normal da oclusão, favorecendo o desempenho adequado das funções correlatas. A ausência prematura de dentes pode resultar em alterações morfológicas, como diminuição do comprimento do arco e perda de dimensão vertical, portanto levando à maloclusão. Alterações funcionais também podem ocorrer, relativas ao processo mastigatório, deglutição e fonação. Conseqüentemente a manutenção de espaço previne e/ou reduz a severidade de possíveis alterações morfológicas e funcionais. O padrão da perda de espaço depende de muitos fatores incluindo idade, estágio do desenvolvimento, quais dentes foram perdidos, presença de apinhamentos ou espaços e relações oclusais (Durward, 2000).

Existe grande variedade de mantenedores de espaço disponíveis, os quais servirão para um mesmo propósito. A indicação do tipo do aparelho relaciona-se à experiência do cirurgião dentista (Terlaje & Donly, 2001) e depende de fatores relativos ao número de dentes perdidos, rizogênese do dente permanente sucessor, idade e colaboração da criança. Próteses removíveis para crianças com dentes ausentes, devido à perda prematura ou anomalias pode ser uma opção de tratamento viável para preservar o espaço entre os dentes, prevenindo alterações funcionais e estruturais além de promover benefício psicológico (Laird, 1966; Walsh, 1976).

Baseado nos dados encontrados na literatura e devido aos escassos trabalhos que abordam as variáveis que influenciam o processo mastigatório em crianças no início da dentição mista, torna-se de interesse o estudo da influência da reabilitação protética bucal nas características morfológicas e funcionais do sistema mastigatório e, conseqüentemente, no respectivo crescimento e desenvolvimento.

II – PROPOSIÇÃO GERAL

Os objetivos desta pesquisa foram:

1. Revisar a literatura sobre a força de mordida máxima e as mais estudadas correlações.

2. Verificar a influência da reabilitação bucal, por meio de prótese parcial removível temporária atuando como mantenedor de espaço funcional, nos aspectos estruturais e funcionais dos músculos mastigatórios, em crianças na fase da dentição mista, antes e seis meses após o tratamento reabilitador, avaliando:

2.1. A força de mordida;

2.2. A espessura dos músculos masseter e porção anterior do temporal.

III – CAPÍTULOS

Esta tese está baseada na Resolução CCPG/001/98/UNICAMP que regulamenta o formato alternativo para teses de Mestrado e Doutorado e permite a inserção de artigos científicos de autoria ou co-autoria do candidato (Anexo 1). Por se tratarem de pesquisas envolvendo seres humanos os projetos de pesquisas destes trabalhos foram submetidos à apreciação do Comitê de Ética em Pesquisa da Faculdade de Odontologia de Piracicaba, tendo sido aprovados (Anexo 2). Assim sendo, esta tese é composta por três capítulos contendo artigos que serão submetidos à publicação, conforme descrito abaixo:

✓ **Capítulo 1**

"Maximum bite force – a review of the literature." Serra MD, Gambareli FR, Gavião MBD. Este artigo será submetido à publicação no periódico *Journal of Oral Rehabilitation*.

✓ **Capítulo 2**

"A six-month evaluation of maximum bite force in children wearing a removable dental prosthesis" Serra MD, Gambareli FR, Gavião MBD. Este artigo será submetido à publicação no periódico *Acta Odontologica Scandinavica*.

✓ **Capítulo 3**

"Masseter and temporalis muscle thickness of children wearing removable dental prosthesis – a six-month evaluation." Serra MD, Gambareli FR, Gavião MBD. Este artigo será submetido à publicação no periódico *Archives of Oral Biology.*

CAPÍTULO 1

MAXIMUM BITE FORCE – A REVIEW OF THE LITERATURE

Running Title: Maximum Bite Force Review

Key words: bite force, review, occlusal force, maximum bite force, clenching

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Abstract:

One method used to evaluate clinically the physiological characteristics and function of the muscles of mastication is the bite force. Maximum bite force is related to the health of the masticatory system, and it is believed that the stronger the bite force, the better the system. Determination of individual bite force levels have been widely used in dentistry mainly in attempts to understand the mechanics of mastication for the evaluation of the therapeutic effects of prosthetic devices and to provide reference values for studies on the biomechanics of prosthetic devices. It is generally agreed that the bite force level is related to a number of physiological factors such as muscle strength, craniomandibular anatomy and neuromuscular feedback mechanisms. Several authors over the years have reported different factors affecting occlusal force. The objective of this paper is to review the literature about maximum bite force, discuss the reasons for the different results in the literature, and report the most studied correlation factors such as masticatory performance, electromyographic activity, facial morphology, temporomandibular joint dysfunctions, muscle size, age, gender, dental status and body variables. For this purpose, a Medline search was undertaken using the term bite force up until November 2005. It is important to stress that the values or results of maximum bite force vary greatly among studies, and therefore they should be compared within the same study or when using the same apparatus, bearing in mind that the conclusions within the study are the most important findings.

Introduction

The strength of the jaw muscles determines the amount of available force to cut or crush the food and various techniques have been used to clinically evaluate the physiological characteristics of the muscles (1, 2) and the mechanics of mastication (3,4). One method is to measure the bite force (5), which is used to evaluate the condition of the masticatory muscles and it is an attempt to quantify the total force of the jaw closing muscles (6, 7). The measurement of bite force is often necessary to assess jaw-closing muscle function and also to compare muscle activity between subjects in a wide variety of experimental situations (8) such as the evaluation of the therapeutic effects of prosthetic devices (9,10) and to provide reference values for studies on the biomechanics of prosthetic devices (11).

Bite force is one of the components of the chewing function and it is exerted by the jaw elevator muscles and is regulated by the nervous, muscular, skeletal, and dental systems (12). Therefore, the condition of those systems will influence biting ability (13) and chewing pattern (14). It is generally agreed that the bite force level is related to a number of physiological factors such as muscle strength (15, 16), craniomandibular anatomy (17, 18), and neuromuscular feedback mechanisms (19). Maximum bite force is mainly related to the health of the masticatory system, and it is believed that the stronger the bite force, the better the system (3, 20). Individuals who have a stronger body musculature system are thought to have a stronger bite force (21).

Since reduced strength is an important factor in overload and hyperactivity of masticatory muscles and a common feature of patients with craniomandibular disorders (3, 12, 22-25), especially with temporomandibular arthritis (20, 26, 27-29), assessment of bite force is relevant for diagnosis and treatment planning (1, 29).

Maximum voluntary bite force is generally thought to be modulated by sensory input from the dentition and surrounding periodontium (30, 31). It is often thought that these sensory receptors are protective in nature. For instance, when the bite force increases to the level where potential damage to the teeth, periodontium, and bone might be produced, the central nervous system, sensing this potential damage, reduces motor output to the muscles involved in generating the bite force (32).

Factors reported to correlate with occlusal force include age (1, 5, 29, 33), dental status (34, 35), salivary flow (33), temporomandibular joint disorder (TMD) (36) and/or orofacial pain (37), facial morphology (29, 38), fractures of the bones involved in the masticatory apparatus (29, 36, 39-45)**.** Additionally, significant relationships between occlusal force and masticatory performance have been demonstrated (42, 46).

The magnitude of maximum bite force depends on both the size of the jaw muscles and the dimensions of the craniofacial complex (47-50). Bite force magnitude also depends on fiber-type composition (51), sarcomere length (52), and jaw muscle activation level (53).

Additionally, the influence of bite force on the vertical stability of any orthodontic treatment result is important. The new position of the dentition should be compatible with the dynamics of the muscular and occlusal forces in all planes (54). It would therefore be advantageous to be able to forecast vertical bite forces in the patient who is to undergo orthodontic treatment (54). To this end, many investigators have attempted to evaluate maximum bite forces.

The objective of this paper is to review the literature about maximum bite force, discuss the reasons for the different results in the literature, and report the most studied correlation factors such as masticatory performance, electromyographic activity, facial morphology, temporomandibular joint dysfunctions, muscle size, age, gender, dental status and body variables. For this purpose, a Medline search was undertaken using the term bite force up until November 2005.

Reasons for Different Results

In the measurement of bite force, the authors report a great variability of results. In the literature one can find several reasons for such differences: measurement of maximum bite force is dependent on the effort of the subject, which is influenced by motivation, pain, and fear (1, 55, 56); technical imperfections (1, 54, 56); the position of the bite force transducer (1, 6, 54, 57, 58); the inter-molar distance or the thickness of the sensor (1, 6, 22, 29, 54, 57-62); the position of the mandible (57, 58, 63); psychological factors (6, 63); painful decayed teeth, or just the fear of pain, may weaken the bite force because of a regulation reflex system or an even higher cortical control mechanism (15); load per periodontal ligament area (31, 57, 58, 64, 65,) therefore the load should be applied to several teeth to measure maximum bite force (57); anatomical factors (57); facial structure (22, 59-61); general muscle force (22, 59-61); sex (22, 59-61); state of dentition (6, 8, 65); attitude of the investigator and patient (7, 22, 59-61); malocclusions (6); signs and symptoms of temporomandibular dysfunction (22, 59-61); material of the bite force transducer (when the transducer material is made of metal, subjects may be reluctant to bite fully for fear of dental damage, pain, etc) (54); lack of give or flexibility (54); dynamic responsiveness (54); accuracy of transducer (54); the strength of the jaw-closing muscles (8); pain threshold of the subject (8); size of masticatory muscles (65). A relatively large error of the method is therefore to be expected in the measurement of maximum bite force (56).

For maximum force, the mandible should be, laterally and sagitally, almost in the intercuspal position (66). Regarding bite force, eletromyographic (EMG) activity studies suggest that the vertical opening of the jaws is most favorable when the interocclusal space in the canine-molar region is 9-20 mm (67-70). Manns, Miralles & Palazzi (67) and MacKenna & Turker (70) have found that the bite force was strongest between 10 to 20 mm. Fields *et al.* (61) reported that the size of the bite gauge in young age groups might be beyond their optimal vertical jaw separation, which in turn might reduce the bite force.

It is also clear that the bite force varies within region in the oral cavity, being greatest in the first molar area and only about one-third to one-quarter of that when measured between the incisors (3, 8, 11, 39, 41, 42, 57, 71, 72). The more posteriorly that the force transducer is placed within the dental arch the greater the bite force, partly because of the level effect of the mandible and partly, because there is a larger area of tooth root and therefore a larger area of periodontal ligament around posterior teeth. This larger area of support is likely to reduce the inhibitory effect of nociceptive afferent volleys on force output (8). Ingervall and Minder (56) reported the use of splints covering the occlusal surfaces distributing the force over a larger part of the occlusal surface, thus avoiding damage to the enamel or filling material.

Total bilateral bite force with support in the molar region in both sides has been shown to have significantly higher values than unilateral bite force (8, 29, 31, 73). Tortopidis *et al.* (8) considered that the variability of the maximum bite force is very small when measured in the same position on different occasions, wherever that position may be in the dental arch; maximum bite force is relatively consistent. The difference between unilateral and bilateral bite force could be explained by feedback mechanisms from the periodontium and by muscle activity balancing the jaws against one another (29). Widman & Ericksson (66) stated that loading single pairs of antagonistic teeth was hazardous to the teeth.

Some factors have been reported by patients to limit the bite force: lack of muscular strength, pain in TMJ area, pain in muscles, pain in the teeth or their supportive structures (57, 74).

Types of Bite Force Transducers

Measurement of maximum forces on teeth has been carried out using a variety of methods, with great variation in results, depending on the exact measurement conditions (61, 71, 75).

The literature describes the use of different apparatus for measuring bite force: the use of strain gauge bite force dynamometers (15, 21, 76, 77); strain gauges attached to metal beams united into forks (5, 6, 20, 32, 40, 66, 67, 71, 78-81); miniature bite force sensors consisted of strain gauge transducers placed in a steel housing mounted in a handle (1, 29, 56, 63, 75, 82-87); strain gauge diaphragm pressure transducers (88); three-component force transducers capable of registering both the direction and magnitude of bite force (19, 48, 89); bite forks based on a piezo-electric phenomenon (62, 90); strain gauges scales (91); transducers made of cobalt-chromium alloys (92); bite force sensors manufactured in a silicone material with properties similar to those of tough foodstuffs (11); bite force recorders with a quartz force transducer adapted to a unilateral housing of no hardened tool steel (57, 58, 69, 93); cross-arch transducers (33, 65); bite force transducers consisted of a pressurized rubber tube made of a flexible material (2, 94); pressure sensitive sheets (44, 46, 95-101); two metal plates with load cell devices (102); Ushaped bite force transducers (7); stainless steel bite force transducers (8, 103-105); electronic bite-forks (106); digital multimeters (55); intra-oral force transducers (60); and elastic devices which conform to the occlusal surfaces of the teeth (54, 107, 108).

In general terms, most instruments are both accurate and precise enough for common load measuring purposes (22). The majority of these systems are able to record force levels in the range of 50-800 N with an accuracy level of 10 N and 80% precision (4, 67). The construction of the recording apparatus is important in the measurement of the bite force. Extreme caution must be exercised when comparing the results reported by different authors unless the same apparatus is used (20). Comparisons within the same study are more reliable than among different studies.

Results of Bite Force (Levels of Bite Force)

The levels of bite force vary greatly from study to study. It has been reported that a population of Eskimos who were living a primitive life, and thus exerting great functional demands on their stomatognathic system, were able to develop mean maximum bite force values of 1550 N (109, 110), which is the greatest bite force registered by unilateral equipment. A bilateral instrument measured the greatest human bite force thus far, 4346 N, for a man with a clenching habit (43).

Mean values for the maximum bite force in the literature have varied in adults from 109 N (111) in long face individuals to 970 N (79). For the incisal region, smaller values, from 50 N (112) to 383 N (69), have been reported.

There are few reports that study bite force in children. The values range in the average molar maximum bite force from 152 N (18) to 450.98 N (77). The values in the incisor area have been described to be significantly smaller: 99.47 N in boys and 75.14 N in girls (62). In the premolar area the values found were in between the molar and incisor regions, with an average of 207.38 N in boys and 147.05 N (62) in girls.

When malocclusion was taken into consideration, Kiliaridis *et al.* (6) found in Angle Class II children values of bite force ranging from 385 to 610 N in the molar region, whereas the range for incisors was 60-130 N. For Angle Class III, the values concerned were 470 N for molars and 90 N for incisors the one patient. Lindqvist and Ringqvist (77) found a value of 500 N in bruxer children.

As stated before, the values of maximum bite force vary greatly among studies. It must be remembered that the correlations and conclusions found in each study are more important than the numeric values achieved.

Correlation with Masticatory Performance

Correlations between bite force and masticatory performance have been studied. Bite force shows a positive relationship with masticatory performance (42, 46, 81) and dietary selection (46, 113), which is closely related to quality of life (101).

Recently, researchers have noted that the increasing softness of foods is an environmental factor that might exert a strong influence on occlusal force (55). Maeda *et al.* (114) reported that the occlusal force of school age children who mainly ate soft diet was significantly lower than those who ate a more fibrous diet.

