UNESP – Universidade Estadual Paulista
“Júlio de Mesquita Filho”
Faculdade de Odontologia de Araraquara
Helder Baldi Jacob

AVALIAÇÃO DO CRESCIMENTO NATURAL E INDUZIDO PELO APARELHO EXTRABUCAL DE THUROW MODIFICADO EM CRIANÇAS HIPERDIVERGENTES COM MÁ-OCLUSÃO CLASSE II, DIVISÃO 1 DE ANGLE

Tese apresentada ao Programa de Pós-Graduação em Ciências Odontológicas- Área de Concentração: Ortodontia, da Faculdade de Odontologia de Araraquara, da Universidade Estadual Paulista “Júlio de Mesquita Filho”, para obtenção do título de Doutor em Ortodontia.

Orientador:
Prof. Dr. Ary dos Santos-Pinto
Co-orientador:
Prof. Dr. Peter H. Buschang

Araraquara
2011

Jacob, Helder Baldi.

Avaliação do crescimento natural e induzido pelo aparelho extrabucal de Thurow modificado em crianças hiperdivergentes com má-oclusão classe II, divisão de 1 de Angle / Helder Baldi Jacob. – Araraquara: [s.n.], 2011.

107 f. ; 30 cm.

Tese (Doutorado) – Universidade Estadual Paulista, Faculdade de Odontologia

Orientador: Prof. Ary dos Santos-Filho

Co-orientador: Prof. Dr. Peter H. Buschang

1. Maloclusão de Angle classe II 2. Crescimento e desenvolvimento 3. Aparelhos de tração extrabucal I. Título

Ficha catalográfica elaborada pela Bibliotecária Marley C. Chiusoli Montagnoli, CRB-8/5646

Serviço Técnico de Biblioteca e Documentação da Faculdade de Odontologia de Araraquara / UNESP

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DEDICATÓRIA

Ao Senhor meu DEUS,

Agradeço por mais esta benção concedida. Dedico-te este trabalho, pois nunca me abandonaste, permanecendo em minha mente e em meu coração em todos os momentos de minha vida, tanto nos bons quanto naqueles em que tive de procurá-lo para me confortar. Ofereço-te esta vitória, me comprometendo a destiná-la para o bem daqueles que me rodeiam, através dos caminhos da docência. Que eu continue sempre levando o seu santo nome em minhas atitudes, mente e coração. Agora e sempre. Amém.

Aos meus pais Orson e Marilene,

Responsáveis pela minha educação e formação moral, além de serem um exemplo de honestidade e humildade que tanto me orgulha. Eu realmente tenho orgulho das minhas origens e agradeço a Deus por vocês terem me gerado e criado. Nos momentos de dificuldade, foi em seus ombros que procurei abrigo. Obrigado por tudo o que ainda estão fazendo para que a minha vida seja melhor. Talvez não consiga agradecer o suficiente ou, até mesmo, o devido. A distância imposta pela busca dos nossos sonhos impossibilita, muitas vezes, o sabor do dia-a-dia. A vocês, que muitas vezes, abriram mão de seus sonhos para que eu pudesse alcançar o meu, o meu muito obrigado. Amo vocês.

Aos meus irmãos Melissa, Newman e Marcel,

Muito obrigado pelo apoio dado nos momentos que mais precisei. Nem sempre nos expressamos como devíamos ou nem sempre nos abraçamos quando podíamos, mas sempre tivemos uns aos outros. Apesar da distância, mantenho vocês dentro do meu coração, sentindo saudades do tempo em que vivíamos sob o mesmo teto. Embora seja óbvio, sinto, neste momento, necessidade de dizer, novamente, que Amo vocês.

Ao Ronaldo, um amigo e irmão do peito,

Obrigado pela sua amizade simples e verdadeira. Não há tempo ou distância que enfraqueça nossa amizade. Você é uma pessoa em quem confio e admiro por seus ideais e conduta. Valeu pelas longas conversas para que pudéssemos transpor os obstáculos profissionais ou pessoais. Conte comigo também sempre que precisar.

Muito Obrigado.

___________*AGRADECIMENTOS ESPECIAIS*

Ao meu orientador **Prof. Dr. Ary dos Santos-Pinto,** pela ajuda nesta pesquisa. Admiro sua humildade em partilhar seus conhecimentos. Sua paciência, mesmo passando do horário previsto, sua simplicidade e carisma no exercício da docência são um reflexo do seu caráter. Transformou o meu sonho em objetivo e melhor, em realidade. Muito obrigado.

Ao **Prof. Dr. Peter H. Buschang**, pelos conhecimentos adquiridos e pela honra de ter trabalhado ao lado de um dos grandes nomes mundiais da pesquisa e ensino ortodôntico. Muito obrigado.

Ao **Prof. Dr. Luiz Gonzaga Gandini Jr.,** responsável direto pela minha ida à Baylor College of Dentistry. Agradeço pelos vários anos de convivência e ensinamento. Sinto-me feliz por ter acreditado e confiado na minha pessoa. Sem a sua ajuda esse trabalho não seria realizado. Jamais esquecerei sua força de vontade e dedicação ao meu sonho. Muito obrigado.

À **Fernanda Borges,** que soube me ouvir e apoiar nos momentos difíceis. Sua atenção e carinho me dão ânimo para continuar nessa luta do dia a dia. Nossas vidas caminham em busca de um só objetivo, de um só sonho e sei que estamos no caminho certo. É bom compartilhar com você essa alegria de objetivo cumprido. Muito obrigado por acreditar e confiar em mim.

À **todos os meus amigos**, embora não sendo muitos, são sinceros e sempre prontos a ajudar quando eu mais preciso. Agradeço o apoio e as palavras de incentivo, pois vocês nunca serão esquecidos. Muito obrigado.

AGRADECIMENTOS

À **Faculdade de Odontologia de Araraquara – UNESP**, na pessoa de seu Diretor, **Prof. Dr. José Claudio Martins Segalla**, pela minha formação como Cirurgião-Dentista, Especialista, Mestre e Doutor.

À **Baylor College of Dentistry** e a **Texas A&M Health Science Center** e a todos os seus professores tempo integral e parcial, que muito me auxiliaram no meu doutorado e no meu crescimento pessoal e profissional, na pessoa do chefe de departamento da Ortodontia, **Prof. Dr. Paul Emile Rossouw.**

À **CAPES**, pelo suporte financeiro.

Aos meus professores, **Dr. Ary dos Santos-Pinto, Dr. Dirceu Barnabé Raveli, Dr. João Roberto Gonçalves, Dra. Lídia Parsekian Martins e Dr. Luiz Gonzaga Gandini Jr.**, pelos conhecimentos transmitidos.

Aos **Professores do Departamento de Clínica Infantil** pela convivência pacífica e harmoniosa em todos esses anos.

Aos **Docentes do Curso de Odontologia** da Faculdade de Odontologia de Araraquara pela participação na minha formação tanto na graduação quanto na pós-graduação.

Aos **alunos do Mestrado da Baylor College of Dentistry**, que tornaram os momentos difíceis, fáceis de conviver.

A **Ricardo Fabris Paulin** que foi responsável direto pela triagem e tratamento dos pacientes tratados com o aparelho extrabucal de Thurow modificado.

Aos meus **colegas de Doutorado**, **Ingrid, Luana, Tatiana e Simone** pelo convívio. Estarei sempre à disposição.

Aos **colegas de pós-graduação** de outros anos e de outras disciplinas pela amizade.

Aos meus **amigos residentes em Dallas**, em especial **Douglas e Rosa Rochetti, e Alexandre e Marilise Carvalho** pelo suporte familiar nos Estados Unidos.

À **Carolina Cirelli, Luana Dib, Márcia Gandini, e Renato Martins** pela amizade e companheirismo.

Agradeço à **Seção de Pós-Graduação** da Faculdade de Odontologia de Araraquara, representada pelos seus funcionários, em especial à **Mara Cândida M. Amaral e Rosângela A. Silva dos Santos.**

A todos os **Funcionários do Departamento de Clínica Infantil.**

Agradeço aos **funcionários da Biblioteca** pela orientação precisa sempre que precisei.

Aos **funcionários do Gestos,** obrigada por sempre me ajudarem.

Aos **pacientes**, obrigado pela confiança e colaboração.

E a **todos** que contribuíram de alguma forma na realização desse trabalho.

SUMÁRIO

RESUMO

Jacob HB. Avaliação do crescimento natural e induzido pelo aparelho extrabucal de Thurow modificado em crianças hiperdivergentes com má-oclusão Classe II, divisão 1 de Angle [Tese de Doutorado]. Araraquara: Faculdade de Odontologia da UNESP; 2011.

RESUMO

Introdução: O presente trabalho foi consubstanciado em três capítulos como se segue: Capitulo I – Mudanças verticais no crescimento craniofacial em indivíduos franco-canadenses entre os 10 e 15 anos de idade; Capítulo II – Tratamento da má-oclusão de Classe II usando aparelho extrabucal com puxada alta, associado à cobertura acrílica maxilar: uma revisão sistemática; Capítulo III – Componentes dentários e esqueléticos da correção da má-oclusão Classe II associada à mordida aberta, induzidos pelo tratamento com o aparelho extrabucal de Thurow modificado. **Proposição:** O capitulo I propôs prover dados de referência para as mudanças de crescimento vertical, avaliar as associações entre as medidas comumente utilizadas para classificar o fenótipo do individuo, determinar se os indivíduos mantêm ou não sua classificação inicial após o período de crescimento e comparar as mudanças ocorridas entre os três fenótipos. O capitulo II propôs avaliar, na literatura, as mudanças esqueléticas e dentárias induzidas pelo tratamento com aparelho extrabucal associado à cobertura acrílica oclusal e às melhorias nas relações vertical e ântero-posterior. O capitulo III propôs avaliar as mudanças esqueléticas e dentárias induzidas pelo aparelho extrabucal de Thurow modificado. **Material e Método:** Capítulo I: foram incluídos 228 indivíduos adolescentes franco-canadenses (119 masculinos e 109 femininos) entre 10 e 15 anos de idade. Cada indivíduo apresentava pelo menos 4 telerradiografias em norma lateral seriadas dos 10 aos 15 anos de idade (1303 telerradiografias). Capitulo II: foi realizada uma busca sistemática da literatura por meio de critérios de inclusão e exclusão usando bancos de dados eletrônicos e manuais. Capitulo III: foram avaliadas as mudanças naturais e induzidas pelo tratamento da Classe II em grupo experimental (13 indivíduos), tratado com o aparelho extrabucal de Thurow modificado, e em um grupo controle (22 indivíduos). Os grupos apresentavam no início do tratamento as mesmas características quanto à idade (8.85 anos para grupo tratado e 8.82 para grupo controle) e ao ângulo do plano mandibular (35.97° para grupo tratado e 36.27° para controle). O tempo de acompanhamento dos dois grupos foi o mesmo (12 meses). **Resultados e Conclusões:** No capitulo I verificou-se que as medidas tipicamente usadas para avaliar as mudanças verticais de crescimento alteram-se significantemente durante o período de crescimento. As mudanças são maiores nos adolescentes masculinos quando comparadas aos femininos. Enquanto a maioria dos indivíduos mantém seu fenótipo de crescimento vertical facial alguns poucos melhoram ou pioram suas características. No capitulo II observou-se que o aparelho extrabucal com *splint* maxilar age melhorando as relações verticais e horizontais entre a maxila e mandíbula. Efeitos como restrição ao deslocamento distal da maxila e controle de erupção vertical e distalização de molares superiores foram obtidos. No capitulo III observou-se que o aparelho de Thurow modificado controla os deslocamentos vertical e horizontal da maxila, rotacionando o plano oclusal de maneira favorável à correção da mordida aberta e diminui a altura inferior facial sem, contudo, mostrar efeitos significativos na mandíbula.