Sufficient bite force is essential in order to maintain a healthy food intake. Miura *et al.* (97, 115) reported that the maximum bite force is significantly related to the mastication score determined by a food intake questionnaire.

Therefore, bite force could be used as a clinical indicator of masticatory performance (81), as they can be correlated.

Correlation with EMG

The values of electromyographic activity (EMG) have been also widely studied in relation to the bite force. A linear relationship between EMG activity and bite force has been found in jaw-closing muscles when an isometric contraction is performed (8, 29, 67, 103, 116). However, non-linear relationships have also been observed (82, 92, 117). While EMG activity decreases, as dental occlusion gets further, masticatory force increases; as EMG increases as we approach maximum jaw opening, bite force decreases (67, 118).

An increase of slope steepness toward maximum bite force during continuously increasing strength of contraction could be expected due to enhanced electrical activity caused by fatigue (22, 82, 119).

The indirect estimation of occlusal force can avoid some of the limitations of the force transducers, first of all the discomfort and fear of maximally clenching on the force transducer (11, 29, 54, 103). However, this is in contrast with the findings of Proeschel & Morneburg (106) who reported that the prediction of chewing force from dynamic EMGs and isometric activity/bite-force relations usually resulted in considerable overestimation. These authors imply task dependent relations between muscle activities and muscle forces and thus between muscle activities and bite-forces.

Correlation with Facial Morphology

Bite force and facial dimensions have been widely correlated in the literature. Previous studies, in adult patients, have shown that the occlusal forces (between the incisors or molars) of individuals with normal facial proportions are intermediate between those of long-faced and short-faced types, who exert low and high forces, respectively (5, 6, 16-18, 48, 56, 61, 76, 84, 98, 107, 120-123). The facial morphology of short-faced individuals is characterized by a small anterior face height, anterior inclination of the mandible, and ‘parallelism’ between the jaw bases, whereas a large anterior facial height, an obtuse gonial angle, and a steep mandibular plane (5) characterize long-faced individuals. Compared with adult long-faced individuals, adult normal-faced individuals exert two to three times higher bite force values during swallowing, chewing, and maximum biting (18).

According to van Spronsen (124), the masticatory muscles of long-faced adults are characterized by disuse atrophy because the low muscle strength cannot be explained solely by the small cross-sectional area of the muscles. This muscle atrophy takes place during the development of the long-face morphology.

Ahlgren (116), Proffitt, Fields & Nixon (18), Bakke *et al.* (125) and Tuxen *et al.* (84) could not demonstrate a significant association between bite force and facial morphology among males and females adults, suggesting that the craniofacial morphology may result from the influence of more contributing factors than has been believed (2). In women, more and stronger correlations have been described between craniofacial morphology and maximum bite forces (both incisal and molar) than in men (93).

No differences in bite force were found between long-faced and normal-faced children (5, 122). Proffit & Fields (122) hypothesized that the correlation between masticatory muscle force and facial form develops during adolescence. Braun *et al.* (107), found a relationship between skeletal divergence and maximum molar bite forces in children aged 7–13 years. Ingervall and Thilander (121) found a clear correlation between bite force and craniofacial morphology in boys, while Ingervall and Minder (56) reported significant relationships between the maximum bite force and the mandibular plane angle for girls.

García-Morales *et al.* (105) stated that two factors make it difficult to establish a relationship between morphology and maximum bite force in children. First, young children have more difficulty following instructions and may be less likely to make a maximum effort during biting tasks. Second, many studies use correlations of single morphological measures rather than multivariate factors.

Correlation with TMD

Correlations between bite force with temporomandibular disorders (TMD) or craniomandibular disorders (CMD) have been widely described in the literature. Patients with TMD have generally longer duration of chewing cycles and lower bite force (20, 27, 29, 37, 44, 60, 97, 121, 126-128), and the weakness of masticatory muscles has been considered to be a factor predisposing for CMD (12, 129). Experimental muscle pain has been shown to reduce bite force (37). TMD-related joint problems have also been associated with lower maximum bite force (24, 44, 58, 130).

Children with muscle tenderness of the anterior temporal and the superficial masseter also have been found to have significantly lower bite force than those without tenderness of these muscles, and the bite force has showed a significant negative correlation with the Helkimo Clinical Dysfunction Index (85).

Nevertheless, Waltimo & Könönen (69), Ahlberg *et al.* (58), Hagberg, Agerberg & Hagberg. (25), Lyons & Baxendale (131), and Braun *et al.* (54) did not find any significant association between the subject's symptoms or clinical signs of TMD and maximum bite force both in men and women. Hatch *et al.* (132) found that temporomandibular disorders exert only a small influence on bite force. Hagberg (133) suggested that TMD patients use greater relative masticatory forces than normal subjects do during chewing.

Hansdottir & Bakke (127) found that the lower the pressure pain threshold, the lower the maximum jaw opening and bite force. The presence of long-standing TMJ pain is associated with marked functional impairment, which is probably a result of sensitization mechanisms, reflex adaptation, and long-term hypoactivity of the jaw muscles (127, 134). The difference in occlusal force between subjects with and without TMD might be due to the jaw muscle reflexes of the periodontium and the TMJ in addition to pain tolerance and psychological factors (96). Therefore, the relation between occlusal force and frontal craniofacial morphology in subjects with TMD might be related to the imbalances of the muscle function (85, 96).

An increase in bite force up to normal levels has been reported following successful treatment of TMD (20, 71, 135), this treatment having a positive effect on the masticatory function, because both masticatory efficiency and occlusal force endurance improved after treatment, although these parameters do not seem to be of clinical diagnostic value (136).

Correlation with Muscle Size

The midbelly cross-sectional area and thickness of human masticatory muscles have been shown to relate to the maximum muscle strength (16, 48, 65, 80, 84, 125, 137). It has been show that the thicker the muscles the stronger the bite forces. Masseter muscle thickness was shown to be the major contributing factor of bite force in adults (48, 65). It has been postulated that the decrease in masseter muscle size may be related to a reduction in masticatory forces utilized by individuals as they age (138). Nevertheless, exercises can increase the magnitude of bite force (139). Kiliaridis *et al.* (6) concluded that four weeks training in adults with a hard chewing gum seems to influence the functional capacity of the masticatory muscles and increase their strength, especially in those with the weakest muscles. Ono *et al.* (13) verified that there was 94% average increase in the bite force after 3 months of chewing training in 3–5-year-old children; the highest increase occurred in the first month, showing that the bite force is a factor that can be changed. In this way, considering that the bite force is a component of masticatory process, the training could be important in children who have low bite force, with the aim to improve the masticatory performance and to contribute to facial growth and development.

Correlation with Age

Bite force has been described in the literature to increase during growth (1, 5, 29, 55, 62, 83, 85, 108, 140). Some authors found a correlation between bite force and age only in girls (56, 71, 83, 87).

Humans have the greatest adaptability and strength in young adulthood, suggesting that after maturation of the craniofacial skeleton the highest maximum bite force can be achieved (58), and than it reaches a plateau (62). A decrease of bite force with age has been described (25, 33, 90, 101, 141) and it has been ascribed mainly to age-dependent deterioration of teeth (71) and to the atrophy of the jaw-closing muscles (101). Bakke *et al.,* (83) reported that the bite force decreases after 25 years in women and after 45 years in men.

Correlation with Gender

A difference of bite force level between genders has been reported in adults and adolescents in several studies, showing that men have stronger bites than women (4, 5, 6, 20, 29, 48, 54, 57, 58, 65, 69, 71, 75, 81, 83, 84, 90, 93, 94, 95, 97, 101, 102, 120, 142-145), which can be explained by men's greater muscular potential, even if the size differences of muscles are taken into account (138, 146). In some investigations, no differences between genders was found statistically significant (15, 75, 78, 147). Similar diet and masticatory habits may be an explanation of the fairly similar maximum bite force in adult males and females, as well as in children (21) in spite of differences in general muscle force between these groups (15).

In children, the same correlation with gender was found in only a few studies (56, 62, 63). Other studies did not find any significant differences in the maximum bite force between boys and girls (5, 21, 76, 77, 86, 105, 140).

Kiliaridis *et al.* (5) stated that with regard to general muscle strength, girls are as strong and large as boys until puberty. The increase in muscle mass during puberty, influenced by androgenic steroids, creates the differences between male and female muscle strength (148). Several investigators have shown that the difference between the sexes is first seen at puberty (108, 120). Shiau & Wang (61) found that boys became significantly stronger than girls after the age of 13 years, and Braun *et al.* (108) and Garner & Kotwal (120) found this difference to start being evident at 17-18 years.

It has also been reported that subjects with complete dentures exhibited no gender difference (71, 102, 149).

Correlation with Dental Status

It has been shown a negative correlation between maximum molar bite force and the number of decayed teeth (62, 63), malocclusion (29, 63, 86, 100, 120, 123, 150-152), the presence of dentures, when compared to natural dentition (46, 90, 71, 91, 102, 149, 153), and number of missing teeth posterior to the canine (40, 62, 83, 95, 99, 101, 145). A positive correlation has been shown between maximum bite force and the number of tooth contacts (29, 56, 58, 65, 83, 86, 99), occlusal stability (20, 27, 29, 56, 62, 71, 83, 85, 87, 90, 102), and stage of dental eruption (86, 87).

Some studies in the literature have shown no differences in bite force between normal and malocclusion in children (2, 87, 100, 116, 154). Miyawaki *et al.* (100) found that only in the post-pubertal group there was a lower level of maximum bite force related to open-bite and suggested that a weak occlusal force may be a promoting factor for, rather than the cause of, open bite.

Helkimo *et al.* (71) observed the bite force of a population between the ages of 15 and 65 years, and found that variations in bite force with dental status were obvious, and that those with complete dentition had 4 to 5 times greater bite forces than denture wearers. The bite strength of natural dentition subjects reported in previous articles (147) was 4.5

times greater than that of the denture wearers. Disagreement is noted with Atkinson and Ralph (155), who found no differences in bite strength between denture wearers and young dentate adults.

The reduction of contraction force may be a result of the negative feedback reflex from the periodontal receptors (62). The remaining teeth next to the missing or decay area tend to accept relatively stronger force than in complete dentition when the elevator muscles exert the same biting force (62). The feedback system then regulates the muscle contraction to a weaker level for the remaining teeth in order not to exceed the safety margin of the periodontal tissues (156). It has been reported that denture wearers bite the transducers with less strength because they are fearful of damaging their dentures while biting with a maximum force (91).

Correlation with Body Variables

Several authors have found positive correlations in children between bite force and growth variables such body height, and weight (2, 21, 62, 140). However, other authors didn't find any statistically significant correlations between bite force and height in children (5, 108) or low correlation coefficients between weight and height and maximum bite force in adolescents (94).

In adults, some authors (76, 98) found significant correlations between body height and maximum molar bite force, whereas others did not (15, 54, 57, 58). The masticatory habits of the population may influence the bite force more than body dimensions (15). Maximum bite force must evidently depend on more complex factors than body size, such as the cross-sectional area of masticatory muscles and jaw biomechanics (157).

Conclusions

Bite force is one of the most studied components of the chewing function. It is studied to evaluate the condition of the masticatory muscles and system, since it is believed to be related to the health of the masticatory system. Several authors have studied the various correlations between bite force and other components of the masticatory system, and the most reported correlations found in the literature are with masticatory performance, electromyographic activity, facial morphology, temporomandibular joint dysfunctions, muscle size, age, gender, dental status and body variables. It is important to stress that the values or results of maximum bite force vary greatly among studies, and therefore they should be compared within the same study or when using the same apparatus, bearing in mind that the conclusions within the study are the most important findings.

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CAPÍTULO 2

A six-month evaluation of maximum bite force in children wearing a removable dental prosthesis

Running Title: Bite force in children with dental prosthesis

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Abstract

Objective: The aim of this study was to evaluate the effect of a dental prosthesis on the bite force in children from six to nine years old, of both genders, with early loss of primary molars. **Material and methods**: Bite force was determined with a pressurized rubber tube transducer connected to a sensor element. Body height and weight were measured through an anthropometric scale, and the facial proportions were evaluated on standard photographs, in order to correlate to the bite force, before and six months after the placement of a removable dental prosthesis. When indicated, paired or unpaired *t* tests, Wilcoxon or Mann-Whitney tests, Spearman's or Pearson's coefficients and adjusted different regression models were applied on the data, at $p<0.05$. **Results:** It was not found any statistical significant difference between genders. Bite force magnitude ranged from 160 to 410 N (mean values of 302±61N and 345±43N before and after the rehabilitation, respectively). There was statistical significant increase in bite force, body weight and height after 6 months of the placement of the prosthetic device. Facial proportions and bite force were not correlated. It was only found a correlation between bite force and body height in the second evaluation ($r=0.521$, $p=0.007$) and the adjust determination coefficient was 24.01%. **Conclusion**: The findings of this study suggest that the placement of the removable dental prosthesis increased the bite force, suggesting that the rehabilitation treatment is adequate to replace the missing posterior primary teeth, with possibility to improve the function of the masticatory system.

Key words: Facial Morphology, Mixed Dentition, Occlusal Force, Premature Teeth Loss, Space Maintainer

Introduction

Chewing is a developmental function and its maturation occurs from learning experiences. The bite force is one of the components of the chewing function. The strength of the jaw muscles determines the amount of available force to cut or crush the food and various techniques have been used to clinically evaluate the physiological characteristics of the muscles of mastication [1, 2]. One of them is the determination of individual bite force levels that have been widely used in dentistry, mainly in attempts to understand the mechanics of mastication [3-5], for the evaluation of the therapeutic effects of prosthetic devices [6-9] and to provide reference values for studies on the biomechanics of prosthetic devices [10].

The bite force increases with age from childhood, stays fairly constant from 20 to 40 years of age, and then declines [11]. However, the bite force increases with the chewing necessity [12], but decreases with dentition deterioration, like decayed and missing teeth, which tend to lead to weaker bite forces [13, 14]. Many people lose natural teeth with age, leading to a decline in masticatory function [15, 16, 17], which in turn affects food selection and nutritional well-being [18, 19].

Nowadays, although the prevalence of dental decay appears to be declining, a considerable number of children still suffer from dental decay [19-22]. Broadbent *et al.* [23] observed that if caries occurs in a primary tooth, the successor tooth is more than twice as likely to have a demarcated enamel defect (hypoplasia). In the case of early tooth loss (for reasons other than trauma, e.g., extraction due to caries/abscess), the permanent successor tooth is five times more likely to have a demarcated defect. Sometimes the extraction of teeth is necessary to diminish the probability of injuries to the permanent teeth, especially when there is a periapical lesion involving the crypt of the subjacent tooth. Nevertheless, the premature tooth loss often leads to disturbances of masticatory functions, space loss and alteration in the proper contact of the inclined planes of the teeth [24]. In this way, premature loss of primary teeth is an indication for prosthetic provision in the form of space retainers or partial dentures. Without prompt treatment, different acquired facial-occlusal defects may develop [25].

To our knowledge, there are no reports in the literature that study removable dental prosthesis in children, or its effects on the functional aspects of the stomatognathic system. The hypothesis tested was that six months after wearing a removable dental prosthesis, the children would have a gain in bite force. The aim of this study was to evaluate the effect of a removable dental prosthesis on the bite force of children before and after the oral rehabilitation. Furthermore, the correlations of facial proportions and body variables were verified.

Material and Methods

Subjects

Two hundred and forty nine children who were to start dental treatment in the Department of Pediatric Dentistry, Dental School of Piracicaba (State University of Campinas, Brazil) with ages ranging from 6 to 9 years old were scanned and 25 children, 13 boys and 12 girls, were selected. Written and verbal consent was obtained from each child's parents and the research was approved by the Ethics Committee of the Dental School.

The children were selected after detailed anamneses were obtained with the parents, verifying the absence of systemic disturbance, which could compromise the masticatory system, and absence of parafunctional habits. A standard clinical examination, which included a morphological and functional evaluation of the masticatory system, was performed. The children were in the mixed dentition, and the inclusion criteria were the normality of the oral tissues, presence of upper and lower first permanent molars in Angle's Class I relationship, primary or permanent incisors, and primary canines, without form or structure anomalies and alterations that could compromise their cervico-occlusal and mesio-distal dimensions. The children presented premature loss of one or more primary molars, which could be uni or bilateral, superior or inferior, or indication for extraction, after the conditions of these teeth were assessed by clinical and radiographic examinations, as well as the eruption process and degree of root formation of the permanent teeth, indicating the need of space maintenance. After diagnosis, individual treatment plan was established, including: detailed parental and child education and instructions in relation to feeding behavior and oral hygiene, fluoride therapy, extraction of teeth, restoration of the cavities, pulpar treatment, when indicated. Impressions of the children's upper and lower arches were taken with alginate (Jeltrate®), and the dental casts were mounted in a joint articulator. The removable dental prosthesis were fabricated with auto-polymerized acrylic resin (Vipi Flash®, Vipi) and artificial teeth (Biotone®), which were adapted to the dimensions of the primary teeth (figures 1 and 2), and retained by clasps, made of orthodontic stainless steel wires (0.7 mm), in the permanent first molars. The artificial teeth were set up in maximum intercuspation.

Maximum bite force, facial proportions, body weight and height were determined before and 6 months after the placement of the removable prosthesis. The question why a control group had not been selected might be raised, which could be a limitation of the study. Comparisons among children with different oral conditions, facial patterns and body variables, would have misled the results. The best control group should be composed by children with premature loss of primary teeth, without prosthesis or space maintainers, but if the respective treatment is not carried out, the children can be damaged due to the possibility of developing severe malocclusion and impaired mastication. Besides, an anti-ethical conduct would be adopted. The decision that each child would be his/her own control was, therefore, considered reliable [26].

Bite force measurement

Bite force was determined with a transducer, which consisted of a pressurized rubber tube (diameter of 10 mm) connected to a sensor element (MPX 5700, Motorola SPS, Austin, TX, USA) (figure 3). The tube and the sensor were connected to a converse analogue/ digital electronic circuit, fed by an analogical signal coming from the pressure-sensitive element. The system was connected to the computer and the software for reading the pressure sign was developed in Basic language. This software generates a text file in column form with the pressure data that is easily read by Excel. Three bite force evaluations were conducted in each subject, who bit the tube with maximum force three times successively for 5 s, with a 10-s interval among each bite. The tube was placed between the posterior maxillary and mandibular first molars bilaterally, being elastically deformed during biting, conforming to the occlusal anatomy of the individual maxillary and mandibular teeth, as it was flexible, thereby providing a more uniform force distribution. To obtain the highest bite values possible, the subjects were trained before the test and they were urged to do their very best. They were seated in chairs with their heads in an upright position, keeping the Frankfort plan approximately parallel to the floor (figure 4).

The difference between maximum and minimum pressures for each evaluation was calculated and the mean value of the three, for each subject, was selected. The values from the pressurized tube transferred to Excel were obtained in pounds per square inch (psi) and later they were converted into Newtons (N), taking in account the area of the tube, since force is equal pressure times area.

The average bite force of all the three measurements was in line with the maximum values, indicating good reproducibility of the method. In addition, this method was already tested in our laboratory with good results as stated by Rentes *et al.* [2] and Bonjardim *et al.* [27]. The reliability of the bite force measurements was determined on 10 randomly selected children using the Dahlberg's formula: $ME= \sqrt{\Sigma(m_1- m_2)^2/2n}$ on two repeated measurements (x_1, x_2). The measurement error (MSE) was also calculated considering that $MSE= [(\sqrt{\Sigma d2})/2n)]/[(M1+M2)/2n] \times 100$, being d=the difference between the second and the first recordings; n=the number of double measurements; M1/M2=mean of measurements assessed at the two occasions. The method error was 16.28 N and the measurement error was 6.55%.

Facial proportions

Frontal facial photographs of the subjects were taken in a standardized way so that their facial morphology could be determined, as described by Kiliaridis and Kälebo [28]. The subjects were standing at a distance of 1.05 m from the camera, which was adjusted to the same level as the subject's eyes. The subjects were standing, under natural light against a light background and in a relaxed position. The head was positioned so that the saggital and the Frankfort plan would remain, respectively, perpendicular and parallel to the ground. The mandibular position was in maximum clenching with the lips in the resting position.

Three images were obtained from each subject, transferred to the computer, and the best one was chosen for the measurements. The measurements were done directly on the computer screen, using the analyzing imaging software (ImageLab, Softium Informática Ltda - ME). Through reference points in the picture, the system was calibrated to transform the dimensions of the digitized image (pixel) into real dimensions (mm).

The anterior facial height (FH), the bizygomatic facial width (FWz), and the intergonial width (FWa) were measured on the photographs (figure 5). These measurements were used to calculate the proportions of the face (FH/FWz and FH/FWa). The proportions are more reliable, since they permit the elimination of the enlargement of the images [28]. The reliability of the facial proportions measurements was assessed by re-measuring two randomly selected photographs. The ME and MSE was 0.027 mm and 0.0% for FH/FWz ratio, respectively; for the FH/FWa the correspondent values were and 0.034 mm and 0.0%.

Body Variables

Weight and height were determined through an anthropological commercial scale. The body mass index (BMI= Weight/Height^2) was determined for each subject.

Statistical Analysis

The normality of the distributions was assessed by the Shapiro-Wilk's *W*-test. The comparisons between genders were performed through unpaired *t* test or Mann-Whitney tests, and the comparisons between evaluations of the bite force, body variables and facial proportions through paird *t* test or Wilcoxon. The correlations among the variables were assessed by Spearman's or Pearson's coefficients and adjusted different regression models to the data were applied in each correlation significant at the $p < 0.05$ level. All analyses were carried out using SPSS1 9.0 (1998; SPSS, Chicago, IL, USA).

Results

There was no statistical significant difference (p>0.05) among the variables for boys and girls (Table I). Therefore, the data were pooled. The descriptive statistics for bite force, facial proportions and body variables at the two examinations are demonstrated in Table I.

There was a statistical significant difference in the maximum bite force between the two examinations ($p<0.0001$) (Figure 6).

Body height showed significant correlation with bite force at the second evaluation (Table III), whereas no correlation was observed with body weight and body mass index, in both evaluations (Tables II and III) ($p>0.05$). Linear regression showed that the adjust determination coefficient was 24.01% (p value of $f = 0.0075$).

Bite force was not correlated with FH/FWz and FH/FWa ratios in the evaluation before, or six month after the placement of the prosthesis (Tables II and III).

Discussion

Primary teeth play a critical role in the growth and development of a child. In addition to their role in esthetics, eating, speech, and to encourage normal function and resultant expected growth, the other main function of a primary tooth is to hold space for the permanent successor until it is ready to erupt [29]. When a child presents with premature loss of teeth, it is important to determine the level of cooperation expected from both the child and the parents, in order to decide the dental prosthetic treatment. For this study the selected children were able and collaborated in wearing the removable prosthesis, which was chosen due to its advantages [30] related to the ease with which it is cleaned, adjusted, and maintained, the minimal damage that is caused to adjacent teeth and its low cost. Furthermore, functional stimulus on the alveolar ridges by the acrylic part serves to develop the alveolar bone, the alveolar process and the succedaneous teeth [31, 32]. However, there are some disadvantages as the tendency for the prosthesis to accumulate plaque and the need for constant attention and periodic revisions, which require excellent child and parent cooperation. Thus, in this study the children were in constant follow up, therefore the plaque control was stimulated periodically.

In this study, there was no statistically significant difference between male and female subjects ($p>0.05$), which is in accordance with the findings of previous investigations [2, 11, 14, 33-39], which was attributed to the age of the children. Kiliaridis *et al.* [35] have stated that with regard to general muscle strength, girls are as strong and large as boys until puberty. The increase in muscle mass during puberty, influenced by androgenic steroids, creates the differences between male and female muscle strength [40, 41]. The difference between boys and girls has been reported to start to be evident after the age of 9 years [42], 13 years [14], 17 years [34], 18 years [41]. Garner & Kotwal [34] found that the average bite force values for females 11-16 years old were equal to or even higher than those for males, which is in accordance to this study, that found an equal bite force for girls (Table I).

The bite force magnitude ranged from 160 to 410 N (mean values in Table I), which is in accordance with previous investigations that found similar values [2, 14]. Other investigators found lower values [43], or higher values [44, 45]. However, the values of maximum bite force vary greatly among studies, due to several factors like location of bite force transducer, material, size, lack of "give" or flexibility, dynamic responsiveness and accuracy of transducer and sensitivity of the teeth, muscles and temporomandibular joints [46]. These factors add to the normal biological intra-individual variation and to technical imperfections. Nevertheless, it must be considered that the correlations and conclusions found in each study are more important than the values achieved.

The results showed a significant increase in bite force from the first evaluation, before the placement of the prosthesis, to the second evaluation (6 months after the placement of the prosthesis) ($p<0.01$). This increase may be due to the stability of occlusion and increase in number of tooth contacts seen given by the artificial teeth. The number of antagonistic tooth contacts has been found to be a great factor of influence on bite force [13, 44, 47, 48], which increases when more chewing is required [12]. Tooth contacts allow greater force distributions among teeth, thus reducing localized pain perception and permitting harder biting; good occlusal stability results in strong muscles permitting harder biting [47].

The subjects in this study had absence of teeth prior to the treatment, which were replaced by the artificial teeth adapted on the removable prosthesis. Therefore, they could chew better, improving the muscle function and consequently increasing the bite force. In this way, considering that the bite force is a component of masticatory process, the training could be important in children who have low bite force, with the aim to improve the masticatory performance and to contribute to facial growth and development [2]. It seems that an increase in muscle function (as in exercise) provokes an increase in bite force. Ono *et al.* [49] verified that there was 94% average increase in the bite force after 3 months of chewing training in 3–5-year-old children, showing that the bite force is a factor that can be changed. Kiliaridis *et al.* [50] obtained the same results after training an age group varying from 20 to 31 years old during 4 months.

It is widely accepted that there is an interaction between maximum bite force, jaw muscle size and craniofacial morphology [33, 51, 50]. Several authors have found a correlation between bite force and facial morphology, stating that individuals with longer faces have lower bite forces [33, 39, 52-56]. Sonnesen & Bakke [44] found in boys, but not in girls, a clear correlation between bite force and craniofacial morphology. Ingervall & Minder [47] reported significant relationships between the maximum bite force and the mandibular plane angle for girls but not for boys, while Kiliaridis *et al.* [35] showed only weak relationships between craniofacial morphology and the maximum incisal bite force, and no correlation with the maximum molar bite force, in children 7–13 years of age.

However, in this study it was not found a significant correlation between facial morphology and bite force, corroborating with others studies [3, 35, 43, 50, 57, 58]. These findings could be due to the fact that the subjects had similar facial morphological proportions. The children's age could be also an explanation, as it has been hypothesized that the correlation between masticatory muscle force and facial form develops during adolescence [59].

The correlation coefficients between bite force and weight or body mass index in this study were not significant, which is in agreement with others [27, 35, 41]. It was verified a correlation between body height and maximum bite force in the second evaluation, which could suggest that the subjects grew at the same time as they gained bite strength. The adjust coefficient determination showed that the height in the second evaluation explained only 24.01% on the bite force variability, agreeing with Linderholm & Wennström [60], Weijs & Hillen [61], and Waltimo & Könönen [62], who considered that bite force evidently depends on more complex factors than body size, such as the cross-sectional area of masticatory muscles and jaw biomechanics. Thus, the significant increase in height and weight from the first to the second evaluation (Table I) suggests that the prostheses could have allowed the children to feed better, maybe choosing from a wider selection of foods, since they were able to chew better. Nevertheless, it must be taken into consideration that children are in constant growth and development, which could be a factor of influence. The height and weight before and after 6 months remained in the same percentile of the respective growth curves for almost all children, showing that they grew up into the normality. Therefore, the growth and the development could have influenced the increase of muscle strength, but partially, as the respective variability was weakly explained by height. On the other hand, the association between the placement of the prosthesis in children and the enhancement in masticatory performance related to the increase in bite force, as well as the dietary changes after the insertion of the prosthesis must be further studied.

The findings of this study corroborate the ones of Kotsiomiti *et al.* [63] and Dominguez & Aznar [64], considering that by replacing missing teeth, several oral functions could be maintained or re-established.

Conclusion

The findings of this study suggest that the placement of the removable dental prosthesis increased the bite force, suggesting that the rehabilitation treatment is adequate to replace the missing posterior primary teeth, with the possibility to improve the function of the masticatory system.