Palavras-chave: Maloclusão de Angle classe II; crescimento e desenvolvimento; aparelhos de tração extrabucal**;** cefalometria.

ABSTRACT

Jacob HB. Evaluation of natural growth induced by Modified Thurow appliance in hyperdivergent adolescents with class II division 1 malocclusion [Tese de Doutorado]. Araraquara: Faculdade de Odontologia da UNESP; 2011.

ABSTRACT

Introduction: The present study was consubstantiated in three chapters as follows: Chapter I – Craniofacial vertical changes in French-Canadians subjects between 10 to 15 years of age; Chapter II –Treatment of class II malocclusion using High-Pull Headgear with a splint: a systematic review; Chapter III- Dental and Skeletal components of class II open-bite treatment with a Modified Thurow Appliance. **Material and Methods:** Chapter I: data were collected from the sample of French-Canadians population. 228 adolescents subjects were included (119 male and 109 female) between 10-15 years of age. Each subject had at least four serial radiographs available. Additionally, the first and the last one radiographs were necessarily taken, respectively, at 10 and 15 years of age. Thus, 1303 lateral cephalograms were used. Chapter II: based on inclusion and exclusion criteria, four articles were selected from a literature research, in order to obtain the data. Chapter III: two groups were assessed. They were divided into experimental group (13 subjects) and a control group (22 subjects). Both groups had before treatment the same features as for age (8.85 years of age for the treated group and 8.82 for the untreated group), and as for mandible plane angle (35.97° for the treated group and 36.27° for the untreated group). The groups were followed up for 12 months. **Proposition:** The chapter I aimed to provide reference data for vertical growth changes, evaluate the associations among the measures commonly used to classify the patients phenotype. The chapter II, evaluated in literature, skeletal and dental changes occurred in class II malocclusion treatment, using High-pull headgear appliance with a splint and also the improvement on vertical and anteroposterior relationships. The chapter III analysed skeletal and dental changes caused by Modified Thurow Appliance. **Results and Conclusions:** In the chapter one, was concluded that the measures typically utilized to evaluate vertical growth changes alter significantly during growth period. These changes are greater in male than in female subjects. Whereas in majority of the adolescents the vertical growth phenotype was maintained, in a few others the characteristics were improved or worsened. The chapter II showed that the High-pull headgear cause dental and skeletal effects and improves the vertical and horizontal maxillary-mandibular relationships. The chapter III demonstrated that Modified Thurow Appliance controls the maxilla vertical and horizontal displacement, causing a rotation in the oclusal plane.

Key words: Class II malocclusion; growth and development; extrabucal appliances.

INTRODUÇÃO GERAL

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A sociedade atual caracteriza-se pelo estabelecimento de rígidos padrões de preferência estética[26] e sendo a face uma característica chave na determinação da atratividade física do ser humano[27], cada vez mais pessoas procuram o tratamento ortodôntico quando sua aparência dentofacial desvia-se das normas sociais e culturais[17]. A face depende de um estado de equilíbrio e harmonia das proporções estabelecidas pelas estruturas que a compõem como dentes, esqueleto craniofacial e tecidos moles[23]. As má-oclusões são caracterizadas pelo desequilíbrio do sistema estomatognático, ou seja, a desarmonia entre as estruturas esqueléticas, dentárias e neuromusculares, apresentando uma grande prevalência na população e manifestando-se precocemente.

A determinação do padrão esquelético é uma importante ferramenta do diagnóstico ortodôntico e, a fim de analisar e entender a má-oclusão, não é apenas necessário observar a relação entre dentes maxilares e mandibulares mas também os ossos basais em que esses dentes estão posicionados. Embora ortodontistas tradicionalmente foquem as relações dentoesqueléticas ântero-posteriores, muitas má-oclusões são devidas ao desenvolvimento vertical anormal. Dois tipos faciais distintos têm sido relatados na literatura: hiperdivergente e hipodivergente que são geralmente associados à mordida aberta e à mordida profunda, respectivamente[22]. Um completo entendimento do normal e anormal do crescimento vertical é necessário para avaliar e, mais efetivamente, tratar pacientes com fenótipos hiper ou hipodivergentes[16].

Em termos de tipo facial, o fenótipo hiperdivergente é associado com excessiva altura facial ântero-inferior relativa à ântero-superior. A altura da face posterior tende a ser aproximadamente metade da face anterior, associada a um ramo mandibular curto. As discordantes dimensões produzem um efeito cumulativo que resulta em uma face anterior alongada. Por definição, sujeitos hiperdivergentes têm o ângulo do plano mandibular aumentado, associado com um padrão de crescimento de rotação para baixo da mandíbula, aumentando dessa forma a altura facial ântero-inferior[9,11,20,24,33,35,40]. Enquanto alguns investigadores notaram uma inclinação para baixo da região posterior do palato em pacientes hiperdivergentes quando comparados com indivíduos dentro dos limites considerados normais[20,24,32,33,40,], outros não notaram essa diferença[9,38]. A altura facial posterior de indivíduos hiperdivergentes também apresenta controvérsias com alguns estudos mostrando alturas menores[21,33] e outros não encontraram diferenças[2]. Ambas as alturas dentofaciais (excessiva[35,37] e normal[30]) foram relatadas em indivíduos hiperdivergentes.

Há vários fatores que poderiam explicar essas controvérsias mas, talvez, o maior deles possa ser que os estudos anteriores[4,22,29,30] não possuíam amostras suficientemente grandes para eliminar a possibilidade de erro tipo II (por exemplo, apresentar diferença entre grupos quando na verdade não existia). Indivíduos hiperdivergentes foram, na grande maioria das vezes, caracterizados sem uma comparação a uma amostra de indivíduos normais ou essa amostra não possuía tamanho adequado. Enquanto várias medidas têm sido utilizadas para classificar má-oclusões verticais, sua validade ainda necessita ser estabelecida. No único estudo que estatisticamente avaliou se as medidas usadas realmente refletem os aspectos da discrepância vertical, Dung e Smith[10] mostraram alta correlação somente entre o plano mandibular e a proporção da altura facial póstero-anterior. Embora vários trabalhos possam ser encontrados na literatura onde foram avaliados problemas verticais[7,10,11,21,28,32,38], uma amostra representativa da população com maior número de indivíduos faz-se necessária pois seria de grande valia para a estimativa dos percentis, que não são possíveis em amostras pequenas.

Em indivíduos hiperdivergentes a posição ântero-posterior da maxila e da mandíbula claramente mostra ser retrusiva[9,33,38]. Baseado nos achados da literatura[7], o tratamento de pacientes hiperdivergentes deve ser direcionado a corrigir problemas nos três planos do espaço (vertical, ântero-posterior e transversal). Estudando os componentes da má-oclusão Classe II, McNamara[19] mostrou que a retrusão esquelética da maxila foi encontrada em conjunção com o excessivo desenvolvimento vertical, o mesmo podendo ser aplicado à mandíbula. A má-oclusão Classe II, Divisão 1 caracteriza-se pelo relacionamento da cúspide mésio-vestibular do primeiro molar superior ocluindo mesialmente o sulco mésio-vestibular do primeiro molar inferior[1]. Certos casos com esse tipo de má-oclusão mostram desvios morfológicos restritos aos dentes e osso alveolar, enquanto outros envolvem desarmonias de bases ósseas com características marcantes que se distribuem de forma variável nas dimensões ântero-posterior, vertical ou transversal.

A má-oclusão Classe II é o fenótipo hiperdivergente mais comum e, normalmente, requer redução na altura dentoalveolar na maxila e mandíbula, redução no ângulo goníaco, aumento na inclinação do plano palatino, expansão maxilar e rotação anti-horária do plano mandibular[7]. Em contraste, indivíduos hiperdivergentes Classe III surgem com menos freqüência e são mais difíceis de serem tratados não cirurgicamente[7].

Aparelhos extra-bucais com puxada alta são tradicionalmente o aparelho de escolha para tratar indivíduos com má-oclusão Classe II hiperdivergentes. Os aparelhos extrabucais podem ser inseridos em bandas cimentadas em molares maxilares ou em aparelhos removíveis. Se a terapia utilizando aparelhos extra-bucais causa mudanças esqueléticas na maxila em humanos, isso ainda permanece controverso[2,3,6,15]. O aparelho de Thurow foi desenvolvido para aplicar forças distais e verticais, controlando o movimento dos molares maxilares. O aparelho original, que incorpora uma puxada alta e cobertura acrílica maxilar, que serve como um “bite-block” aumentando também a unidade de ancoragem, mostrou restringir o crescimento maxilar, a inclinação dos dentes maxilares e a erupção dos dentes posteriores[8,34]. Tem sido reportado que o aparelho de Thurow pode diminuir o ângulo ANB, inibir o deslocamento horizontal da maxila, controlar o seu crescimento vertical, manter o ângulo do plano mandibular, mover os molares superiores distalmente e melhorar a relação labial[12,14,31,36,37,39]. Contudo, esses achados foram baseados em estudos de casos clínicos ou estudos sem um grupo controle adequado. Estudos prévios de casos-controle não foram hábeis em distinguir entre as mudanças dentoalveolares e esqueléticas produzidas pelo aparelho[8,25,41].

Conhecer o crescimento natural do ser humano é essencial para o diagnóstico de anormalidades ou patologias que possam ocorrer durante a vida do indivíduo[5]. Neste sentido, o estudo do processo natural de crescimento e desenvolvimento é de suma importância para um correto diagnóstico de alterações maxilo-mandibulares e, a fim de determinar o adequado momento para se estabelecer o tratamento, é importante verificar se o padrão de crescimento em pacientes hiper ou hipodivergentes permanece estável ou não. Aparelhos extra-bucais têm mostrado efetividade na modificação do crescimento maxilar quando associados a coberturas oclusais[5,25,39,41] mas, até os dias de hoje, os efeitos do tratamento com essa abordagem terapêutica não foram estudados através de revisão sistemática. Já a capacidade de diferenciar a correção por contribuição dental ou esquelética, pelo uso do aparelho de Thurow modificado, é importante para assegurar que os objetivos do tratamento possam ser atingidos. Clinicamente, o entendimento dos efeitos do aparelho de Thurow é vital para a correção da má-oclusão de Classe II em pacientes hiperdivergentes em crescimento.

Portanto, a importância deste estudo em conhecer as mudanças verticais naturais ocorridas no período da adolescência com uma amostra grande, não tratada, torna-se necessária para suprir a necessidade de eliminar as inconsistências encontradas em outros trabalhos bem como para servir de referência para avaliar as mudanças induzidas no crescimento maxilo-mandibular pelo aparelho de Thurow modificado, distinguindo quais as respostas dentoalveolares e esqueléticas que ocorreram.

PROPOSIÇÃO GERAL

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O objetivo deste trabalho é o de avaliar o crescimento e desenvolvimento maxilo-mandibular esquelético e dento-alveolar, naturais e induzidos pelo tratamento ortopédico da má-oclusão de Classe II, divisão 1, com o aparelho extrabucal.

Os objetivos específicos do trabalho são:

1) prover dados de referência para mudanças de crescimento vertical que ocorrem na adolescência;
2) avaliar as associações entre as medidas usadas para descrever o desenvolvimento vertical;
3) determinar se os sujeitos classificados como hiperdivergentes, dentro de limites normais ,e hipodivergentes mantêm sua classificação na adolescência;
4) comparar mudanças de crescimento entre os diferentes tipos de fenótipo na adolescência;
5) realizar uma revisão sistemática da literatura sobre as mudanças na quantidade e direção do crescimento esquelético, erupção dentária e melhorias no relacionamento ântero-posterior produzidos com splint maxilar;
6) avaliar as mudanças na quantidade e direção do crescimento esquelético, erupção dentária e melhorias no relacionamento ântero-posterior produzidas pelo aparelho de Thurow modificado.

Considerando as particularidades de cada objetivo específico, foram eles tratados em capítulos distintos de forma a facilitar a análise e compreensão dos resultados inerentes à proposição inicial do trabalho como um todo.

CAPÍTULOS

CAPÍTULO 1

Vertical craniofacial growth changes in French-Canadians subjects between 10 to 15 years of age*(Mudanças verticais no crescimento craniofacial em indivíduos franco-canadenses entre os 10 e 15 anos de idade)*

*Artigo submetido e aceito para publicação na American Journal Orthodontics and Dentofacial Orthopedics. Formatação e referências seguindo as normas da publicação da revista.

CAPÍTULO 2

Treatment of Class II malocclusion using high-pull headgear with a splint: a systematic review*(Tratamento da má-oclusão Classe II usando aparelho extrabucal com splint: uma revisão sistemática)*

*Artigo submetido para publicação na Dental Press Journal of Orthodontics. Formatação e referências seguindo as normas da publicação da revista.

CAPÍTULO 3

Dental and skeletal components of Class II open-bite treatment with a modified Thurow appliance*(Componentes dentários e esqueléticos da Classe II com mordida aberta tratados com aparelho modificado de Thurow)*

*Artigo submetido para publicação na Dental Press Journal of Orthodontics. Formatação e referências seguindo as normas da publicação da revista.

CAPÍTULO 1

*VERTICAL CRANIOFACIAL GROWTH CHANGES FRENCH-CANADIANS SUBJECTS BETWEEN 10 TO 15 YEARS OF AGE**

*Artigo submetido e aceito para publicação na American Journal Orthodontics and Dentofacial Orthopedics. Formatação e referências bibliográficas seguindo as normas da publicação da revista.

RESUMO

Introdução: Este estudo 1) descreveu as modificações do crescimento vertical que ocorreram em pacientes adolescentes não tratados e 2) analisou a validação das medidas comumente utilizadas para classificar as tendências de crescimento verticais. **Material e Método:** A amostra consistiu de 228 indivíduos (119 masculinos e 109 femininos) entre 10 e 15 anos de idade com oclusão normal ou má-oclusões e que tiveram telerradiografias laterais (N=1303) tiradas anualmente. Baseados em 6 pontos, 3 ângulos cefalométricos (PPA,MPA,PP/MPA), e 2 relações (PFH:AFH e UFH:LFH) foram medidos. Uma análise multinível foi realizada para cada curva de crescimento, e os valores estimados foram avaliados através do SPSS. **Resultados:** As variações dos crescimentos para cada uma das 5 medidas seguiram basicamente modelos polinomiais (linear ou quadrado). Em média, PPA e PFH:AFH aumentaram, enquanto que MPA e PP/MPA diminuíram. A proporção UFH:LFH aumentou durante os primeiros anos e depois diminuiu. MPA,PP/MPA, e PFH:LFH mostraram relativamente alta intercorrelação; PPA demonstrou uma correlação moderada para baixa com UFH:LFH; UFH:LFH mostrou uma correlação moderada com PP/MPA. Aproximadamente 75-86% dos indivíduos mantiveram a sua classificação inicial. Os indivíduos classificados como hiperdivergentes aos 15 anos de idade demonstraram mudanças significativas maiores no crescimento do que aqueles classificados dentro dos limites normais ou hipodivergentes. **Conclusões:** As medidas tipicamente utilizadas para classificar as tendências do crescimento vertical mudaram significativamente durante a adolescência, sendo maiores essas mudanças nos indivíduos masculinos do que nos femininos. Enquanto que MPA,PFH:AFH, e PP/MPA mediam o mesmo fenótipo, PPA e UFH:LFH foram relativamente independente das outras medidas. A maioria dos indivíduos estudados manteve o mesmo padrão vertical, porém, alguns pioraram e outros obtiveram melhora em seu padrão facial.

ABSTRACT

Introduction: Due to limited available reference data, this study 1) described the vertical growth changes that occur in untreated adolescents 10-15 years of age and 2) evaluated the validity of measures commonly used to classify patients' vertical growth tendencies. **Methods:** The sample consisted of 228 subjects (119 males and 109 females) between 10 and 15 years of age with normal or malocclusions who had lateral cephalograms (N=1303) taken annually. Based on 6 landmarks, 3 angles (PPA, MPA, PP/MPA) and 2 proportions (PFH:AFH and UFH:LFH) were calculated. To reduce error, each subject's growth curve was estimated using multilevel modeling procedures, and the estimated values were analyzed using SPSS. **Results:** Growth changes between 10-15 years for each of the five measures followed relatively simple (linear or quadratic) polynomial models. On average, PPA and PFH:AFH increased, while the MPA and PP/MPA decreased. The UFH:LFH ratio increased during the first few years and then decreased. MPA, PP/MPA, and PFH:AFH showed moderately high intercorrelations; PPA displayed moderate to moderate low correlations with UFH:LFH; UFH:LFH showed a moderate correlation with PP/MPA. Approximately 75-86% of the individuals classified as hyper- or hypodivergent at 10 years maintained their classification. Subjects classified as hyperdivergent at 15 years of age showed significantly greater growth changes than subject classified as within normal limits, who in turn showed greater changes than hypodivergent subjects. **Conclusions:** Measures typically used to classify vertical growth tendencies changed significantly during adolescence, with males generally showing greater changes than females. While MPA, PFH:AFH, and PP/MPA were measuring the same phenotypic attribute, PPA and UFH:LFH were relatively independent of other three measures. While most subjects maintained their vertical facial types, some worsened and other improved.

INTRODUCTION

Even though orthodontists have traditionally focused on anteroposterior dentoskeletal relationships, many malocclusions are due to abnormal vertical development. A thorough understanding of both normal and abnormal vertical growth is necessary to evaluate developing malocclusions[1] and more effectively treat patients with hyper- and hypodivergent phenotypes.

While various measures have been used to classify vertical malocclusions, their validity remains to be established. Classifications have been based on dental overbite,[2,3] the upper-to-lower anterior facial height ratio,[4] posterior-to-anterior facial height ratio,[5] the mandible plane angle,[6-12] the palatal plane angle,[11, 13-15] the palatal-to-mandibular plane angle,[6,16] the gonial angle,[11-13,17-18] and even on the perception of increased or reduced lower facial height.[19] In the only study that has statistically evaluated whether typically used measures reflect the same aspects of vertical discrepancy, Dung and Smith[20] showed a high correlation (0.90) only between the mandibular plane angle and posterior-to-anterior facial height ratio; of the remaining 20 correlations, four were moderately low and the rest were low or very low. If the various measures are more or less independent of each other, they represent different phenotypic attributes and cannot be used interchangeably for vertical classification of patients.

Existing reference data for longitudinal vertical growth of adolescents are inconsistent and limited. The palatal plane angle has been reported to increase between 10-15 years for females,[21-23] and decrease for males.[23,24] With the sexes combined, the palatal plane has been shown to both increase[2,25] and decrease.[26] The upper to lower facial height and the posterior to anterior facial height ratios have also been reported to both increase[21-23] and decrease[21-23] during adolescence, depending on the sample and sex. While most studies have shown that the mandibular plane angle decreases during adolescence,[2,22-28] Bhatia[21] showed slight increases between 10-15 years. The palatal to mandible plane angle is the only measure showing consistent changes (increases) across studies.[21-24,27] Important, existing longitudinal reference data[21-23] for adolescent vertical development are based on relatively small samples (usually <75 subjects), making it difficult to estimate the extreme percentiles, where many of the orthodontic patients might be expected to be located.

In order to determine the appropriate timing of treatment, it is also important to determine whether the growth patterns of untreated as hyper- or hypodivergent patients remain stable. Based on a sample of 20 males and 15 females, Bishara et al[29] showed that 77% maintained their facial type between 5 and 25.5 years of age; the rest normalized, became more hyperdivergent or more hypodivergent. Based on a larger sample, it has also been shown that 33-64% of individuals classified as having either high, average or low mandibular plane angles at 6 years of age maintained their classification through 15 years of age.[30] The individuals' mandibular plane angles both improved or worsened over time, but the differences average out because the growth curves representing the high, average or low angle subsamples maintained the group differences between 6-15 years.

Larger sample sizes and more reliable estimates of vertical growth are necessary to reconcile the existing inconsistencies. This project's overall aim was to describe the vertical growth changes that occur during adolescence. The specific aims were to:

1. provide reference data for the vertical growth changes that occur;
2. evaluate the associations between measures used to describe vertical development;
3. determine whether subjects classified as hypodivergent, within normal limits, or hyperdivergent maintain their classifications between 10 and 15 years of age, and;

4. compare growth changes of subjects classified as hypodivergent, within normal limits, or hyperdivergent.

MATERIALS AND METHODS

The French-Canadian sample was collected by the Human Growth Research Center, University of Montreal, Canada. The subjects were drawn from three randomly selected schools districts representing the socioeconomic background of the larger population.[31] Within each of the districts, the individuals were chosen at random from 107 schools, which had also been chosen at random. This mixed-longitudinal sample included 228 untreated adolescents (119 males and 109 females) between 10 and 15 years of age, with normal occlusion and malocclusions. Each subject included in the sample had at least four serial radiographs available.

Data collection and analysis

Lateral cephalograms (total N=1303) were taken annually, usually within ± 12 days of the subjects' birthdays. Based on six landmarks identified on each tracing, the following three angles and two proportions were computed:

1. Palatal Plane Angle (PPA; S-N/ PNS-ANS): the angle formed by the anterior cranial base and the palatal plane;
2. Mandibular Plane Angle (MPA; S-N/Go-Me): the angle formed by the anterior cranial base and the mandibular plane;
3. Palatal Plane-Mandibular Plane Angle (PP/MPA): the angle formed by the palatal plane and the mandibular plane;
4. Posterior and Anterior Facial Height Proportion (PFH: AFH; S-Go: N-Me): the ratio of posterior facial height to anterior facial height;

5. Upper and Lower Facial Height (UFH: LFH; N-ANS: ANS-Me): the ratio of upper facial height and lower facial height.

The cephalograms were traced on acetate paper and the landmarks were digitized by a single operator. Replicate analyses of 60 randomly chosen cephalograms produced reliabilities for the six landmarks ranging between 0.947 and 0.996, and method errors ranging between 0.15 mm and 0.72 mm.