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Figure 1

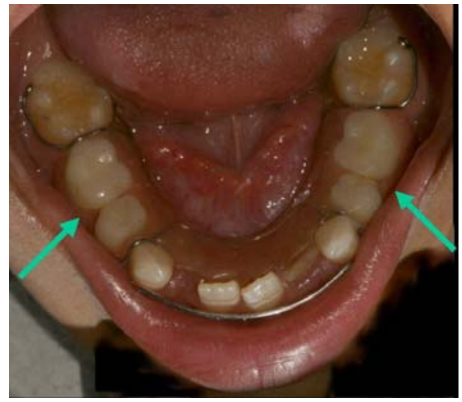


Figure 2

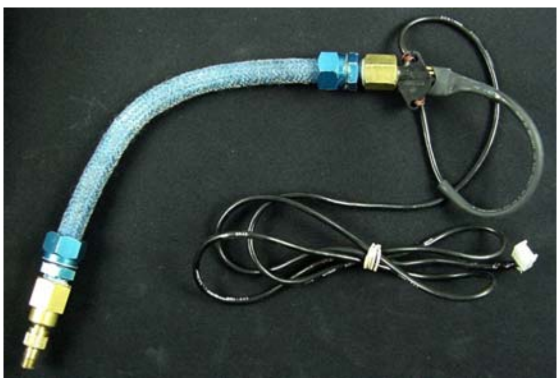


Figure 3

Figure 4

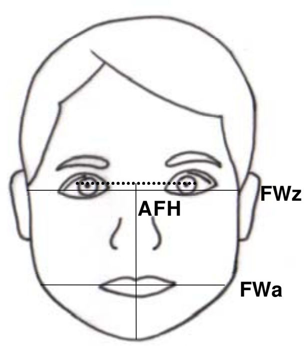
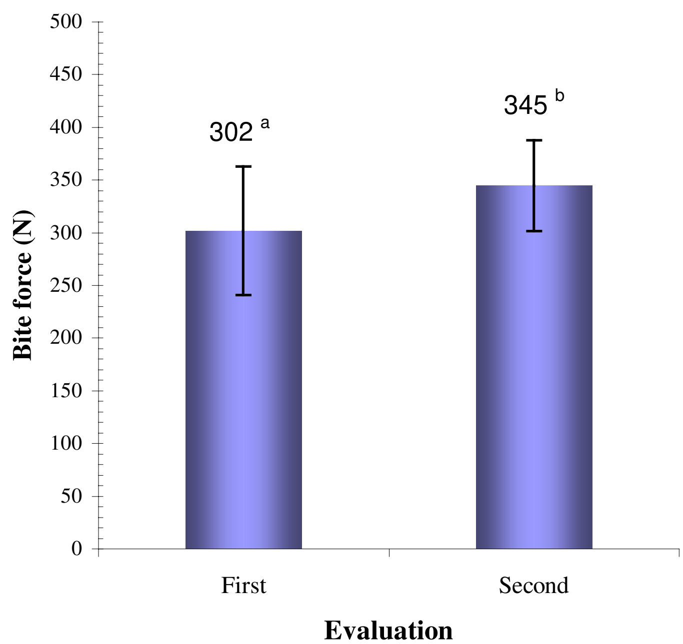


Figure 5



500
450
400
350
300
250
200
150
100
50
0
Bite force (N)
302 a
345 b
First
Second
Evaluation

Figure 6

Legends to the figures:

Figure 1: subject without the prosthesis

Figure 2: subject with the prosthesis in place. The arrows show the artificial teeth

Figure 3: Bite force pressure tube

Figure 4: Subject biting the pressure tube

Figure 5: Facial Morphology – AFH anterior facial height, FWz bizygomatic facial width, and FWa intergonial width.

Figure 6: Mean value of bite force in Newtons (N) in the first and second evaluations. Different letters means statistical difference.

Table I. Mean values and standard deviation (±SD) for bite force (N), weight (Kg), height (m), body mass index (kg/cm^2), and facial proportions (mm)

	1st Evaluation			2nd Evaluation		
	Girls	Boys	Mean	Girls	Boys	Mean
BF	309 ^{a} ±66	295 ^{a} ±58	302 ^{A} ±61	359 ^{b} ±37	331 ^{b} ±55	345^B ±43
Weight	22.81 ^{a} ±3.68	26.24 ^{a} ±6.93	24.59 ^{A} ±5.77	24.44 ^{b} ±4.27	27.89 ^{b} ±8.071	26.24 ^{B} ±6.63
Height	1.22 ^{a} ±0.06	1.25 ^{a} ±0.06	1.23 ^{A} ±0.06	1.26 ^{b} ±0.07	1.27 ^{b} ±0.06	1.27^B ±0.06
BMI	15.17 ^{a} ±1.46	16.71 ^{a} ±2.98	15.97 ^{A} ±2.45	15.41 ^{a} ±1.52	16.95 ^{a} ±3.51	16.21 ^{A} ±2.80
FH/FWa	0.659 ^{a} ±0.02	0.659 ^{a} ±0.03	0.659^A ±0.03	0.656 ^{a} ±0.02	0.653 ^{a} ±0.03	0.654 ^{A} ±0.03
FH/FWz	0.777 ^{a} ±0.04	0.794 ^{a} ±0.38	0.786 ^{A} ±0.04	0.775 ^{a} ±0.04	0.802 ^{a} ±0.04	0.789 ^{A} ±0.04

Similar small letters in the same line mean no statistical difference ($p>0.05$) between genders

Different capital letters in the same line mean statistical difference ($p<0.05$) between evaluations

Table II. Matrix of correlation for bite force, facial proportions and body weight, height, and body mass index (BMI) – first evaluation

	1.	2.	3.	4.	5.	6.
1. Bite force	-	*0.3363*	*0.5549*	*0.8953*	*0.3697*	*0.1953*
2. FH/FWz	-0.201	-	*0.0000*	*0.1985*	*0.5885*	*0.5087*
3. FH/Fwa	-0.124	0.730**	-	*0.9985*	*0.6951*	*0.5904*
4. Weight	-0.028	-0.266	0.000	-	*0.0000*	*0.0000*
5. Height	0.187	-0.114	0.083	0.894**	-	*0.0014*
6. BMI	-0.268	-0.139	-0.113	0.870**	0.602**	-

*p<0.05; **p<0.01; p values in italics

Table III. Matrix of correlation for bite force, facial proportions and body weight, height, and body mass index (BMI) – second evaluation

	1.	2.	3.	4.	5.	6.
1. Bite force	-	*0.3178*	*0.1157*	*0.0827*	*0.0075*	*0.6655*
2. FH/FWz	-0.208	-	*0.0000*	*0.1983*	*0.8050*	*0.0030*
3. FH/Fwa	-0.323	0.727**	-	*0.8010*	*0.5460*	*0.3922*
4. Weight	0.354	-0.266	0.053	-	*0.0000*	*0.0000*
5. Height	0.521**	-0.052	0.127	0.872**	-	*0.0078*
6. BMI	0.091	-0.569**	-0.179	0.835**	0.519**	-

*p<0.05; **p<0.01; p values in italics

CAPÍTULO 3

Masseter and temporalis muscle thickness of children wearing removable dental prosthesis – a six-month evaluation

Running Title: Muscle thickness and dental prosthesis

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Abstract

(1) Objective: to evaluate the effect of a dental prosthesis in the masseter and anterior portion of the temporalis muscles thickness of children 6 to 9 years old, with early loss of primary molars. **(2) Design:** Muscle thickness of twenty-five subjects was measured during relaxation and maximum clenching, using the Just-vision 200 digital ultrasonography system. Besides that, the subjects' body height and weight were measured through a scale, and the facial morphology was evaluated on standard photographs, in order to correlate to the muscle thickness, before and after six months of the placement of a removable dental prosthesis. When indicated, paired or unpaired *t* tests, Wilcoxon or Mann-Whitney tests, Spearman's or Pearson's coefficients were applied to the data. **(3) Results:** It was not found any statistical significant difference between genders in any of the variables ($p>0.05$), so the data were pooled. The contracted muscles were thicker than the relaxed ones, with statistical significant difference ($p<0.05$). The masseter muscle thickness, body weight and height were significantly larger and correlated at the second evaluation. It was not found any correlations between facial morphology and the muscle thickness ($p>0.05$). **(4) Conclusion:** the findings of this study suggest that a removable dental prosthesis improved the function of the masticatory system, increasing the size of the masseter muscle.

Key words: Children, dental prosthesis, masseter muscle, muscle thickness, temporalis muscle, ultrasonography

Introduction

Ultrasonography (US) has been found to be an accurate and reliable method, with a low error in measurement of the thickness of the masseter muscle *in vivo*.[1-7] It adds valuable information to the conventional examinations of jaw muscle functions and the interaction within the craniomandibular system.[6] This technique allows for large-scale longitudinal study of changes in jaw-muscle thickness during growth, in relation to change in biomechanical properties of masticatory muscles.[2,8]

For clinical examinations, US has several advantages over magnetic resonance imaging (MRI) and computerized tomography because it is a rapid, inexpensive technique, the equipment can be easily handled and transported, and in contrast to computerized tomography, it has no known cumulative biological effect.[2,9-11] Therefore, safety and financial factors render ultrasound the most appropriate technique for assessing large superficial muscle groups[12] for rehabilitation purposes.[13] US is also advantageous compared to MRI because the latter would require sedation in children less than 10 years of age.

Significant correlations have been found between facial proportions and the ultrasonographic thickness of the masseter in adults. The relationship between masticatory muscle thickness and anterior face height seems to be negative, i.e. individuals with thinner masticatory muscles have longer faces. Such an association has been found for the masseter,[1,6,8,14-16] and the anterior portion of the temporalis and medial pterygoid muscles.[14]

Broadbent *et al.*[17] found in their study about prediction of enamel defects in permanent dentition, that if caries occurs in a primary tooth, the successor tooth is more than twice as likely to have a demarcated enamel defect. In the case of early tooth loss (for reasons other than trauma, e.g., extraction due to caries/abscess), the permanent successor tooth is five times more likely to have a demarcated defect. Sometimes the extraction of teeth is necessary to diminish the probability of injuries to the permanent teeth, especially when there is a periapical lesion involving the crypt of the subjacent tooth. Removable dental prostheses for children with missing teeth can be a viable treatment option for preserving the space, for providing psychological benefit to the child, and for avoiding the phonetic alterations that premature tooth loss could cause.[18,19]

There are a number of space maintenance appliances available and an array of types that will serve the same purpose. The appliance utilized is a decision that practioner makes due to experience and familiarity with certain appliances.[20] It was stated by McDonald and Avery[21] that if space closure is going to occur, it will usually take place within six months after the loss of the tooth. If space maintenance is required, it is important, therefore, that the appliance be placed as soon as possible, following the extraction of a tooth.[20]

To our knowledge, there are no reports in the literature that study removable dental prosthesis in children, or its effects on the morphological aspects of the stomatognathic system. The aim of this study was to assess the thickness of the masseter and anterior portion of the temporalis muscle by means of ultrasonography before and after the rehabilitation with removable prosthesis in children, and to correlate the muscle thickness with facial proportions and body variables.

Material and Methods

Subjects

Two hundred and forty nine children from 6 to 9 years old, who were to start dental treatment in the Department of Pediatric Dentistry, Dental School of Piracicaba (State University of Campinas, Brazil), were scanned and 25 of them were selected, 12 female and 13 male. Written and verbal consent was obtained from each child's parents and the research was approved by the Ethics Committee of the Dental School.

The children were selected after detailed anamneses were obtained with the parents, verifying the absence of systemic disturbance, which could compromise the masticatory system, and absence of parafunctional habits. A standard clinical examination, which included a morphological and functional evaluation of the masticatory system, was performed. The children were in the mixed dentition, and the inclusion criteria were the normality of the oral tissues, presence of upper and lower first permanent molars in Angle's Class I relationship, primary or permanent incisors, and primary canines, without form or structure anomalies and alterations that could compromise their cervico-occlusal and mesio-distal dimensions. The children presented premature loss of one or more primary molars, which could be uni or bilateral, superior or inferior, or indication for extraction after the conditions of these teeth were assessed by clinical and radiographic examinations, as well as the eruption process and degree of root formation of the permanent teeth. After diagnosis, individual treatment plan was established, including: detailed parental and child education and instructions in relation to feeding behavior and oral hygiene, fluoride therapy, extraction of teeth, restoration of the cavities; pulpar treatment, when indicated. In order to replace the missing teeth and to maintain the space for the successor, as well as to give back the aesthetic, the children received removable dental prosthesis with artificial teeth adapted. For that purpose, impressions of the children's upper and lower arches were taken with alginate (Jeltrate®), and the dental casts were mounted in a joint articulator. The removable dental prosthesis were fabricated with auto-polymerized acrylic resin (Vipi Flash®, Vipi) and artificial teeth (Biotone®), which were adapted to the dimensions of the primary teeth (figures 1 and 2), and retained by clasps, made of orthodontic stainless steel wires (0.7 mm), in the permanent first molars. The artificial teeth were set up in centric occlusion.

Body weight and height, muscle thickness and facial proportions were determined before and 6 months after the placement of the removable prosthesis. The lack of a control group could be considered a limitation of this study, but the decision was made considering that the best control group should be composed by children with premature loss of primary teeth, without prosthesis or space maintainers. Nonetheless, if the diagnosis is made and the treatment is not performed, an anti-ethical behavior would be applied, due to the possibility of the children developing severe malocclusion and impaired mastication. On the other hand, the different facial and body characteristics, even in normal children as controls, could influence the comparisons. For that reason, it was decided that each child would be his/her own control.[22]

Muscle thickness

The thickness of masseter and anterior portion of the temporalis muscles were measured using the Just-Vision 200 digital ultrasonography system (Toshiba Corporation, Japan) (figure 3) and the images were obtained with a high-resolution real-time 56mm/10-MHz linear-array transducer (figure 4). The recordings were performed bilaterally during relaxation and under contraction. The location of the muscles was obtained through palpation (the area of greatest lateral distention); for the masseter the site of measurement was close to the level of the occlusal plane, approximately in the middle of the mediolateral distance to the ramus and perpendicular to it[23] (figure 5). For the anterior portion of the temporalis muscle the transducer was placed in front of the anterior border of the hair line, at the deepest part of the temporal fossa, perpendicular to the underlying bone (figure 6). In order to be perpendicular to the bones, the transducer was moved until they were depicted on the screen as a sharp white line. The thickness was measured directly on the screen with an accuracy of 0.1 mm.

All trials were conducted in a properly darkened room, being the subjects seated in an upright, neutral but comfortable position, with the Frankfort Horizontal plane parallel to the floor. The registrations were repeated twice with an interval of at least 5 minutes. The thickness per side was calculated as the mean of the two measurements. To avoid tissue compression, a generous amount of airtight inert gel was applied under the probe.[24] Contrast between muscle and subcutaneous tissue was enhanced by asking the subject to clench and relax alternately.

All scans were carried out by same observer (MDS), properly trained, to eliminate the inter-observer difference. The reliability of the measurements was determined on 10 ramdomly selected children using the Dahlberg's formula: $EM= \sqrt{\Sigma(x_1- x_2)^2/2n}$ on two repeated measurements (x_1, x_2). The method error was 4.1% and 2.8% for the right and left relaxed masseter, and 2.9 % and 2.5% for the contracted masseter, respectively; 6.5% and 6.2% for the right and left relaxed temporalis muscle; and 4.3% and 7.0% for the contracted temporalis muscle.

Facial proportions

Frontal facial photographs of the subjects were taken in a standardized way so that their facial proportions could be determined, as described by Kiliaridis and Kälebo.[1] The subjects were standing under natural light against a light background and in a relaxed position, at a distance of 1.05 m from the camera, adjusted to the same level of the subject's eyes. The head was positioned so that the saggital and the Frankfort plan would remain, respectively, perpendicular and parallel to the ground. The mandibular position was in maximum clenching with the lips in the resting position. Three images were obtained from each subject, transferred to the computer, and the best one was chosen for the measurements, which were done directly on the computer screen, using the analyzing imaging software (ImageLab, Softium Informática Ltda - ME). Through reference points in the picture, the system was calibrated to transform the dimensions of the digitized image (pixel) in real dimensions (mm).