Statistical analysis

The first step of the analysis was to determine the shapes of the subjects' average growth curves between 10 to 15 years of age. To this end, multilevel procedures[32,33] were used to derive sex specific polynomial for each of the five measures. Males and females were evaluated separately due to well established growth differences.[21-24] The shape of the average growth curve was determined by the order of the polynomial, which was estimated by the fixed part of the model. A linear polynomial is a straight line; a quadratic polynomial describes a curve. The terms of the polynomials provide information about the average size of the measure at 12.5 years of age (constant term), the yearly growth changes (linear term), and growth acceleration or deceleration (quadratic term). The random part of the model estimated between subject variation between subjects at one level and between ages, nested within subjects, at another level. Iterative generalized least squares were used to estimate the model parameters. Multilevel models (see Hoeksma and van der Beek[34] for a more complete explanation of the procedures) are well suited for assessing mixed longitudinal[35] and have proven to be especially well suited for evaluating craniofacial growth.[36-39]

Having determined the expected shape of the curves (i.e. based on the order of the polynomials), each individual's growth curves were estimated based on the average polynomials. In other words, each subject had a polynomial the same order as the average polynomial that described his/her growth curves for each of the five measures. The multilevel procedures provided residuals (differences between the average polynomial terms and each subject's polynomial terms) for each of the each subjects' polynomials. The residuals made it possible to compute a separate and different growth curve for each subject. Because the polynomials represent the 'best fit' of each individual's curve, they eliminate within subject variance (i.e. technical error) and provide error free (adjusted) growth estimates. Using each subject's polynomial, adjusted growth estimates were computed at each whole year between 10 and 15 years of age.

Based on the subjects' error free estimates, percentiles were calculated for each of the measures. The sample sizes made it possible to estimate the 5^{th} and the 95^{th} percentiles, as well as the 25^{th}, 50^{th} and 75^{th} percentiles. The individuals' estimates at 10 and 15 years of age were used to classify them as hypodivergent (below the 25^{th} percentile), within normal limits (between the 25^{th} and 75^{th} percentiles) or hyperdivergent (above the 75^{th} percentile), and to evaluated changes in classification over time.

Pearson product-moment correlations were used to estimate the interrelationships between the five measures at 15 years of age. Finally, analyses of variance, with Bonferroni *post hoc* comparisons, were performed to evaluate group differences in the growth changes that occurred between 10 and 15 years of age analyses were performed using SPSS (Version 15, SPSS Inc., Chicago, Ill) and a .05 level of significance.

RESULTS

The multilevel models showed significant growth changes and sex differences for all of the measures (Tables 1 and 2). The polynomial models, explaining

92.5-95.7% of the total variation, followed either linear or quadratic patterns of change over time. The PPA, which was significantly larger in females than males at 12.5 years of age, increased significantly more over time in males (Figure 1). The MPA was larger in females, but decreased significantly more between 10-15 years of age in males. The PP/MPA angle decreased linearly in males, and curvilinearly in females (i.e. they decreased more before 12.5 years of age than after). The PFH:AFH ratio was significantly larger and increased more in males than females. The UFH:LFH ratio increased between 10-12 years and then decreased between 13-15 years of age, resulting in little or no change between 10-15 years in females and a slight increase over time in males. Percentile distributions were estimated based on the values computed from each of the individuals' growth curves (Table 3 and 4).

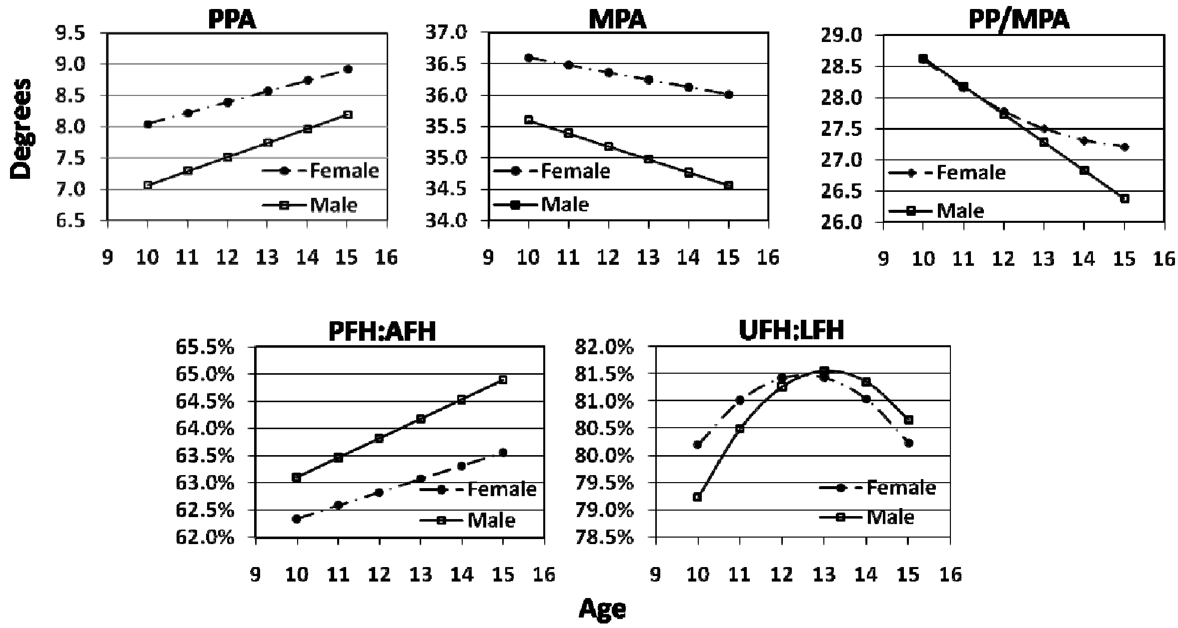

Figure 1. Longitudinal changes of five vertical measures between 10 and 15 years of age.

Table 1. Polynomial models describing the growth changes between 10 and 15 years of measures of vertical discrepancy.

			Constant (at 12.5 yrs)		Linear		**Quadratic**	
Variable	Units	Sex	Estimate	SE	Estimate	SE	Estimate	**SE**
PPA	deg	Male	7.6252	.26965	.22683	.032211	-.026811	**.013582**
		Female	8.4813	.21956	.17423	.031785		
MPA	deg	Male	35.073	.40361	-.20846	.044672		
		Female	36.305	.42807	-.11612	.0059376		
PP/MPA	deg	Male	27.500	.39719	-.44789	.046818		
		Female	27.629	.43560	-.27898	.048177	.044448	**.020616**
PFH:AFH	%	Male	.63998	.0031156	.0035563	.00033898		
		Female	.62945	.0033643	.0024354	.00040530		
UFH:LFH	%	Male	.81472	.0062580	.0028390	.00075270	-.0024350	**.00030463**
		Female	**.81478**	**.0055723**	**.000061298**	**.00068954**	**-.0020210**	**.00032739**

PPA of 10 year-old males =7.6252 + [.22683*(10-12.50)]-[.026811*(10-12.5)^2]

Table 2. Estimates of random variation between subjects, and between measurement occasions nested within subjects.

		Between Subjects Variation			**Within Subject Variation**
Variable	Sex	Constant	Linear	Quad	**Constant**
PPA	Male	8.8013	.092876	.0081867	**.46624**
	Female	6.0430	.085791		**.36678**
MPA	Male	19.920	.15403		**1.3378**
	Female	22.943	.27806		**1.5901**
PP/MPA	Male	19.263	.17186		**1.4056**
	Female	23.591	.17730	.012212	**1.0489**
PFH:AFH	Male	.11841	.00076783		**.0095829**
	Female	.14246	.0011978		**.0085664**
UFH:LFH	Male	.47353	.0051109	.00035919	**.025582**
	Female	**.37958**	**.0035245**	**.00041381**	**.024374**

Table 3. Percentile distribution for vertical discrepancy measures of French-Canadian males and females between 10 and 15 years of age.

		Age (years)											
		Male						Female					
Measurement	Percentiles	10	11	12	13	14	15	10	11	12	13	14	15
PPA (degrees)	5th	2.18	2.18	2.20	2.29	2.35	2.51	4.53	4.82	4.85	4.85	4.91	4.86
	25th	5.20	5.32	5.57	5.87	5.86	5.69	6.39	6.54	7.08	7.08	7.15	7.30
	50th	7.15	7.29	7.54	7.79	7.98	8.08	8.07	8.20	8.52	8.52	8.68	9.07
	75th	9.24	9.49	9.68	9.90	10.17	10.44	9.39	9.56	9.84	9.84	10.06	10.35
	95th	11.89	12.04	12.27	12.53	12.71	12.83	12.08	12.22	12.86	12.86	13.34	13.68
MPA (degrees)	5th	26.91	27.00	27.19	27.27	27.27	27.37	27.46	28.03	28.37	28.69	29.03	29.26
	25th	32.10	31.86	31.76	31.88	31.71	31.68	33.65	33.81	33.81	33.91	33.68	33.75
	50th	35.20	35.12	34.97	34.78	34.55	34.35	36.35	36.30	36.25	36.26	36.04	35.99
	75th	39.32	38.89	38.60	38.16	37.61	37.28	39.89	39.53	39.14	38.83	38.28	38.30
	95th	44.46	44.22	43.41	42.81	42.10	42.29	44.95	44.78	44.28	43.81	43.89	43.96
PP/MPA (degrees)	5th	21.46	21.38	21.07	21.07	20.82	20.57	19.30	19.63	19.74	19.74	19.85	20.10
	25th	25.24	24.75	24.21	24.21	23.91	23.62	24.64	25.08	25.41	25.33	25.49	24.96
	50th	28.26	27.75	26.58	26.58	25.93	25.78	27.97	28.09	27.91	27.68	27.51	27.61
	75th	32.08	31.34	30.22	30.22	29.87	29.50	31.14	30.91	30.54	30.18	29.68	29.45
	95th	38.66	37.92	36.45	36.45	35.28	34.21	36.86	36.74	36.29	35.86	35.49	35.47
PFH:AFH (%)	5th	58.35	58.50	58.63	58.62	58.97	59.13	57.12	57.39	57.50	57.62	57.74	57.85
	25th	60.92	61.17	61.41	61.68	61.95	62.13	59.91	59.97	60.17	60.31	60.38	60.29
	50th	62.72	63.27	63.60	64.07	64.45	64.86	62.14	62.41	62.70	62.99	63.17	63.54
	75th	65.28	65.69	65.88	66.36	66.89	67.37	64.34	64.52	64.73	64.88	65.24	65.51
	95th	68.95	69.61	70.15	70.96	71.55	71.87	67.62	68.18	68.73	69.31	69.88	70.48
UFH:LFH (%)	5th	71.19	69.84	68.85	68.86	68.26	66.85	70.31	70.06	69.72	69.67	69.57	69.40
	25th	78.27	77.37	76.78	76.70	76.41	75.66	78.72	77.95	77.49	77.49	77.09	76.42
	50th	82.33	82.33	82.33	82.28	81.73	80.45	83.50	82.76	82.15	81.99	81.38	80.50
	75th	87.10	86.57	86.75	86.94	87.20	86.57	87.09	86.06	85.57	85.48	85.03	84.06
	95th	92.72	92.51	92.63	92.67	92.79	93.00	92.01	90.82	90.41	90.71	90.73	89.86

Table 4. Percentile distribution for growth changes (yearly and five yearly) of vertical growth measures of French-Canadian males and females between 10 and 15 years of age.

		Age (years)											
		Male						Female					
Measurement	Percentiles	10-11	11-12	12-13	13-14	14-15	10-15	10-11	11-12	12-13	13-14	14-15	10-15
PPA (degrees)	5th	-0.02	-0.06	-0.16	-0.45	-0.71	-0.79	-0.25	-0.51	0.00	-0.25	-0.25	-1.26
	25th	0.22	0.15	0.05	-0.05	-0.15	0.26	-0.03	-0.05	0.00	-0.03	-0.03	-0.13
	50th	0.35	0.29	0.24	0.16	0.12	1.21	0.20	0.40	0.00	0.20	0.20	0.99
	75th	0.46	0.42	0.43	0.46	0.49	2.14	0.35	0.69	0.00	0.35	0.35	1.74
	95th	0.66	0.57	0.59	0.74	0.80	2.94	0.63	1.27	0.00	0.63	0.63	3.17
MPA (degrees)	5th	-0.75	-0.75	-0.75	-0.75	-0.75	-3.73	-0.93	-0.93	-0.93	-0.93	-0.93	-4.66
	25th	-0.41	-0.41	-0.41	-0.41	-0.41	-2.06	-0.30	-0.30	-0.30	-0.30	-0.30	-1.51
	50th	-0.20	-0.20	-0.20	-0.20	-0.20	-0.99	-0.08	-0.08	-0.08	-0.08	-0.08	-0.39
	75th	0.02	0.02	0.02	0.02	0.02	0.12	0.11	0.11	0.11	0.11	0.11	0.57
	95th	0.30	0.30	0.30	0.30	0.30	1.50	0.52	0.52	0.52	0.52	0.52	2.61
PP/MPA (degrees)	5th	-1.08	-2.16	0.00	-1.08	-1.08	-5.41	-1.24	-1.04	-0.78	-0.61	-0.68	-3.47
	25th	-0.73	-1.45	0.00	-0.73	-0.73	-3.63	-0.79	-0.64	-0.50	-0.37	-0.16	-2.28
	50th	-0.39	-0.79	0.00	-0.39	-0.39	-1.97	-0.57	-0.44	-0.32	-0.18	0.07	-1.39
	75th	-0.21	-0.42	0.00	-0.21	-0.21	-1.04	-0.13	-0.13	-0.07	-0.03	0.30	-0.31
	95th	0.07	0.14	0.00	0.07	0.07	0.35	0.71	0.55	0.41	0.29	0.65	1.79
PFH:AFH (%)	5th	-0.04	-0.04	-0.04	-0.04	-0.04	-0.18	-0.31	-0.31	-0.31	-0.31	-0.31	-1.56
	25th	0.22	0.22	0.22	0.22	0.22	1.10	0.06	0.06	0.06	0.06	0.06	0.30
	50th	0.38	0.38	0.38	0.38	0.38	1.90	0.28	0.28	0.28	0.28	0.28	1.38
	75th	0.50	0.50	0.50	0.50	0.50	2.48	0.42	0.42	0.42	0.42	0.42	2.12
	95th	0.69	0.69	0.69	0.69	0.69	3.43	0.62	0.62	0.62	0.62	0.62	3.12
UFH:LFH (%)	5th	-0.03	-0.46	-0.82	-1.23	-1.97	-4.09	-0.80	-0.79	-0.83	-0.96	-2.96	-4.29
	25th	0.67	0.36	-0.07	-0.57	-1.16	-0.33	0.16	-0.09	-0.30	-0.65	-1.98	-2.04
	50th	1.34	0.79	0.24	-0.12	-0.62	1.19	0.86	0.42	0.04	-0.42	-1.49	-0.67
	75th	1.75	1.23	0.72	0.25	-0.20	3.58	1.58	1.01	0.41	-0.14	-1.10	0.92
	95th	2.53	1.92	1.33	0.74	0.31	6.66	2.33	1.56	0.75	0.15	-0.18	2.41

Males and females displayed similar intercorrelations among the five measures of vertical discrepancy (Table 5). The MPA showed moderately high positive correlations with PP/MPA, moderately high negative correlations with PFH:AFH, and moderately low negative correlations with UFH:LFH. PPA showed low positive correlations with MPA and UFH:LFH, and low negative correlations with PP/MPA and PFH:AFH. PP/MPA demonstrated moderate negative correlations with PFH:AFH and UFH:LFH. UFH:LFH showed moderately low positive correlations with PFH:AFH .

Table 5- Correlations, along with probabilities, at 15 years of age between five commonly used measures of vertical discrepancy, with males above and females below the main diagonal.

	PPA	MPA	PPA/MPA	PFH:AFH	**UFH:LFH**
PPA		.372 (<.001)	-.203 (.002)	-.300 (.001)	**.562 (<.001)**
MPA	.311 (.001)		.763 (<.001)	-.873 (<.001)	**-.345 (<.001)**
PP/MPA	-.143 (.139)	.856 (<.001)		-.601 (<.001)	**-.734 (<.001)**
PFH:AFH	-.292 (.002)	-.872 (<.001)	-.795 (<.001)		**.320 (<.001)**
UFH:LFH	.409 (<.001)	-.472 (<.001)	-.715 (<.001)	.415 (<.001)	

Depending on the measure, 75-86% of the individuals classified at hypodivergent (i.e. < 25th percentile) at 10 years of age were hypodivergent at 15 years of age, with 37-53% becoming even more hypodivergent (Figure 2). Of those who were initially hypodivergent, 14-25% changed to be within normal limits (25th-75th percentiles) at 15 years of age. Of those who were within normal limits at 10 years, 8-13% became hypodivergent, 7-11% became hyperdivergent (>75th percentile) and 79-85% maintained their classification. Most (77-85%) 10 year-old hyperdivergent adolescents remained hyperdivergent; 14-23% were within normal limits at 15 years of age. Of those who remained hyperdivergent, 27-48% became even more hyperdivergent over the five year period. Four percent of the individuals initially classified as hyperdivergent based on the PP/MPA were hypodivergent at 15 years of age.

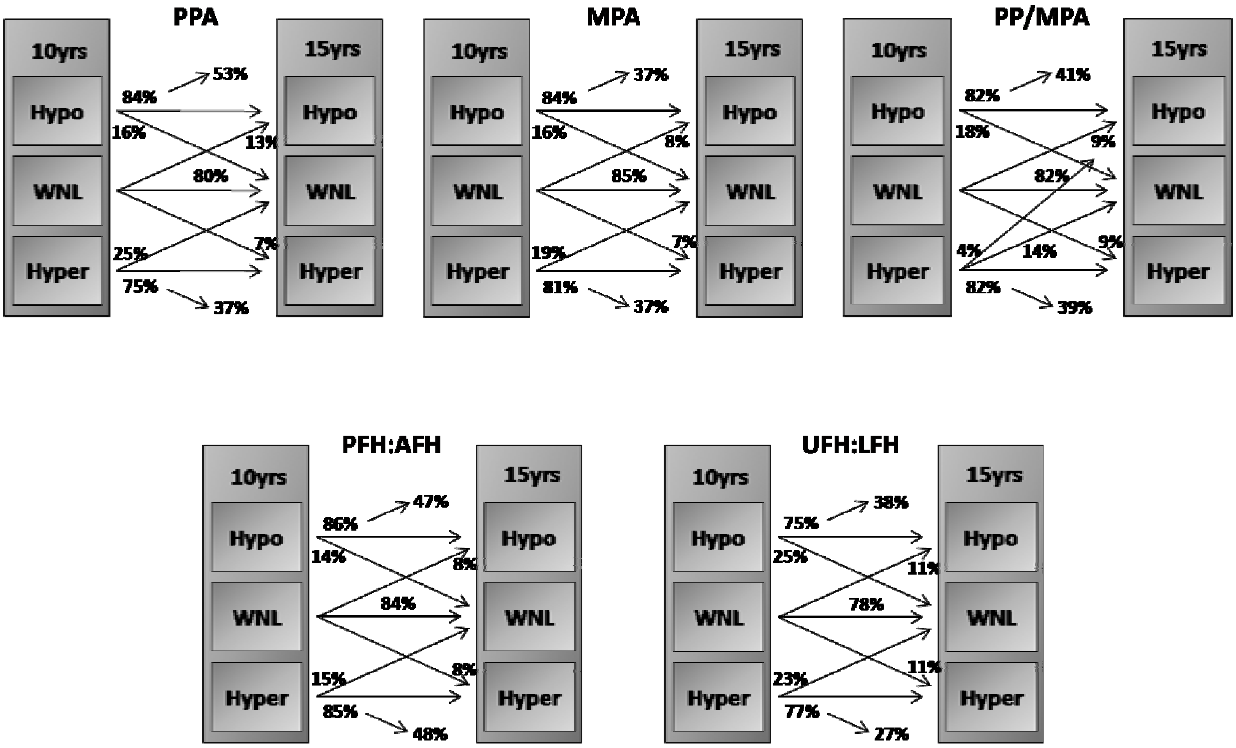

Figure 2. Frequencies of subjects with classified as hypodivergent (Hypo), within normal limits (WNL), and hyperdivergent (Hyper) at 10 years of age, who maintained and changed their classifications between 10 and 15 years of age.

Based on the classifications at 15 years of age, all five of the vertical measures showed significant ($p<.05$) group differences in the growth changes that occurred between 10-15 years of age (Table 6). The hypodivergent individuals showed little or no change between 10-15 years of age. Those individuals classified as hyperdivergent at 15 years showed the greatest changes over time, especially for PFH:AFH.

Table 6- Changes in vertical growth measures that occurred between 10-15 years of adolescents classified at 15 years of age as (1) Hypodivergent -below the 25th percentile, (2) Within normal limits-between 25th and 50th percentiles or (3) Hyperdivergent -above the 75th percentile.