The anterior facial height (FH), the bizygomatic facial width (FWz), and the intergonial width (FWa) were measured on the photographs (figure 7). These measurements were used to calculate the proportions of the face (FH/FWz and FH/FWa). The proportions are more reliable, since they permit the elimination of the enlargement of the images.[1] The reliability of the facial proportions measurements was assessed by re-measuring two randomly selected photographs also using the Dahlberg's formula. The method error was 0.027 mm (0%) for the index FH/FWz, and 0.034 mm (0%) for the FH/FWa.

Body Variables

Weight and height were determined through an anthropological commercial scale. The body mass index (BMI= Weight/Height^2) was determined for each subject.

Statistical Analysis

The normality of the distributions was assessed by the Shapiro-Wilk's *W*-test. The comparisons between genders were performed through unpaired *t* test or Mann-Whitney tests, and the comparisons between evaluations of the muscle thickness, body variables and facial proportions through paird *t* test or Wilcoxon. The correlations among the variables were assessed by Spearman's or Pearson's coefficients and adjusted different regression models to the data were applied in each correlation significant at the $p < 0.05$ level. All analyses were carried out using SPSS1 9.0 (1998; SPSS, Chicago, IL, USA).

Results

There was no statistical significant difference (p>0.05) among the variables for boys and girls, therefore, the data were pooled. There was a significant increase in masseter muscle thickness from the first to the second evaluation (Table 1). The descriptive statistics for muscle thickness is expressed in Table 1; and for facial proportions, weight, height and body mass index are expressed in Table 2.

No statistical significant differences between left and right sides were found for the masseter muscle, therefore, the mean side values were used for all the comparisons (Table 1). In relation to the temporalis muscle, it was found a statistical significant difference between left and right side in the relaxed position at the first evaluation (p=0.0121), showing a higher average for the left side (Table 1). Therefore, the comparisons of muscle thickness in the relaxed position were done separately on the right and left side. Nevertheless, the correspondent value at the second evaluation was not statistically different (p=0.7610). For the contracted temporalis muscle there were no differences between sides in both evaluations (p=0.0534, p=0.2506, first and second evaluations, respectively).

The ultrasonographic evaluation determined that thickness increased significantly from the relaxed to the maximally contracted state (p=0.000) in both evaluations (figures 8, 9, 10 and 11). On the scan, this change was directly visible, as the muscle bulged during contraction and the septa curled.

The significant correlations found between muscle thickness and body variables and the respective adjusted regression models are presented in Table 3. It can be observed that weight was positively correlated with all muscle thicknesses at the second evaluations. However, the correlations were weak or moderate and the regression models showed that about 45% of the variability in masseter thickness could be explained by the weight, whereas for the temporalis the weight showed no significant influence on thickness, since the adjust determination coefficients were very low (p values of f >0.05). The height showed positive and weak correlation with the relaxed masseter and contracted temporalis thickness at the first evaluation and positive and moderate correlations for relaxed and contracted masseter thickness at the second evaluation. The regressions models showed that from 13.57% to 30.29% of the variability on the respective thickness were due to height. The BMI was correlated with relaxed masseter at the second evaluation.

There was no correlations between muscle thickness and facial proportions (p>0.05)

Discussion

After the premature loss of a primary tooth, it is necessary to maintain space, function, and preserve the arch length, allowing the permanent tooth to erupt unhindered into proper alignment and occlusion.[25] The level of cooperation expected from both the child and the parents is a relevant fact in the decision for the rehabilitation. In the present study the removable prosthesis was chosen, due to its indication for great loss of primary teeth. Furthermore, functional stimulus on the alveolar ridges serves to develop the alveolar bone, the alveolar process and the succedaneous teeth.[26,27] Besides, a removable prosthesis has certain advantages:[28] (1) the ease with which it is cleaned, adjusted, and maintained; (2) the minimal damage that is caused to adjacent teeth; (3) high tolerance level among children; and (4) its low cost. The disadvantages include the tendency for the prosthesis to accumulate plaque and the need for constant attention and periodic revisions, which require excellent child and parent cooperation. In this study the subjects were in constant follow up, therefore the plaque control and appliance using were stimulated periodically.

The results of this study did not show significant differences in masseter muscle thickness between the left- and right-hand side ($p>0.05$), which is in accordance with Close *et al.*[13] and Raadsheer *et al.*[8] This might be because the mandible functions simultaneously on both sides, therefore the alterations that happen in one side are likely to happen on the other side as well. This condition seems not to be the same when an alteration is present in only one of the sides, like in the posterior crossbite cases.[29] Nevertheless, the temporalis showed difference between right and left sides, which could be attributed to occlusion imbalance determined by the premature teeth loss or large decayed teeth before the placement of the prosthesis. Thus, the oral status before the rehabilitation could be influencing negatively the function and consequently, decreasing the muscle size. After six months of oral rehabilitation, it was observed no statistical difference between sides, inferring that the reestablished function could determine the muscle symmetry. It has been reported that children use more the temporalis muscle than masseter muscle on the chewing process, as it has been inferred that in the masticatory function the electric potential of anterior portion of temporalis tends to decrease in proportion to age and masseter increases, having a leading role in the masticatory mechanism in normal children.[30]

Moreover, the difference between right and left side on the temporalis muscle in relaxed position ($p<0.05$) might have also been caused by the greater susceptibility of this muscle to technical errors than the masseter (6.5% and 6.2% in the relaxed temporalis, against 4.1% and 2.8% for the masseter muscle, in the right and left sides, respectively) because of its specific morphology and orientation relative to the mid-saggital plane.[31] Measurements of the temporalis muscle cross-section, for instance, could be biased, since its scan plane will cut some of its fibers obliquely. Moreover, it has been verified in the literature a lower reproducibility for the relaxed than the contracted muscles, which may be due to the fact that the thickness of the relaxed muscle is more susceptible to the pressure with which the transducer is held against the cheek.[1,8] Nevertheless, during contraction on both evaluations (before and after the placement of the prosthesis) and during relaxation on the second section of exams, there was not a statistical significant difference between sides ($p>0.05$) for the temporalis muscle.

The contracted muscles (both masseter and temporalis) were significantly thicker than the relaxed ($p<0.05$), which is in accordance with the findings of the literature.[2,6,8,32] When a muscle is contracted, sliding of the muscle fiber filament and increase in fiber diameter cause thickening.[32] This change could be observed concomitant with the start of contraction and the difference between sides on temporalis at the first examination could be due to the amount of requested fibers on both sides to perform the contraction.

In this study, it was not found a significant difference in muscle thickness, body variables, or facial morphology between genders, so the data were pooled. These findings are in contrast with previous results in the literature. Close *et al.*[13] and Kiliaridis & Kälebo[1] found that masseter cross-sectional area was larger in males than in females, however, their study was done in adult subjects. Kiliaridis *et al.*[23] found the same association in children from 7 to 18 years old; Raadsheer *et al.*[8] reported that males had significantly thicker masseter muscles than females in all age groups. Nevertheless, it seems that a greater masseter muscle width develops in males during pubertal growth.[8]

The subjects in this study had absence of teeth prior to the treatment, which was replaced by a removable prosthesis. In this way they probably could chew better, which may have increased the muscular exercise. It seems that an increase in muscle function provokes an increase in masseter muscle thickness.[33] This may be the cause of enlargement of the masseter muscle posterior to the treatment. All masticatory muscles influence the mandible, but the masseter seems to be a good representative, since the variation in the total cross-sectional area of all masticatory muscles appears to be the result mainly of variation in the masseter cross-sectional area.[2] This is also reflected in the finding that, out of all the jaw muscles, only the thickness of the masseter muscle was correlated significantly with bite force magnitude, [6,31,34-37,] and the masseter thickness has also been correlated to posterior tooth contacts.[6]

The mean values of thickness (Table 1) are in accordance with Bertram *et al.*,[4] Kiliaridis & Kälebo,[1] Benington *et al.*,[15] Kiliaridis *et al.*,[23] but differing from others.[1-3,8,24,33,38] These differences in masseter muscle thickness can be attributed to the age of the sample, since it was observed a correlation between masseter muscle thickness and age in children from 7 to 18 years of age.[23]

The correlations between body variables and masseter muscle thickness at the second evaluation of this study were more prevalent than at the first, when the masseter muscle during relaxation and the temporalis muscle during contraction correlated only to body height. After 6 months of rehabilitation, it was verified a correlation between masseter muscle thickness and all the body variables, except for the correlation between body mass index and contracted masseter. There was a weak or moderate influence of these variables on thickness, as the regression models explained about 15% to 45% of the variability (Table 3). For the temporalis muscle in the second evaluation, the thickness in relaxed and contracted positions was significantly and moderately related to body weight, with the *f* values of the regression models not significant. Therefore, the variability on thickness must be explained by other factors. Kiliaridis & Kälebo,[1] in an adult sample found that the thickness of the masseter muscle during contraction was significantly related to the women's body weight and body constitution (bw/s). Raadsheer *et al.*[8] reported a significant relation between 'height' and 'weight' on the one hand and 'muscle thickness' on the other, i.e. with increasing body height and weight, muscle thickness also increased.

These changes in correlation between body variables and muscle thickness between the first and second evaluation, especially in the masseter muscle, might be due to the fact that this muscle mostly influences the mandible, and it is most related to the masticatory functions. Furthermore, the increase in height, weight and body mass index from the first to the second evaluation and its relation to the masseter muscle thickness may suggest that the prostheses could have allowed a wider selection of food, since the children were able to chew better. Nevertheless, it must be taken into consideration that the children are in constant growth and development, which could be influencing the results. The height and weight before and after 6 months remained in the same percentile of the respective growth curves for almost all children, showing that they grew up into the normality. The growth and development during the six months had influence, but partially, since the adjusted determination coefficients were moderate, showing that other factors could have acted, increasing the muscles thickness. Accordingly, it is possible to infer, since the prosthesis could have improved the mastication, the muscles could have been more exercised, consequently increasing their size, as verified by Bakke *et al*.[33] In this way, the correlation between the placement of the prosthesis in children and the enhancement in masticatory performance, as well as the dietary changes after the insertion of the prosthesis, must be further studied.

No statistical significant correlations between facial morphology, as measured by the FH/FWz and FH/FWa proportions, and muscle thickness were found in this study. These findings are in contrast with the ones reported previously in the literature, which correlate thicker muscles with short faced individuals.[2,3,6,8,15,16,39-42] However, the age sample on those studies were different from that of our sample, and also the subjects were not children wearing prosthesis. In addition, there was a similarity in the facial proportions among the subjects (Table 2).

In conclusion, the findings of this study suggest that the placement of the removable dental prosthesis influenced the morphological aspect of the muscles, increasing the thickness of the masster muscle, suggesting that the rehabilitation treatment is adequate to replace the missing posterior primary teeth, with the possibility to improve the function of the masticatory system.

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Figure 1: subject without the prosthesis

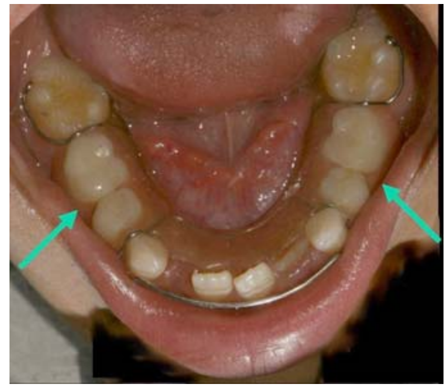

Figure 2: subject with the prosthesis in place

Figure 3 – Ultrasound equipment

Figure 4 – Ultrasound linear-array transducer

Figure 5 – Position of the transducer for the masseter muscle

Figure 6 – Position of the transducer in the anterior portion of the temporalis muscle

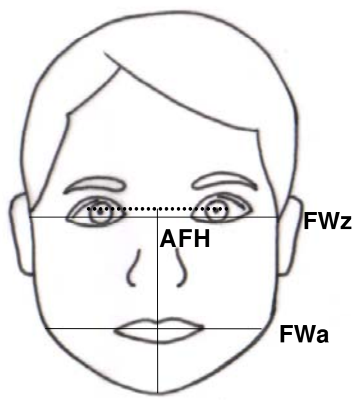

Figure 7 – Facial Morphology – FH anterior facial height, FWz bizygomatic facial width, and FWa intergonial width

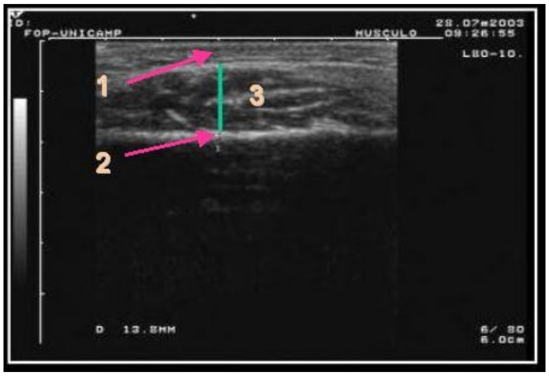

Figure 8 – Image of the masseter muscle during relaxation; (1) surface of transducer, (2) mandibular ramus, (3) thickness of the masseter muscle

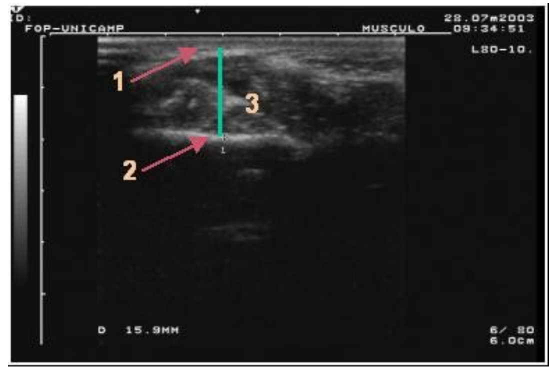

Figure 9 – Image of the masseter muscle during clenching; (1) surface of transducer, (2) mandibular ramus, (3) thickness of the masseter muscle

Figure 10 - Image of the temporalis muscle during relaxation: (1) surface of the transducer (2) temporalis bone, (3) temporalis muscle thickness.

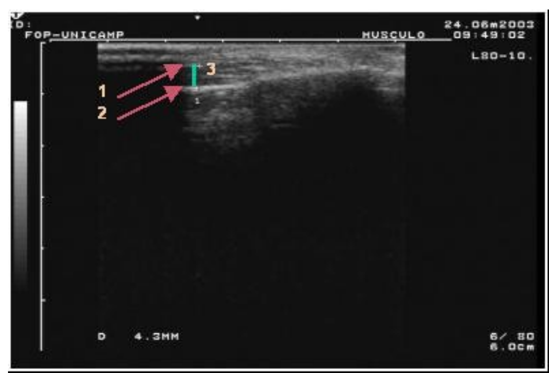

Figure 11 – Image of the temporalis muscle during clenching: (1) surface of the transducer, (2) temporalis bone, (3) temporalis muscle thickness.

Table 1 – Mean values (standard deviation) for muscle thickness (mm) in the first and second evaluations

	1st evaluation						2nd evaluation					
	Relaxed			Contracted			Relaxed			Contracted		
	Right	Left	Mean	Right	Left	Mean	Right	Left	Mean	Right	Left	Mean
Masseter	9.6[a] (0.9)	9.5[a] (0.8)	9.5[a] (0.8)	11.0[b] (0.8)	11.0[b] (0.8)	11.0[b] (0.7)	10.5[c] (0.9)	10.4[c] (1.0)	10.6[c] (0.9)	11.8[d] (1.0)	11.7[d] (1.1)	11.8[d] (1.0)
Temporalis	3.4[a] (0.5)	3.6[b] (0.5)	3.5[b] (0.8)	4.3[c] (0.6)	4.4[c] (0.6)	4.3[c] (0.6)	3.3[a] (0.4)	3.3[a] (0.4)	3.3[a] (0.4)	4.4[c] (0.5)	4.5[c] (0.5)	4.4[c] (0.5)

Different small letters in the same line mean statistical difference between sides and evaluations

Table 2 – Mean values and standard deviation (SD) for facial proportions (mm), weight (Kg), height (m), and body mass index (Kg/m^2) at the first and second evaluations

	1st evaluation		2nd evaluation	
	Mean	SD	Mean	SD
FH/FWz	0.659[a]	0.026	0.654[a]	0.025
FH/FWa	0.786[a]	0.039	0.789[a]	0.042
Weight	24.59[a]	5.77	26.24[b]	6.63
Height	1.23[a]	0.06	1.27[b]	0.06
BMI	15.97[a]	2.45	16.21[a]	2.80

Different small letters in the same line show statistical significant difference between evaluations

Table 3. Significant correlations and adjusted determination coefficients for muscles thickness and body variables at the first and second evaluation of the exams

	Weight			Height				BMI		
	1st evaluation	2nd evaluation		1st evaluation		2nd evaluation		1st evaluation	2nd evaluation	
	r	r	ADC	r	ADC	r	ADC	r	r	ADC
1. Relaxed masseter	-	0.525*	44.82%$^{\circ\circ}$	0.438*	15.63%$^{\circ}$	0.576*	30.29%$^{\circ\circ}$	-	0.460*	35.63%$^{\circ\circ}$
2. Contracted masseter	-	0.399*	45.68%$^{\circ\circ}$	-	-	0.506*	22.31%$^{\circ\circ}$	-	-	-
3. Relaxed temporalis	-	0.414*	8.02%	-	-	-	-	-	-	-
4. Contracted temporalis	-	0.451*	15.09%	0.458*	13.57%	-	-	-	-	-

ADC: Adjusted determination coefficient

*p<0.05;

$^{\circ}$ p value of *f* <0.05; $^{\circ\circ}$ p value of *f* <0.01

IV – CONCLUSÕES GERAIS

Dentro dos limites deste estudo, podemos concluir que:

1. A força de mordida é um dos componentes da mastigação, sendo estudada para avaliar as condições dos músculos e do sistema mastigatório. Os valores da força de mordida variam entre estudos, devido às diferentes metodologias, aparelhos utilizados e às condições morfológicas e funcionais do sistema estomatognático. As comparações entre estudos devem ser cautelosas, sendo as respectivas conclusões de maior importância.
2. A prótese parcial removível temporária influenciou os aspectos funcional e morfológico dos músculos, demonstrados através do aumento na força de mordida e na espessura muscular.

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DELIBERAÇÃO CCPG – 001/98

Dispõe a respeito do formato das teses de Mestrado
e de Doutorado aprovadas pela UNICAMP

Tendo em vista a possibilidade, segundo parecer PG Nº 1985/96, das teses de Mestrado e Doutorado terem um formato alternativo àquele já bem estabelecido, a CCPG resolve:

Artigo 1º - Todas as teses de mestrado e de doutorado da UNICAMP terão o seguinte formato padrão:

I) Capa com formato único, dando visibilidade ao nível (mestrado e doutorado), e à Universidade.
II) Primeira folha interna dando visibilidade ao nível (mestrado ou doutorado), à Universidade, à Unidade em foi defendida e à banca examinadora, ressaltando o nome do orientador e co-orientadores. No seu verso deve constar a ficha catalográfica.
III) Segunda folha interna onde conste o resumo em português e o Abstract em inglês.
IV) Introdução Geral.
V) Capítulo.
VI) Conclusão geral.
VII) Referências Bibliográficas.
VIII) Apêndices (se necessários).

Artigo 2º - A critério do orientador, os Capítulos e os Apêndices poderão conter cópias de artigos de autoria ou de co-autoria do candidato, já publicados ou submetidos para publicação em revistas científicas ou anais de congressos sujeitos a arbitragem, escritos no idioma exigido pelo veículo de divulgação.

Parágrafo único – Os veículos de divulgação deverão ser expressamente indicados.

Artigo 3º - A PRPG providenciará o projeto gráfico das capas bem como a impressão de um número de exemplares, da versão final da tese a ser homologada.

Artigo 4º - Fica revogada a resolução CCPG 17/97.

COMITÊ DE ÉTICA EM PESQUISA

UNIVERSIDADE ESTADUAL DE CAMPINAS

FACULDADE DE ODONTOLOGIA DE PIRACICABA

CERTIFICADO

Certificamos que o Projeto de pesquisa "Análise ultrasonográfica dos músculos masseter e temporal e força de mordida antes e após a colocação de mantenedor de espaço funcional em crianças na dentição mista", protocolo CEP nº **032/2004**, dos Pesquisadores ***Márcia Diaz Serra*** e ***Maria Beatriz Duarte Gavião***, está de acordo com a Resolução 196/96 do Conselho Nacional de Saúde - MS e foi aprovado pelo Comitê de Ética em Pesquisa da Faculdade de Odontologia - UNICAMP.

We certify that the research project "Ultrasonografic analyses of the masseter and temporalis muscles and bite force before and after the use of functional space maintainer in children during mixed dentition", register number **032/2004**, of ***Márcia Diaz Serra*** and ***Maria Beatriz Duarte Gavião***, is in agreement with the recommendations of 196/96 Resolution of the National Health Committee - Brazilian Health Department and was approved by the Research Ethics Committee of the School of Dentistry of Piracicaba - State University of Campinas - UNICAMP.

Piracicaba - SP, Brazil, June 2004

Cinthia P Machado Tabchoury

Profa. Dra. Cinthia Pereira Machado Tabchoury

Secretaria

CEP/FOP/UNICAMP

Prof. Dr. Jacks Jorge Júnior

Coordenador

CEP/FOP/UNICAMP

DADOS INDIVIDUAIS

Tabela 1 – Valores individuais de força de mordida (N), médias e desvios padrões (DP) para primeira e segunda sessões de exames

Sujeito	**1ª sessão**	**2ª sessão**
1 ♀	299,585	369,330
2 ♂	369,330	384,013
3 ♀	325,281	339,964
4♂	266,549	325,281
5 ♂	361,988	387,683
6 ♀	391,354	409,708
7♂	251,866	304,724
8 ♂	339,964	339,964
9 ♀	284,902	347,305
10 ♀	160,097	310,598
11♀	339,964	339,964
12♂	373,000	376,671
13 ♂	288,573	328,951
14 ♂	303,256	288,573
15 ♀	229,841	288,573
16 ♂	226,171	281,232
17♀	354,647	395,025
18 ♂	337,210	367,494
19 ♀	321,610	350,976
20 ♂	226,170	255,536
21 ♀	281,232	384,012
22 ♀	325,281	369,329
23 ♀	398,696	406,037
24 ♂	204,146	380,342
25 ♂	284,903	288,573
Média	301,825	344,794
DP	61,326	43,018

Tabela 2 – Valores individuais dos índices de proporções faciais – AFA/DB e AFA/DI (mm) – médias e desvios padrões (DP) para primeira e segunda sessões de exames

	1ª sessão		2ª sessão	
Sujeito	AFA/DB	AFA/DB	AFA/DB	AFA/DB
1 ♀	0,639	0,777	0,640	0,785
2 ♂	0,653	0,836	0,663	0,810
3 ♀	0,688	0,802	0,684	0,812
4♂	0,673	0,804	0,654	0,806
5 ♂	0,622	0,800	0,622	0,800
6 ♀	0,694	0,836	0,687	0,781
7♂	0,701	0,816	0,666	0,843
8 ♂	0,636	0,743	0,643	0,823
9 ♀	0,648	0,720	0,657	0,757
10 ♀	0,663	0,789	0,632	0,739
11♀	0,677	0,794	0,667	0,786
12♂	0,619	0,720	0,606	0,716
13 ♂	0,639	0,758	0,635	0,781
14 ♂	0,649	0,817	0,652	0,796
15 ♀	0,644	0,761	0,628	0,766
16 ♂	0,643	0,780	0,641	0,775
17♀	0,622	0,702	0,652	0,736
18 ♂	0,664	0,765	0,648	0,763
19 ♀	0,685	0,829	0,685	0,829
20 ♂	0,692	0,843	0,710	0,879
21 ♀	0,643	0,763	0,626	0,701
22 ♀	0,633	0,774	0,635	0,756
23 ♀	0,673	0,782	0,673	0,850
24 ♂	0,680	0,803	0,655	0,808
25 ♂	0,699	0,839	0,688	0,830
Média	0,659	0,786	0,654	0,789
DP	0,026	0,039	0,025	0,042

♂ meninos; ♀ meninas

Tabela 3 – Valores individuais de peso (Kg), altura (m) e índice de massa corporal (IMC), médias e desvios padrões (DP) para primeira e segunda sessões de exames

	1ª sesão			2ª sessão		
Sujeito	**Peso**	**Altura**	**IMC**	**Peso**	**Altura**	**IMC**
1 ♀	31,00	1,27	19,22	33,50	1,36	18,25
2 ♂	26,00	1,28	15,87	27,90	1,32	16,01
3 ♀	27,10	1,32	15,55	28,70	1,36	15,63
4♂	24,00	1,20	16,67	24,90	1,24	16,33
5 ♂	31,40	1,33	17,75	33,80	1,35	18,55
6 ♀	24,50	1,30	14,50	25,20	1,33	14,35
7♂	21,00	1,21	14,34	23,50	1,26	14,92
8 ♂	32,50	1,27	20,31	36,60	1,30	21,66
9 ♀	18,90	1,16	14,17	20,30	1,17	14,83
10 ♀	20,50	1,18	14,72	21,50	1,20	15,06
11♀	20,00	1,18	14,36	20,80	1,21	14,21
12♂	44,50	1,34	24,78	49,10	1,37	26,35
13 ♂	23,70	1,22	15,92	24,80	1,24	16,13
14 ♂	22,00	1,20	15,28	22,80	1,21	15,57
15 ♀	22,00	1,18	15,80	24,50	1,19	17,30
16 ♂	17,00	1,14	13,08	17,70	1,18	12,82
17♀	21,90	1,20	15,21	23,60	1,24	15,35
18 ♂	24,00	1,23	15,86	25,20	1,25	16,13
19 ♀	20,00	1,17	14,61	19,60	1,21	13,39
20 ♂	26,50	1,26	16,83	25,40	1,29	15,26
21 ♀	20,80	1,20	14,44	22,70	1,24	14,76
22 ♀	26,50	1,29	15,92	30,00	1,31	17,62
23 ♀	20,50	1,23	13,55	22,90	1,27	14,20
24 ♂	27,50	1,34	15,43	29,20	1,36	15,79
25 ♂	21,00	1,18	15,08	21,70	1,21	14,82
Média	24,59	1,23	15,97	26,24	1,27	16,21
DP	5,77	0,06	2,45	6,63	0,06	2,80

♂ meninos; ♀ meninas

Tabela 4 – Valores individuais de espessura do masseter relaxado e contraído (mm), médias e desvios padrões (DP)

	1ª sessão						2ª sessão					
	Relaxado			Contraído			Relaxado			Contraído		
Sujeito	**Direito**	**Esquerdo**	**Média**	**Direito**	**Esquerdo**	**Média**	**Direito**	**Esquerdo**	**Média**	**Direito**	**Esquerdo**	**Média**
1 ♀	10,7	10,8	10,7	11,6	12,4	12,0	10,8	10,3	10,5	12,1	11,5	11,8
2 ♂	9,9	10,3	10,1	11,4	11,5	11,5	11,4	11,6	11,5	12,8	12,6	12,7
3 ♀	9,7	9,4	9,5	10,7	10,8	10,7	11,3	10,5	10,9	11,9	11,4	11,6
4♂	9,7	8,9	9,3	10,4	10,3	10,4	9,9	9,9	9,9	10,5	10,8	10,7
5 ♂	10,6	10,4	10,5	12,7	12,7	12,7	12,2	12,1	12,1	13,7	12,9	13,3
6 ♀	9,7	9,3	9,5	11,0	10,4	10,7	10,0	9,7	9,8	11,2	11,0	11,1
7♂	11,8	10,0	10,9	12,8	10,8	11,8	12,1	10,4	11,2	12,8	11,3	12,1
8 ♂	9,5	9,5	9,5	11,1	10,8	10,9	11,5	10,8	11,1	12,6	11,4	12,0
9 ♀	8,5	9,7	9,1	10,3	11,3	10,8	9,2	9,8	9,5	10,8	11,5	11,1
10 ♀	8,7	8,9	8,8	10,4	10,6	10,5	9,5	9,6	9,5	10,5	10,1	10,3
11♀	10,0	10,1	10,0	12,2	12,2	12,2	10,5	11,5	11,0	11,6	13,4	12,5
12♂	10,1	10,6	10,3	10,9	11,4	11,1	12,1	13,0	12,5	14,0	15,3	14,6
13 ♂	10,5	9,6	10,1	11,9	11,4	11,7	10,3	11,7	11,0	11,6	12,4	12,0
14 ♂	8,1	8,5	8,3	9,7	10,0	9,8	10,6	10,3	10,4	11,5	12,0	11,8
15 ♀	9,8	9,4	9,6	11,1	10,6	10,8	10,6	10,0	10,3	12,3	11,1	11,7
16 ♂	9,9	9,3	9,6	10,7	9,9	10,3	9,6	9,2	9,4	11,5	10,2	10,9
17♀	8,3	8,0	8,1	10,2	9,4	9,8	10,5	10,2	10,3	11,6	11,7	11,6
18 ♂	8,7	8,9	8,8	10,5	10,2	10,3	8,7	9,5	9,1	9,6	10,9	10,2
19 ♀	10,7	9,3	10,0	11,3	10,9	11,1	10,5	10,4	10,4	11,5	11,8	11,6
20 ♂	8,8	9,1	9,0	9,8	10,5	10,1	10,0	10,7	10,4	11,1	11,7	11,4
21 ♀	9,3	9,0	9,1	11,2	11,4	11,3	10,8	11,1	10,9	11,8	12,5	12,1
22 ♀	9,6	10,6	10,1	10,8	12,1	11,4	10,3	10,5	10,4	11,2	12,1	11,6
23 ♀	9,3	9,5	9,4	10,5	10,9	10,7	10,2	8,7	9,4	12,1	9,7	10,9
24 ♂	10,1	10,3	10,2	11,5	12,2	11,9	11,2	10,7	10,9	12,6	12,1	12,3
25 ♂	7,8	8,0	7,9	11,5	10,6	11,0	10,1	9,5	9,8	12,1	11,0	11,5
Média	9,6	9,5	9,5	11,0	11,0	11,0	10,5	10,4	10,6	11,8	11,7	11,8
DP	0,9	0,8	0,8	0,8	0,8	0,7	0,9	1,0	0,9	1,0	1,1	1,0