		Hypodivergent		Within normal limits		Hyperdivergent		Group Differences	Paired Group Differences		
		<25th (1)		25th-75th (2)		>75th (3)			Post Hoc		
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Probability	(1)vs.(2)	(1)vs.(3)	(2)vs.(3)
PPA (degrees)	Male	**0.33**	1.02	0.83	0.96	1.18	0.80	.003	**NS**	.002	**NS**
	Female	**-0.02**	1.16	0.99	1.14	1.52	1.28	<.001	.001	<.001	**NS**
MPA (degrees)	Male	**-0.26**	1.49	-1.26	1.47	-1.40	1.78	.007	.014	.020	**NS**
	Female	**0.23**	2.11	**-0.52**	2.17	-1.68	2.28	.006	**NS**	.005	**NS**
PP/MPA (degrees)	Male	-1.65	1.45	-2.08	1.51	-3.14	2.04	.002	**NS**	.002	.014
	Female	**-0.22**	2.34	-0.69	2.08	-1.93	2.80	.021	**NS**	.025	**NS**
PFH:AFH (%)	Male	0.95	1.02	1.84	0.92	2.51	0.78	<.001	<.001	<.001	.004
	Female	**0.07**	1.44	1.14	1.17	2.39	0.89	<.001	.001	<.001	<.001
UFH:LFH (%)	Male	1.49	3.30	-1.51	2.86	-4.70	2.86	<.001	<.001	<.001	<.001
	Female	-2.49	1.55	-2.64	1.49	-2.40	1.68	**NS**	**NS**	**NS**	**NS**

Bold= statistically significant change NS= no statistically significant group difference

DISCUSSION

With the exception of UFH:LFH, the measures pertaining to the mandible showed that, on average, hyperdivergent tendencies decreased between 10-15 years age. The mandibular plane decreased almost one degree, the palatal to mandibular plane angle decreased approximately 1.5-2.5 degrees, and the posterior-to-anterior face height ratio increased approximately 1.5- 2%. With the exception of Bhatia and Leighton,[21] who reported a slight increase for males and stable relations for females, previous longitudinal studies of untreated children have also shown decreases in the MPA between 10-15 years of age, ranging from 0.8 to 3.5 degrees. The PP/MPA has consistently been shown to decrease between 0.6 and 2.9 degrees between 10 and 15 years of age.[21-24] Saksena et al[23] showed a slight decrease in the PFH:AFH ratio for females and increases for males.[23] Based on the correlations observed in the present study, the tendencies toward hyperdivergence decreased because there was greater posterior than anterior vertical growth of the mandible. This suggests that true mandibular rotation played a major role in altering vertical skeletal relationships. It has been previously shown that the mandible undergoes 0.4-1.0 deg/yr of forward rotation during adolescence.[40-42]

The PPA increased approximately one degree between 10 and 15 years. Saksena et al[23] and Nanda[24] also found increases in the PPA in adolescent females, and slight decreases for males. Bhatia and Leighton[21] and Riolo et al[22] reported increases in the PPA for both adolescent males and females. Increases of the PPA over time indicate that the anterior maxilla undergoes greater vertical growth changes, including both displacement and remodeling, than the posterior maxilla. On average, subjects showed increases in the PPA and decreases in MPA. The low positive correlations observed between PPA and MPA, suggest that subjects who had the greatest increases in PPA showed the smallest decreases in the MPA, and vice versa. The increase of the PPA suggests that the midface either rotated backwards or that there was substantially greater resorption on the anterior than posterior aspect of the nasal floor.

Adolescent males displayed less hyperdivergence and greater decreases in hyperdivergence over time than females. At 15 years of age, males showed less divergence of the mandible (ie. smaller MPA and PP/MPA angles; greater percentages of PFH:AFH, UFH:LFH) than females. While there already were sex differences for the MPA and PFH:AFH at 10 years of age, the differences increased because males underwent greater reductions than females. Reduced vertical discrepancies among males than females could be due to sex differences in the development of muscle strength that occur during adolescence; weaker and stronger muscles have been associated with the development of hyper- and hypodivergent growth patterns, respectively.[43,44] Previous longitudinal studies are less consistent in the sex differences reported, with females exhibiting greater vertical discrepancies at the younger age, and males showing greater divergence at older ages, and vice versa, depending on the measure and the study.[21-24] The lack of consistency could be due to population differences and sample compositions. It is also possible that the other samples had differing proportions of individuals, particularly females, who dropped out to receive treatment. Importantly, the sex differences identified were relatively small (usually less than one degree or one percent) and probably would not have been identified without the large sample size available for the present study. The error-free estimates that were used also ensure more reliable estimates of the sex differences.

While most individuals who were hyper- or hypodivergent at 10 years of age, remained divergent at 15 years, a substantial number moved toward normodivergence in their vertical relationships. For example, 15-25% (depending on the measure) of the subjects who were classified as hyperdivergent at 10 years were no longer hyperdivergent at 15. Similarly, 14-25% of 10 year-old subjects classified as hypodivergent changed their classification by 15 years of age. These changes do not support the notion that facial patterns are maintained throughout growth.[45] Based on smaller sample followed longitudinally, Bishara and Jakobsen[29] reported that approximately 77% maintained their facial type (classified based on PFH:AFH) between 5 and 25.5 years of age, which compares favorably to the results of the present study. The changing patterns are important because they indicate that some skeletal relationships should be expected to improve without treatment; the challenge that remains is how to distinguish those who will exhibit good growth patterns from the rest.

While some subjects improved, a substantial number also worsened over time. Of the 75-85% who remained hyperdivergent over the 5-year study period, over one third became more hyperdivergent over time; similar proportions of subjects who were hypodivergent at 10 were even more hypodivergent at 15 years of age. Differences in true rotation previously reported among individuals with low and high mandibular plane angles[46] could partially explain why hypo- and hyperdivergent adolescents might be expected to worsen over time.

The associations indicate that the five measures pertained to different phenotypic attributes. The greatest concordance was observed between MPA, PFH:AFH, and PP/MPA; these three measures were closely associated and represent the same phenotype characteristic. They are perhaps the best measures of hyperdivergence. Dung and Smith[20] reported similar associations between these three measures. Because the MPA is included in the PP/MPA, an association between these two might be expected. The association between the MPA and PFH:AFH is probably due to mandibular rotation, which is primarily in a forward direction decreasing the MPA, due to greater inferior displacement of the posterior than anterior mandible.[6,24,47] The PPA showed little or no association with the other measures, indicating that it is not a good measure of overall hypo- or hyperdivergence. UFH:LFH was also relatively independent of the other measures, suggesting that hyperdivergence is based more on posterior than anterior growth changes.

The changes that occurred between 10-15 years of age were related to the individual's facial type at 15 years of age, with hyperdivergent subjects showing greater improvements than hypodivergent subjects, who showed little or no change. This is in contrast with the previous literature, which shows that short-face subjects undergo greater changes than vertical, long-faced, individuals.[24,29] The inconsistency of results is difficult to explain and may be population specific (Table 7). While the present sample is considerably larger than the samples used for the previous comparisons, sample size cannot explain the differences observed.

Table 7- Comparison of vertical measures between longitudinal studies.

		Present study		Bhatia and Leighton		Riolo et al		Saksena et al		Nanda	
PPA	Male	7.15	8.08	6.5	6.8	6.1	6.9	8.5	8.0	4.98	4.14
	Female	8.07	9.07	7.8	8.1	7.5	7.8	9.7	10.2	4.72	5.10
MPA	Male	35.20	34.35	35.8	36.2	34.7	33.2	36.6	33.1	34.77	34.70
	Female	36.35	35.99	34.4	34.4	35.3	32.4	36.4	35.6	33.51	33.69
PP/MPA	Male	28.26	25.78	29.3	27.6	28.5	26.2	28.1	25.2	29.78	29.22
	Female	27.97	27.61	28.5	26.3	27.8	24.6	26.7	25.5	29.97	28.62
PFH:AFH	Male	62.72	64.86	62.5	64.2	62.00	63.82	58.71	62.66	XXX	XXX
	Female	62.14	63.54	62.3	64.1	60.99	63.73	63.46	62.42	XXX	XXX
UFH:LFH	Male	82.33	80.45	84.4	83.8	75.90	76.92	73.14	73.69	XXX	XXX
	Female	83.50	80.50	84.4	83.6	79.78	79.56	73.22	74.14	XXX	XXX

CONCLUSIONS

Based on a French-Canadian sample of 228 adolescents followed between 10-15 years of age, the following conclusions can be drawn:

1. PPA, PFH:AFH, and UFH:LFH increased significantly between 10-15 years, while MPA and PP/MPA decreased, with males generally showing greater changes than females;
2. The five measures were not measuring the same phenotypic attribute; while MPA and PFH:AFH were strongly intercorrelated, the PPA and UFH:LFH were relatively independent of the other measures;
3. Approximately 75-86% of the subjects maintained their vertical growth classifications between 10-15 years of age;
4. Hyperdivergent subjects showed greater improvements overtime than subjects within normal limits, while hypodivergent showed little or no change over the observation period.

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CAPÍTULO 2

*TREATMENT OF CLASS II MALOCCLUSION USING HIGH-PULL HEADGEAR WITH A SPLINT: A SYSTEMATIC REVIEW**

*Artigo submetido para publicação na Dental Press Journal of Orthodontics. Formatação e referências bibliográficas seguindo as normas da publicação da revista.

RESUMO

Objetivos: Fazer uma revisão sistemática das evidências científicas mostrando a efetividade do aparelho extrabucal com cobertura oclusal associado à puxada alta em pacientes com má-oclusão Classe II em crescimento. **Material e método:** um levantamento na literatura foi realizado através de busca em bancos de dados eletrônicos cobrindo o período de janeiro de 1966 a dezembro de 2008 e utilizou *Medical Subject Headings (MeSH).* Inicialmente a seleção foi baseada em títulos e resumos; após essa etapa os artigos potencialmente selecionados foram integralmente observados. Os critérios de inclusão apresentaram pacientes em crescimento entre 8 e 15 anos de idade, má-oclusão de Classe II tratada com aparelhos extrabucal com cobertura oclusal e puxada alta, e com grupo controle também com má-oclusão de Classe II. Os estudos selecionados foram avaliados metodologicamente. **Resultados:** quatro artigos foram selecionados; nenhum foi estudo controlado randomizado. Os artigos claramente formularam seus objetivos e usaram medidas apropriadas. Os estudos mostraram que houve melhora nas relações esqueléticas e dentais, deslocamento da maxila distalmente, controle da erupção vertical e distalização dos molares superiores. Dois estudos mostraram uma suave inclinação horária do plano palatino. A mandíbula não foi afetada. **Conclusão:** embora a falta de forte evidência demonstrasse os efeitos do aparelho extrabucal com cobertura oclusal, estudos realizados indicaram que a relação ântero-posterior melhorou devido a distalização da maxila e dos molares superiores, com pequeno ou nenhum efeito na mandíbula. Uma maior preocupação quanto ao design deveria ser dada para melhorar a qualidade de pesquisas com esse tipo de abordagem.

Palavras chave: ortodontia; maloclusão de angle Class II; resultado de tratamento

ABSTRACT

Objective: To systematically review the scientific evidence pertaining to the effectiveness of high-pull headgear in growing Class II subjects. **Material and methods:** A literature survey was performed by electronic database search. The survey covered the period from January 1966 to December 2008 and used Medical Subject Headings (MeSH). Articles were initially selected based on their titles and abstracts; the full articles were then retrieved. The inclusion criteria included growing subjects between 8 to 15 years of age, Class II malocclusion treatment with extraoral high-pull headgear, and a control group with Class II malocclusion. References from selected articles were hand-searched for additional publications. Selected studies were evaluated methodologically. **Results:** Four articles were selected; none were randomized controlled trials. All of the articles clearly formulated their objectives and used appropriate measures. The studies showed that high-pull headgear treatment improves skeletal and dental relationship, displaces the maxilla distally, controls vertical eruption and distalizes the upper molars. Two of the studies showed a slight clockwise rotation of the palatal plane; the others showed no significant treatment effect. The mandible was not affected by the treatment. **Conclusions:** While there is a lack of strong evidence demonstrating the effects of high-pull headgear with a splint, existing studies indicate the AP relations improve due to distalization of the maxilla and maxillary molars, with little or no treatment effects in the mandible. Greater attention to the design and reporting of studies should be given to improve the study quality such trials.