Tabela 5 – Valores individuais de espessura do temporal relaxado e contraído (mm), médias e desvios padrões (DP)

	1ª sessão						2ª sessão					
	Relaxado			Contraído			Relaxado			Contraído		
Sujeitos	**Direito**	**Esquerdo**	**Média**	**Direito**	**Esquerdo**	**Média**	**Direito**	**Esquerdo**	**Média**	**Direito**	**Esquerdo**	**Média**
Sujeito	3,5	3,3	3,4	4,6	4,6	4,6	3,5	3,2	3,4	4,3	4,3	4,3
1 ♀	3,3	3,4	3,3	4,5	4,4	4,4	3,6	4,4	4,0	4,8	5,4	5,1
2 ♂	3,6	4,2	3,9	4,4	4,9	4,7	3,4	3,7	3,5	4,4	4,9	4,6
3 ♀	3,2	3,3	3,2	3,7	4,2	4,0	2,7	3,0	2,9	3,6	4,6	4,1
4♂	3,3	3,2	3,2	4,4	4,0	4,2	3,4	3,4	3,4	4,5	4,3	4,4
5 ♂	3,7	3,9	3,8	5,0	5,1	5,0	3,8	3,9	3,8	5,2	5,2	5,2
6 ♀	3,2	3,5	3,3	3,9	4,2	4,1	3,0	3,2	3,1	3,9	4,1	4,0
7♂	4,0	4,4	4,2	4,8	5,0	4,9	3,6	3,4	3,5	5,2	5,0	5,1
8 ♂	4,2	4,0	4,1	5,0	4,7	4,8	3,8	3,9	3,8	4,7	4,9	4,8
9 ♀	3,0	3,4	3,2	3,9	4,0	4,0	3,3	3,0	3,1	4,1	3,9	4,0
10 ♀	3,3	3,9	3,6	4,0	4,6	4,3	3,2	3,1	3,1	4,1	4,4	4,3
11♀	3,9	4,3	4,1	4,6	4,9	4,7	3,4	3,5	3,4	4,8	5,1	4,9
12♂	2,7	3,1	2,9	3,3	3,6	3,4	2,8	2,8	2,8	3,6	3,7	3,6
13 ♂	3,4	3,1	3,2	4,2	4,1	4,2	3,3	3,0	3,1	4,2	4,1	4,1
14 ♂	3,0	3,2	3,1	4,1	4,1	4,1	3,1	3,3	3,2	4,7	4,9	4,8
15 ♀	3,2	3,3	3,2	3,7	3,8	3,8	2,8	3,0	2,9	3,9	4,1	4,0
16 ♂	4,0	3,9	3,9	3,9	4,4	4,1	3,4	3,4	3,4	4,7	4,8	4,7
17♀	5,1	4,6	4,9	6,5	6,2	6,4	4,8	3,9	4,4	5,7	5,4	5,5
18 ♂	2,7	3,0	2,8	3,7	3,6	3,6	3,4	3,5	3,5	4,9	4,4	4,6
19 ♀	3,0	3,2	3,1	3,7	3,7	3,7	3,3	3,1	3,2	4,1	4,1	4,1
20 ♂	3,1	3,5	3,3	3,9	4,3	4,1	2,9	3,3	3,1	3,9	4,3	4,1
21 ♀	3,3	3,5	3,4	3,8	4,3	4,0	3,4	3,2	3,3	4,6	4,7	4,7
22 ♀	2,6	4,0	3,3	4,7	4,3	4,5	3,3	2,7	3,0	4,7	3,8	4,2
23 ♀	3,7	4,0	3,8	4,7	4,9	4,8	3,5	3,6	3,5	4,4	4,6	4,5
24 ♂	3,5	3,6	3,5	4,1	4,3	4,2	2,8	3,0	2,9	3,7	3,8	3,8
Média	3,4	3,6	3,5	4,3	4,4	4,3	3,3	3,3	3,3	4,4	4,5	4,4
DP	0,5	0,5	0,8	0,6	0,6	0,6	0,4	0,4	0,4	0,5	0,5	0,5

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

MENOR:____

As informações contidas neste prontuário visam firmar acordo por escrito, mediante o qual o responsável pelo menor, objeto de pesquisa, autoriza sua participação, com pleno conhecimento da natureza dos procedimentos e riscos a que se submeterá o paciente, com capacidade de livre arbítrio e sem qualquer coação.

I – TÍTULO DO TRABALHO EXPERIMENTAL:

Análise ultrasonográfica dos músculos masseter e temporal e força de mordida antes e após a colocação de mantenedor de espaço funcional em crianças na dentição mista

Responsáveis: Márcia Diaz Serra

Maria Beatriz Duarte Gavião

II - OBJETIVO

O objetivo deste estudo será verificar a influência de aparelhos mantenedores de espaço, constituídos de uma base de acrílico e dentes artificiais para substituir dentes decíduos (de leite) que foram extraídos (arrancados) precocemente, sobre a força de mordida e a espessura de músculos mastigatórios, de crianças de 6 a 9 anos de idade.

III - JUSTIFICATIVA

Os dentes decíduos são importantes no estabelecimento da dentição permanente. Os itens a serem estudados são de importância para avaliar o desenvolvimento da face, pois verificaremos o quanto a falta de dentes interfere no tamanho dos músculos e na capacidade de morder os alimentos, assim como a melhora com o uso do aparelho.

IV - PROCEDIMENTOS DO EXPERIMENTO

Serão examinadas crianças que iniciarão tratamento odontológico na Faculdade de Odontologia de Piracicaba, e aquelas com perda precoce de dentes decíduos posteriores ou com indicação de extração serão convidadas a participar da pesquisa.

As crianças serão tratadas de acordo com suas necessidades. Será instalado o aparelho após o término do tratamento restaurador e cirúrgico [extração do(s) dente(s)].

Avaliação da força de mordida – Avaliaremos a força máxima com que a criança consegue morder. Será utilizado um tubo de borracha pressurizado, ou seja, enchido com ar, o qual estará conectado a um computador. A criança inicialmente ficará em uma posição confortável, sentada. Em seguida o tubo será posicionado entre os arcos superior e inferior, na altura dos molares. As crianças serão devidamente treinadas na realização da mordida do tubo transmissor, antes da realização do experimento e será solicitado a cada uma morder, com o máximo de força, 3 vezes seguidas, com 30 segundos de intervalo aproximadamente, entre cada mordida.

Ultra-sonografia – Os músculos da mastigação serão avaliados através do exame de ultra-som, nas posições de repouso (lábios fechados sem contato entre os dentes superiores e inferiores) e contração máxima (dentes em contato). Os participantes permanecerão sentados eretos, com as cabeças em posição normal. Os registros serão repetidos duas vezes.

Peso e altura corporais - Serão determinados pela balança.

Morfologia facial - A análise da forma da face será realizada através de fotografias frontais das crianças. Será utilizada câmera digital Canon montada em tripé.

V - RISCOS ESPERADOS

Os procedimentos realizados não oferecem riscos uma vez que os exames clínicos e o tratamento odontológico seguem os passos da rotina clínica. Não haverá nenhum método invasivo na obtenção dos dados, utilizando-se instrumental adequado.

A aparelhagem para avaliação da força de mordida é extremamente segura, não oferecendo nenhum risco ao paciente. Antes do experimento verificaremos a disponibilidade da criança em colaborar na realização do teste e a capacidade de morder corretamente o tubo transmissor.

Na análise da espessura dos músculos masseter e temporal o exame de ultra-sonografia utilizado não oferece riscos já que é uma técnica indolor e rotineiramente utilizada no acompanhamento de grávidas, para observação do desenvolvimento do bebê.

Todos os cuidados com a limpeza do equipamento e procedimentos serão assegurados de acordo com as regras determinadas na Faculdade de Odontologia de Piracicaba/UNICAMP.

VI – BENEFÍCIOS ESPERADOS

O benefício está relacionado diretamente com o aumento da força de mordida e a melhora da mastigação permitindo que as crianças tenham condições de se alimentarem de forma mais adequada. Assim como a manutenção dos espaços dos dentes perdidos precocemente que irá favorecer a correta erupção (nascimento) dos dentes permanentes. Além disso, as crianças participantes da pesquisa terão atendimento clínico, consistindo de atividades educativas, preventivas (profilaxia e aplicação de flúor) e curativas (tratamentos de cárie necessários), contribuindo, desta maneira, para a melhoria de sua saúde bucal.

VII – FORMA DE ACOMPANHAMENTO E ASSISTÊNCIA

Após o término do tratamento odontológico as crianças serão examinadas a cada 2 meses, para verificação da efetividade do tratamento curativo, assim como da manutenção do aparelho e da verificação do entendimento das orientações preventivas (higiene e controle da dieta). Caso se observe que a criança precisa de intervalos mais freqüentes, estes serão instituídos de acordo com a necessidade. Seis meses após a instalação do aparelho, que a princípio corresponderá à terceira sessão da manutenção do tratamento, a criança realizará novamente os exames de ultra-sonografia e força de mordida.

VIII – GARANTIA DE ESCLARECIMENTO

O responsável pelo menor tem a garantia de que receberá respostas a qualquer pergunta ou esclarecimento sobre qualquer dúvida à cerca dos procedimentos, riscos, benefícios, empregados neste documento e outros assuntos relacionados à pesquisa. Também serão dadas informações sobre o diagnóstico das alterações detectadas, o prognóstico e o plano de tratamento que será instituído, de acordo com os critérios adotados pelas disciplinas do Departamento de Odontologia Infantil.

IX - RETIRADA DO CONSENTIMENTO

O responsável pelo menor tem a liberdade de retirar seu consentimento a qualquer momento e deixar de participar do estudo, sem qualquer prejuízo ao atendimento odontológico a que a criança está sendo ou será submetida na Faculdade de Odontologia de Piracicaba -UNICAMP.

X – GARANTIA DE SIGILO

Os responsáveis pelo presente estudo se comprometem a manter o sigilo de qualquer informação ou imagem obtida, e que os dados obtidos serão confidenciais e utilizados apenas para fim de pesquisa sem que seja necessária a identificação do paciente.

XI – FORMAS DE RESSARCIMENTO

Garante-se que os participantes da pesquisa não terão qualquer gasto e também não terão despesas quanto ao tratamento odontológico. Se for necessário, o responsável poderá ser encaminhado ao Serviço Social, para avaliação sócio-econômica, podendo solicitar auxílio financeiro para transporte e alimentação, recursos esses que serão fornecidos pelos responsáveis da pesquisa.**XII – FORMAS DE INDENIZAÇÃO**

Não está previsto nenhum tipo de indenização uma vez que o projeto não oferece riscos aos pacientes. **XIII- CONSENTIMENTO PÓS-INFORMAÇÃO**

Eu ____, responsável pelo menor ____, certifico que tendo lido as informações acima e suficientemente esclarecido (a) de todos os itens, estou plenamente de acordo com a realização do experimento. Assim, autorizo a execução do trabalho de pesquisa exposto acima.

Piracicaba, _____ de __________________ de 200_.

NOME(legível)____RG_______

ASSINATURA____

ATENÇÃO: A sua participação em qualquer tipo de pesquisa é voluntária. Em caso de dúvida quanto aos seus direitos, escreva para o Comitê de Ética em Pesquisa da FOP-UNICAMP. Endereço - Av. Limeira, 901 - CEP/FOP - 13414-900 - Piracicaba – SP ou contate 19 34335368.

UNICAMP

UNIVERSIDADE ESTADUAL DE CAMPINAS
FACULDADE DE ODONTOLOGIA DE PIRACICABA
DEPARTAMENTO DE ODONTOLOGIA INFANTIL

MENTE·MANV·CORDE

AUTORIZAÇÃO PARA DIAGNÓSTICO E/OU EXECUÇÃO DE PLANO DE TRATAMENTO

PACIENTE____PG_________

Por este instrumento de autorização por mim assinado, dou pleno consentimento à FACULDADE DE ODONTOLOGIA DE PIRACICABA - UNICAMP - DEPARTAMENTO DE ODONTOLOGIA INFANTIL, para por meio de seus professores e alunos devidamente autorizados, a fazer diagnóstico, planejamento e tratamento odontológico de meu (minha) filho (a), de acordo com os conhecimentos enquadrados no campo da Especialidade em Odontopediatria.

Tenho pleno conhecimento que esta clínica e laboratórios, aos quais meu (minha) filho (a) se submete para fins de diagnóstico e/ou tratamento, tem como principal objetivo a instrução e demonstração destinados a profissionais da área de saúde. Concordo, pois, com toda orientação seguida, quer para fins didáticos, de diagnóstico e/ou tratamento.

Concordo plenamente também, que todas as radiografias, fotografias, históricos de antecedentes familiares, resultados de exames clínicos e de laboratório, e quaisquer outras informações concernentes ao diagnóstico, planejamento e/ou tratamento, constituem propriedade exclusiva desta Faculdade, a qual dou plenos direitos de retenção, uso para quaisquer fins de ensino e pesquisa, além de sua divulgação em jornais e revistas científicas do país e exterior.

Piracicaba, _____de___________________ de 200_

NOME (legível)_______________________________________RG____________

____

ASSINATURA (pai, tutor ou responsável)

Ficha de Exames

Data: ___/___/___　　　　**Sessão: ____**

Nome: ____

IDADE: ___________　　　　　　　　SEXO: _______________

Peso: ____________ Kg　　　　　　　　**Altura: __________ m**

Nome dos arquivos

FM ____

US ____

Ultra-som

	Direito				Esquerdo			
	Relaxado		Contraído		Relaxado		Contraído	
	Mass	Temp	Mass	Temp	Mass	Temp	Dir	Esq
1ª								
2a								
Média								

Força de Mordida

1ª mordida _____________
2ª mordida _____________
3ª mordida _____________
Média _____________

FICHA CLÍNICA

DATA___/___/____

1. IDENTIFICAÇÃO

Nome____Apelido______________

Data de nascimento _____/_____/______Idade_____anos e _____meses

Sexo__________Raça__________________

Endereço______________________________________Bairro________________________

Cidade______________________CEP_____________Telefone______________________

Pai ____Idade ______anos

Estado civil: ❑ solteiro ❑ casado ❑ divorciado ❑ viúvo ❑ outros

Grau de instrução: ❑ sem escolaridade ❑ 1º grau ❑ 2º grau ❑ superior

Profissão_________________________________

End.comercial____Fone____________

Mãe ____Idade______anos

Estado civil: ❑ solteira ❑ casada ❑ divorciada ❑ viúva ❑ outros❑

Grau de instrução: ❑ sem escolaridade ❑ 1º grau ❑ 2º grau ❑ superior

Profissão__________________________________

End.comercial____Fone____________

Irmãos_____________________ Idades________________________________

Pediatra ou clínico responsável____

2. HISTÓRIA PRÉ-NATAL

a. GRAVIDEZ - Normal ❑ Anormal ❑

b. MANIFESTAÇÕES DURANTE A GRAVIDEZ

DOENÇAS ____

MEDICAMENTOS ____

____

INGESTÃO FREQUENTE DE ALIMENTOS AÇUCARADOS? Sim ❑ Não ❑

3. HISTÓRIA NATAL

PARTO - Normal ❑ Fórceps ❑ Cesariana ❑

Complicações durante o parto ____

____

NASCIMENTO - a termo ❑ prematuro ❑_____meses

Peso______________ Altura________________

4. HISTÓRIA NEO-NATAL

PROBLEMAS DURANTE O 1º MÊS DE VIDA

❑ Icterícia ❑ Dificuldades respiratórias

❑ Febre alta ❑ Dificuldades de alimentação

❑ Doenças graves ❑ Dentes do nascimento ao 1º mês

Comentários ____

____

5. HISTÓRIA PÓS-NATAL

DOENÇAS SISTÊMICAS

❑ alergia_________________________ ❑ diabete_______________________

❑ rinite alérgica__________________ ❑ problemas renais________________

❑ resfriados freqüentes____________ ❑ discrasias sanguíneas ____________

❑ sinusite ______________________ ❑ problemas cardíacos _____________

❑ amigdalites ___________________ ❑ febre reumática_________________

❑ verminose _____________________ ❑ hepatite ________________________

❑ anemia_________________________ ❑ asma __________________________

❑ desidratação___________________ ❑ outros_________________________

DOENÇAS DA INFÂNCIA (época)____

❑ catapora ❑ caxumba,

❑ rubéola ❑ coqueluche

❑ sarampo ❑ outras __________

HOSPITALIZAÇÃO ❑ Sim ❑ Não

Motivo____

CIRURGIA____

MEDICAMENTOS

❑ antibióticos ❑ descongestionante

❑ antinflamatórios ❑ antialérgicos

❑ analgésicos ❑ vitaminas

❑ anticonvulsivo ❑ outros

❑ anticatarral

VACINAS ____

INFORMAÇÕES MÉDICAS ADICIONAIS______________________________________

____

DATA DO ÚLTIMO EXAME MÉDICO________________

6. ANTECEDENTES HEREDITÁRIOS

DOENÇAS NA FAMÍLIA

❑ diabetes______________________ ❑ problemas hematológicos________

❑ problemas cardíacos____________ ❑ outros________________________

❑ problemas respiratórios__________ ________________________

7. ALIMENTAÇÃO

AMAMENTAÇÃO NATURAL

- até quantos meses?______________________
- mama ou mamou no seio à noite? Sim ❑ até ____ meses Não ❑
- toma mamadeira suplementar? Sim ❑ desde ____ meses Não ❑
- desmame (como e quando ocorreu)_____________________________________

____

CONSUMO DE LEITE

❑ leite de vaca

❑ leite de soja

❑ leite de cabra

❑ leite em pó   Marca___________________________________

❑ adoçante   açúcar ❑   mel ❑   outros ❑_______________

❑ leite noturno   Sim ❑ quantos_______   Não ❑

- idade da retirada da mamadeira__________________________

- idade que começou a comer frutas e tomar sopa_______________

- considera a alimentação do seu filho equilibrada? ❑ Sim   ❑ Não

razão ____

ALIMENTAÇÃO ATUAL

Diário de dieta (anexo)
❑ Líquido
❑ Pastoso
❑ Semi-sólido
❑ Sólido

Local de alimentação
❑ Em casa
❑ Na casa de familiares
❑ Na escola
❑ Outros

Utiliza complemento alimentar? Qual?
____

Como é o apetite da criança? Que tipo de alimentos prefere? (doce, salgado....)
____

Costuma beber líquidos durante as refeições? ❑ sim   ❑ não

Costuma mastigar os alimentos ?
❑ Sim, predominantemente à direita
❑ Sim, predominantemente à esquerda
❑ Sim, bilateralmente
❑ não
❑ não sabe

8. HÁBITOS

			FREQUÊNCIA		
TIPO	***SIM***	***NÃO***	***ESPORÁDICO***	***NOITE***	***CONTÍNUO***
Sucção dos dedos					
Sucção de chupeta					
Sucção dos lábios					
Mordedura d0s lábios					
Chupeta e dedos					
Onicofagia					
Bruxismo					
Respiração bucal					
Deglutição atípica					
Fonação anormal					

MARCA OU TIPO DE CHUPETA____

INÍCIO (hábito)_________________________FINAL (retirada do hábito)_________________

MÉTODOS USADOS PARA DOMINAR OS HÁBITOS______________________________

CARACTERÍSTICAS COMPORTAMENTAIS:
❑ agitado ❑ irritado ❑ triste
❑ calmo ❑ ansioso ❑ desanimado
❑ alegre ❑ desatento ❑ atento
❑ normal ❑ outros

9. PESO_________ Kg **ALTURA**_________cm (informação obtida com responsável)

10. AVALIAÇÃO PREVENTIVA

Cárie dental na família ❑ mãe ❑ pai ❑ irmãos

Comentários____

____

____

Higiene dental ❑ escova ❑ fio dental ❑ outros

Freqüência ________________________

Responsável pela escovação ❑ pais ❑ criança ❑ ambos

Informação sobre higiene bucal ❑ sim ❑ não

por____

Água fluoretada ❑ sim ❑ não

Comprimidos ou gotas ❑ sim ❑ não

11. HISTÓRIA DENTAL

Primeira visita ao dentista _____________

Comportamento ❑ Bom ❑ Regular ❑ Ruim

Problemas manifestados

❑ Cárie

❑ Dor de dente - ❑ ao comer ❑ espontânea ❑ à noite

❑ Abcesso - ❑ Inflamação ❑Febre

❑ Dentes manchados

❑ Sangramento gengival

❑ Traumatismo

❑ Dentição decídua: data __________________ idade________________

tipo ___________________ seqüela ______________

tratamento ____________________________________

❑ Dentição mista: data __________________ idade________________

tipo ___________________ seqüela ______________

tratamento ____________________________________

12. QUESTIONÁRIO PARA DIAGNÓSTICO DE DTM

1. Seu(sua) filho(a) tem ou teve:

dor de cabeça? SIM ❑ NÃO ❑ quando?______________________

dor de ouvido? SIM ❑ NÃO ❑ quando?______________________

dor nos olhos? SIM ❑ NÃO ❑ quando?______________________

dor no pescoço? SIM ❑ NÃO ❑ quando?______________________

dor no ombro? SIM ❑ NÃO ❑ quando?______________________

dor na mandíbula? SIM ❑ Lado Direito ❑ Lado Esquerdo ❑ NÃO ❑

2.Sente alguma dor quando mastiga ou abre a boca? SIM ❑ NÃO ❑

3.Tem dificuldade para engolir? SIM ❑ NÃO ❑

4.Tem algum problema para abrir a boca quando: conversa❑ boceja❑ grita❑

Qual?_______________

5.Quando abre a boca você ou ele(a) percebe barulho no ouvido? SIM ❑ NÃO ❑

6.Aperta ou range os dentes? SIM ❑ NÃO ❑ Quando? dia❑ noite❑

7.A mandíbula faz algum ruído? SIM ❑ NÃO ❑ Qual?______________________________

8.Sente a mandíbula cansada? SIM ❑ NÃO ❑ Quando?______________________________

9.Está em tratamento ortodôntico? SIM❑ NÃO ❑

13. EXAME CLÍNICO

a. EXAME EXTRA-BUCAL

____

____

b. EXAME INTRA-BUCAL

- Lábios _________________
- Freios labiais____________
- Comissura______________
- Gengiva_______________
- Língua ________________
- Bochehas_________________
- Freio lingual ____________
- Palato_________________
- Assoalho bucal __________
- Fístula _________________
- Abcesso________________

- Anomalias de forma _____________
- Anomalias de número
  agenesias__________
  supranumerários__________
- Anomalias de tamanho______________
- Anomalias de estrutura______________
- Alterações cromáticas_______________
- Destruições coronárias_______________
- Dentes decíduos anquilosados__________
- Dentes decíduos precocemente perdidos___________________

c. EXAME DA OCLUSÃO MORFOLÓGICA

DENTIÇÃO MISTA

Relações oclusais dos dentes permanentes:

Molares

normoclusão	direito ❑	esquerdo ❑
mesioclusão	direito ❑	esquerdo ❑
distoclusão	direito ❑	esquerdo ❑
topo	direito ❑	esquerdo ❑
cruzamento	direito ❑	esquerdo ❑

Caninos

normoclusão	direito ❑	esquerdo ❑
mesioclusão	direito ❑	esquerdo ❑
distoclusão	direito ❑	esquerdo ❑
topo	direito ❑	esquerdo ❑
cruzamento	direito ❑	esquerdo ❑

Incisivos

trespasse horizontal - normal ❑ sobressaliência ❑ cruzamento ❑

cruzamento isolado ____

trespasse vertical - normal ❑ sobremordida ❑ sobressaliência ❑

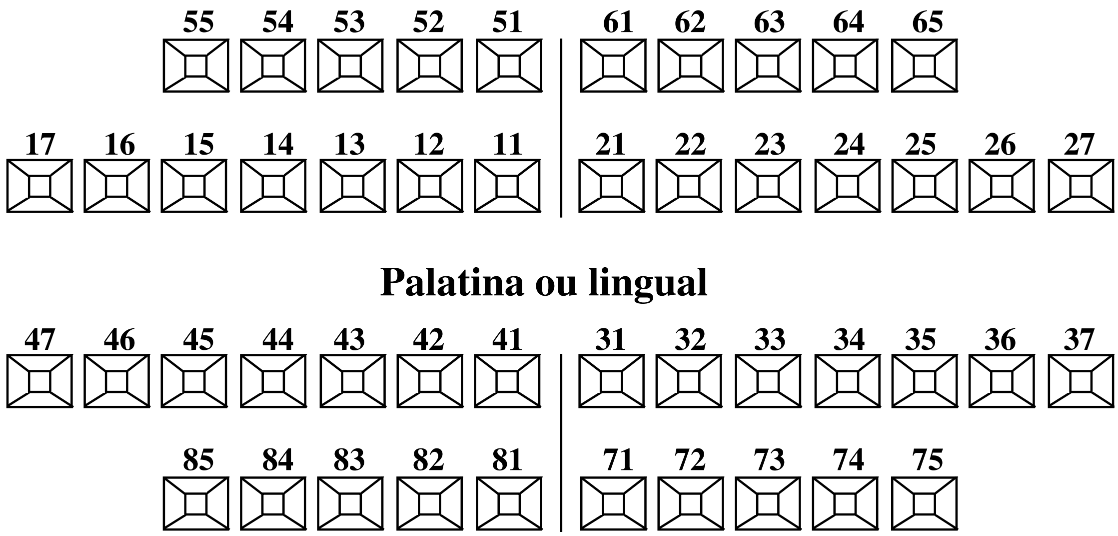
d. EXAME DA OCLUSÃO FUNCIONAL

DESVIO DA MANDÍBULA DURANTE A ABERTURA

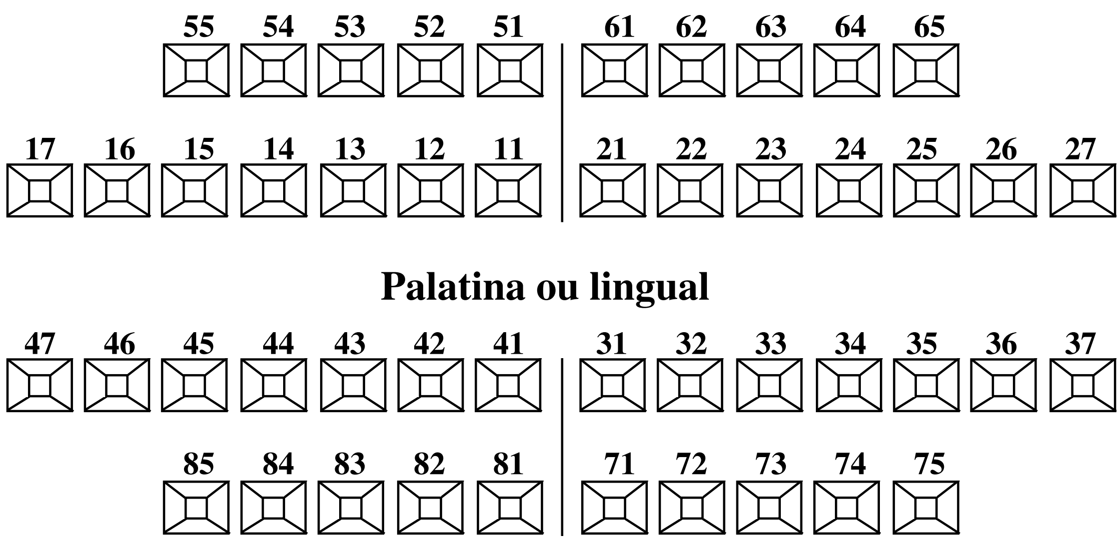
❑ lado direito ❑ lado esquerdo

14. ODONTOGRAMAS

Data____/_____/_____ IPL ____________%



Data____/_____/_____ IPL ____________%



- marcar com 1 círculo os dentes presentes e em erupção

- vermelho - cárie

- azul - tratamento realizado

- verde - restauração presente no exame

- pontilhado - mancha branca

- X - indicado para extração

- / - extraído

15. DESCRIÇÃO GERAL DO ESTADO CLÍNICO E RADIOGRÁFICO SÍNTESE DIAGNÓSTICA

Placa visível / Sangramento gengival (face e dente)

____

____

____

Lesões brancas ativas e passivas (face e dente) - Clínico e Rx

____

____

____

Cavidades ativas e passivas (face e dente)

____

____

____

Restaurações (face e dente)

____

____

____

Risco /atividade de cárie ____

16. PLANO DE TRATAMENTO

____

____

____

____

____

____

____

17. atividades

Data (dia, mês, ano)	Tratamento executado	Aluno	Visto