Key words: orthodontics; high-pull headgear; hyperdivergent

INTRODUCTION

Class II malocclusion can be dental and/or skeletal, involving mandibular deficiency, maxillary excess, or a combination of both.[1,2] Hyperdivergent patients with Class II malocclusion typically present with numerous three-dimensional skeletal and dental problems.[3] They exhibit retrognathic mandibles,[4] long anterior facial heights,[3] large mandibular plane angle,[4] large gonial angles,[3] and greater than average lower to upper anterior facial height ratio.[5-7] Dentally, they often present with open bites[9] and overerupted incisors and molars in both arches.[3]

Orthodontists have attempted to address the vertical dimension of growing hyperdivergent patients in various ways (e.g. bite-blocks, extraction therapy, vertical-pull chin, etc.), with high-pull headgear being perhaps the most common approach. The use of extraoral high-pull forces to modify maxilla growth has a long history. The type of extraoral traction device, as well as the magnitude of force applied and the direction of pull, have been shown to be important considerations.[8,9] High-pull headgear has been shown to modify maxillary growth;[10] when attached to a splint it directs maxillary growth towards a more posterosuperior direction.[11,12] To date, the treatment effects of high-pull headgear have not been systematically studied.

The purpose of this study was to systematically review clinical studies that have evaluated how high-pull headgear treatment with a splint affects growing Class II hyperdivergent patients. The review was focus on:

- Changes in the amount and direction of skeletal growth;
- Control of maxillary and mandibular molar eruption;
- Improvements of the vertical and AP skeletal relationship.

MATERIAL AND METHODS

In order to identify all studies that examined treatment with high-pull headgear in patients with Class II malocclusion, a literature survey was performed using Pubmed and Scopus. The survey covered the period from January 1966 to December 2008. Using the Medical Subject Heading (MeSH) terms "orthodontics", crossed with the MeSH terms "malocclusion, Class II Malocclusion" and "extraoral traction appliance", a total of 442 studies were identified. Only randomized controlled trials (RCTs) or nonrandomized controlled trials (using untreated Class II hyperdivergent patients as controls) were included (Table 1). At the first view no distinction was made between high-pull headgear with a maxillary splint or molars banded. The reference list of each article was hand-searched for additional relevant publications that may have been missed in the database searches.

Following the recommendations by Petrèn et al,[13] the articles were described based on the following: study design, sample size, male and female distribution, mean age of groups, type of orthodontic treatment, treatment duration, success, and authors' conclusion (Table 2).

Table 1- Inclusion and exclusion criteria used to select the articles

Inclusion criteria	Exclusion criteria
• Meta-analyses, randomized clinical trials, prospective and retrospective studies; • Articles published from January 1966 to December 2008; • Studies with Class II malocclusion; • Studies with growing patients 8-15 years; • Studies with extraoral high-pull headgear, using maxillary splints or banded molars • Cephalometric data provided	• Case reports, case series, descriptive studies, opinion articles or abstracts; • Studies with casts. • Not human studies or laboratorial studies; • Adjunctive treatments • Full or partially banded appliances • Subjects with TMJ diseases • No control group or control group with normal occlusion;

Table 2- Summarized data of the studies included in the review (CCT=control clinical trial)

Authors and year	Study design	Sample size	Male (%)	Age (y)	Orthodontic treatment	Treatment duration (m)	Success	Authors' conclusion
Caldwell et al. 1984	CCT	47 HG 52 CG	HG: 45% CG: 52%	HG: M=10.23 F=10.19 CG: M=10.36 F=10.21	Maxillary splint appliance	Between 4 and 20	Not declared (100% implicit)	The maxillary dentition was both tipped and displaced distally, and downward development was inhibited or even slight reversed
Orton et al. 1992	CCT	26 HG 26 CG	HG: 42% CG: 42%	HG: 11.4 CG: 11	Maxillary splint appliance	HG: 13.2 CG: 20.4	Not declared (100% implicit)	Slight maxillary restraint in both sagittal and vertical planes was obtained showing that principal effect was in the maxillary teeth
Üner and Yücel-Eroğlu. 1996	CCT	13 HG 13 CG	HG: 46% CG: 46%	HG: 10.76 CG: 10.39	Maxillary splint appliance	HG: 11.0 CG: 11.3	84%	The HG revealed that the splint had both orthopedic and orthodontic effects on the growth pattern of the dentoskeletal structures
Martins et al. 2008	CCT	17 HG 17 CG	HG: 24% CG: 47%	HG: 8.61 CG: 8.9	Maxillary splint appliance	HG: 20.4 CG: 16.8	Not declared (100% implicit)	The HG correct the Class II primarily by dentoalveolar changes

To document the methodological soundness of each article, a modified version of the quality evaluation described by Antczak et al[14,15]was used (Table 3). The adequacy of sample was determined based on post-hoc power analyses of the primary variable used in each study to evaluate the AP treatment effects on the maxilla. The total quality score was based on assigning 1 point for each “Yes” in the Table, zero points for each “No”, and 1 point for each controled clinical trial (CCT). Prospective and retrospective studies were given one and zero points, respectively. The total number of points possible was 9.

Table 3 – Quality evaluation of the 6 selected studies (CCT: control clinical trial)

Authors and year	Objective clearly formulated	Study design	Adequacy of selection description	Adequate sample size	Appropriate measurement method	Retrospective / prospective study	Appropriate statistical analysis	Description of method error analysis	Blind measurement	Quality score/ total
Caldwell et al. 1984	yes	CCT	no	yes	yes	retrospective	no	no	no	4
Orton et al. 1992	yes	CCT	yes	yes	yes	retrospective	yes	no	no	6
Üner and Yücel-Eroğlu. 1996	yes	CCT	yes	yes	yes	retrospective	yes	yes	no	7
Martins et al. 2008	yes	CCT	yes	yes	yes	prospective	yes	yes	no	8

Schematic diagrams were used to summarize the rotations, displacements and tooth movements associated with the high-pull headgear treatments. Rotations were based on the angular changes of the palatal and mandibular planes. The horizontal and vertical displacements of the maxilla and mandible were based on cranial base superimpositions. Tooth migration and eruption was based on maxillary and mandibular superimpositions. Estimates were based on averages of the four studies that provided tooth movements based on maxillary and mandibular superimpositions.

RESULTS

Based on the information provided in the titles and abstracts of the 442 article identified, all but 17 of the studies were eliminated for a variety of reason (Figure 1). The main reasons for exclusion were: different types of appliances used (e.g. high-pull headgear associated with functional appliance or bonded brackets), the direction of force application (cervical or combination traction), no cephalometric data provided, and case reports. Of the 17 studies identified, only four used untreated Class II control.[12,16-20]

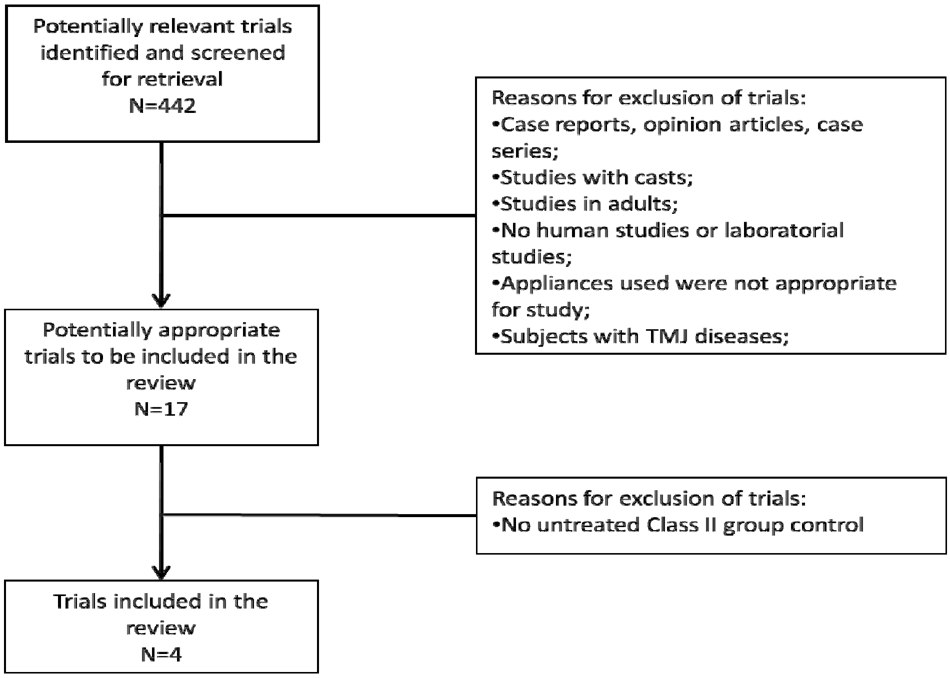

Figure 1- Flow diagram summarizing literature search

Sample sizes of the treatment groups ranged from 13 to 47, with comparable numbers of controls (Table 2). While the sex ratio ranged from 24% to 46% males, none of the studies analyzed sex differences. Pretreatment ages and treatment durations ranged from 8.6-11.4 years and 4-20 months, respectively. All four selected studies compared maxillary orthopedic splint versus no treatment. Three of the studies implied a 100% success Class II correction; the Üner and Yücel-Eroğlu[20] study reported an 84% success rate.

The quality evaluation scores of the four studies ranged from 4-8 (Table 3). None of the articles were RCT; all studies were controlled clinical trials. None of the articles blinded the measurement process. Only one of the studies was prospective and only two described the methods used for the error analysis. Three of the studies adequately described the selection of their subjects and all used appropriate statistical techniques. All of the articles clearly formulated their objectives and all used appropriate measures.

Treatment Effects Produced by High-pull Headgear

Treatments consistently improved the AP skeletal relationships (with the ANB angle decreasing from 0.9-1.5 degrees and the Wits decreasing from 0.6-1.5 mm), decreased overjet (2.6-6.5 mm), and corrected the Class II malocclusions (Table 4).

Table 4- Treatment effects based on significant differences between patients and untreated controls
(NS=no significant group differences; NE=not evaluated)

Authors and year	Antero-posterior relationships	Skeletal-maxillary changes	Dental-maxillary changes	Skeletal-mandibular changes	Dental-mandibular changes
Caldwell et al. 1984	Decreased ANB; decreased overjet	Posterior displacement; backward rotation of palatal plane	Distalized molars; intruded molars; retroclined incisor; intruded incisors	Anterior displacement NS; backward mandibular rotation	Mesialized molar NS; extruded molar NS, incisor retroclined
Orton et al. 1992	Reduction of ANB; decreased overjet	Posterior displacement; backward rotation of the palatal plane	Distalized molars; intruded molars; retroclined incisors; intruded incisors	Anterior displacement NS; mandibular rotation NS	Mesialized molar NS; extruded molars; incisor retroclined NS
Üner and Yücel-Eroğlu. 1996	Correction of Class II molar relations; decreased overjet	Posterior displacement; NS in palatal plane rotation	Distalized molars; molar intrusion NS; proclined incisors; intruded incisors	Anterior displacement NS; mandibular rotation NS	Molar movements NS; incisors retroclined
Martins et al. 2008	Greater decreased ANB and Wits than expected;	Posterior displacement; palatal plane angle NE	Distalized molars; intrusion NE; retroclined incisors	Anterior displacement NS; mandibular rotation NS	Mesialized molar NS; incisor proclined NS; vertical NE

Maxillary Treatment Effects

Although the studies used different criteria to measure the antero-posterior displacement, they all reported statistically significant posterior displacement of the maxilla (ranging from 0.1-1.5 mm) for the treated group, versus anterior displacement for the untreated controls (Figure 2). Of the three studies that evaluated the palatal plane angle, just one study showed statistically significant clockwise rotation between the treated and control groups (Figure 3).

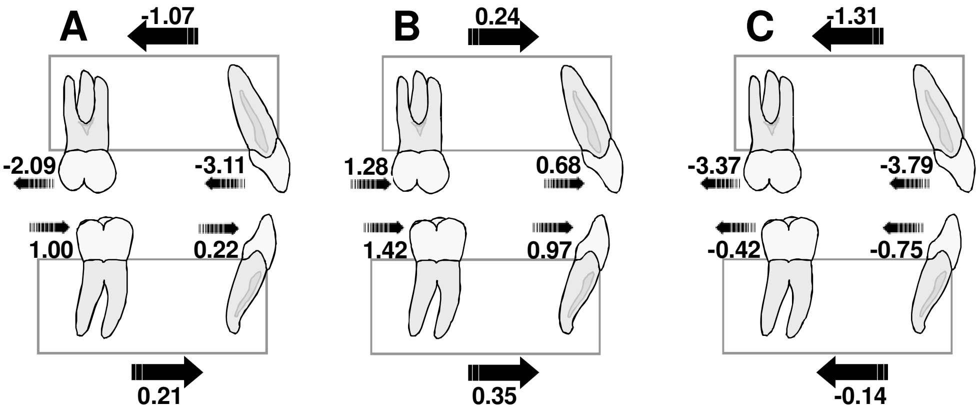

Figure 2 – Schematic diagrams of average horizontal (mm) changes reported for (A) patient treated with headgear and (B) matched untreated controls, along with (C) differences between high-pull headgear and controls.

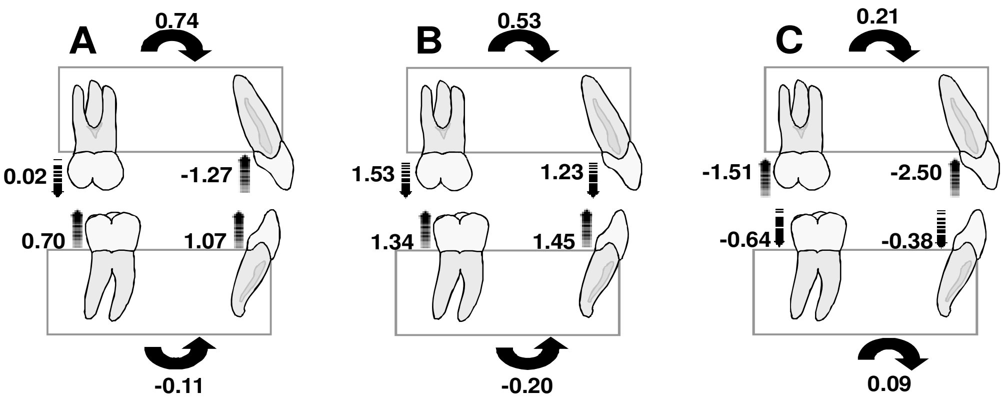

Figure 3 – Schematic diagrams of average vertical (mm) and angular (degrees) changes reported for (A) patient treated with headgear and (B) matched untreated controls, along with (C) differences between high-pull headgear and controls.

All of the studies reported significant distalization of the maxillary molar (ranging between 0.5 and 3.3 mm) and two showed maxillary molar intrusion (between 0.4 and 0.7 mm). The control groups typically showed mesial drift and eruption of the maxillary molars (Figures 2 and 3). Three studies reported statistically significant retroclination (between 4.4 and 11.0 degrees) and intrusion of the maxillary incisors (between 0.2 and 2.1 mm).

Treatment effects on the mandible

All four articles showed no treatment effect on the AP position of the mandible (Figure 2). All studies evaluated the mandibular plane rotation and reported no significant differences between the treated and control groups (Figure 2 and 3).

All studies reported similar amounts of mesial movement of the mandibular molars (ranging between 0.8 mm and 1.2 mm) for the treated and control groups (Figure 2). Of the three studies that evaluated the vertical movements of the molars, all showed no treatment effects, but just one showed relative molar extrusion (Figure 3). Of the four articles that evaluated the incisors, three showed incisor retroclination (ranging from 0.2-1.9 degrees), and one showed incisor proclination (1.0 degree) with no significant difference between both groups.

DISCUSSION

The goal of orthopedic headgear treatment is to correct the dental malocclusion, normalize AP skeletal relationships, and improve – or prevent worsening of the vertical skeletal relationships. The results clearly showed improvement of the dental and AP skeletal relationships. The ANB and Wits appraisal decreased in the treated group; Class II correction was successful in all but one of the studies. Based on the mandibular plane angle, the vertical skeletal relations were generally maintained.

High-pull headgear treatment restricted the forward growth of the maxilla. Based on SNA changes, there was, on average, approximately 1.1 degree posterior repositioning of the maxilla in the treated subjects, compared to slight anterior repositioning for the untreated controls. Studies consistently report that headgears used to correct Class II malocclusions are generally effective in redirecting the maxillary growth posteriorly[10,21,22] or in limiting the forward growth of the maxilla.[23]

High-pull headgear appears to produce a slight clockwise rotation of the palatal plane. However, this effect was small (less than 0.8 deg on average) and inconsistent across studies of high-pull headgear. Other studies evaluating the effects of high-pull, combi, or cervical headgear have also reported a lack of consistent results.[10,23] Clockwise rotation of the palatal plane might be expected considering that the headgear forces are directly through the posterior maxilla, resulting in relatively greater inferior displacement of the anterior maxilla. If the force is applied in the canine area, high-pull headgear has been shown to decrease the palatal plane angle.[24]

Bowden[8,9] previously emphasized how important the point of force application was for understanding changes the palatal plane angle. If the force vector passes through the center of resistance of the maxilla, which is approximately located at the superior and posterior part of the zygomatomaxillary suture,[25,26] no moment will be created and no rotation should be expected. If however, the force vector pass posterior to the center of resistance, clockwise rotation of the maxilla might be expected. The direction and moment created will depend upon the shortest perpendicular distance from the force vector to the center of resistance.

Dentoalveolar changes were largely responsible for the correction of the Class II malocclusions. The maxillary molars were moved and tipped distally. Based on the averages derived for the studies, distal molar movement accounted for approximately 2.1 mm (between 84% and 100%) of the correction. Headgears generally maintain or move the maxillary first molars distally.[23,28] Vertically, high-pull headgear is used to control the vertical movements of the maxillary molars, and may even intrude them slightly, whereas cervical headgear has little or no effects on vertical molar changes.[10,22-25]

Although, on average, the maxillary incisors were retroclined and intruded, there was great variability (from -1.7 to -4.5 mm in horizontal direction and from -2.1 to 0.2 mm in vertical direction) in the changes reported in the four studies evaluated. The literature is also inconsistent in terms of incisor changes for headgear studies in general.[27] The variability could be attributed to differences in the force directions and study appliances used.

There were only very limited effects of the appliance on the mandible. Mandibular sagittal changes were effectively similar in the treated and untreated groups. Of the studies that evaluated the AP position of the mandible, all four reported no treatment effect. As such, headgear improves the sagittal intermaxillary relationship almost exclusively by holding the maxilla. This effect on sagittal intermaxillary relationship is in contrast to functional appliances, which have shown improve sagittal intermaxillary relationship with treatment effects on the mandible.[27,28] Slight clockwise rotation of the mandible occurred in only one study, indicating adequate vertical control. Compared with cervical headgear, the high-pull headgear therapy appears to provide better vertical control.[29]

With respect to mandibular tooth movements, some of the studies showed retroclination of the incisors. This can be explained by anterior contact of these teeth with the acrylic splint that covers the maxillary incisors, exerting a distal force on the incisors. When upper molars are intruded with the high-pull headgear, the lower molar extruded might be expected in order to maintain occlusal contact.[10,22] The lack of significant extrusion in the lower molars in the studies reviewed is associated with the maxillary splints that were used, acting like a bite block to maintain the position of the lower molars. Treatment had no effect on the mesial movements of the mandible molars.

CONCLUSION

While there is a lack of strong evidence demonstrating the effects of high-pull headgear with a splint, based on the information provided in this systematic review of four clinically controlled trials evaluating the effects of high-pull headgear on subjects with Class II malocclusions, the following conclusions can be drawn:

1. High-pull headgear displaces the maxilla posteriorly and slightly rotates the palatal plane clockwise;
2. The upper molars are distalized and the vertical position was maintained by high-pull headgear. Treatment effects on the lower incisors are inconsistent;
3. High-pull headgear treatment consistently improved the AP skeletal relationships, but not the vertical skeletal relationships.

Greater attention to the design and reporting of studies should be given to improve the study quality such trials.

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CAPÍTULO 3

*DENTAL AND SKELETAL COMPONENTS OF CLASS II OPEN-BITE TREATMENT WITH A MODIFIED THUROW APPLIANCE**

*Artigo submetido para publicação na Dental Press Journal of Orthodontics. Formatação e referências bibliográficas seguindo as normas da publicação da revista.

RESUMO

Objetivos: Devido ao número reduzido de artigos estudos que distinguem entre as mudanças dentoalveolares e ósseas produzidas pelo aparelho de Thurow, este estudo propôs avaliar as mudanças dentais e esqueléticas induzidas pelo aparelho de Thurow modificado. **Metodologia:** Estudo clínico conduzido pelo departamento de Ortodontia da Faculdade de Odontologia de Araraquara. A amostra incluiu um grupo experimental de 13 indivíduos entre 7 e 10 anos de idade com má-oclusão Classe II e mordida aberta anterior e um grupo controle de 22 indivíduos com idades, plano mandibular e má-oclusão similares. Baseado em 14 pontos cefalométricos, 8 ângulos (SN.ANS, SNA, PPA, SN.Pog, SNB, MPA, PP/MPA, ANB) e 3 medidas lineares (N-Me, ANS-Me, S-Go) foram avaliados movimentos maxilares e mandibulares horizontais e verticais dentários e esqueléticos (ANS, PNS, U1, U6, Co, Go, Pog, L1, L6. **Resultados e conclusões:** O tratamento produziu diminuição significantemente maior no ângulo entre o plano palatino e o plano mandibular do grupo controle, devido ao aumento do ângulo do plano palatino. Os ângulos ANB, SNA e SN.ANS diminuíram significantemente mais no grupo tratado. A PNS sofreu remodelação superiormente. A altura facial inferior (ANS-Me) diminuiu no grupo tratado enquanto aumentou no grupo controle. O aparelho controlou deslocamento vertical e horizontal da maxila, rotacionou a maxila para melhorar a mordida aberta e diminuiu a altura facial inferior.

PALAVRAS- CHAVE: Classe II; mordida aberta; ortopedia; cefalometria

ABSTRACT

Objective: Due to the lack of studies that distinguish between the dentoalveolar and basal changes produced by the Thurow appliance, this study evaluated the dental and skeletal changes induced by modified Thurow appliance. **Methods:** This case-control study was conducted in Department of Orthodontics between 2002 and 2004 (Araraquara Dental School, Araraquara, SP, Brazil). The sample included a treated group of 13 subjects between 7 and 10 years of age with Class II malocclusion and anterior open-bites and a control group of 22 subjects matched to age, sex and mandibular plane angle. Based on 14 landmarks, 8 angles (SN.ANS, SNA, PPA, SN.Pog, SNB, MPA, PP/MPA, ANB) and 3 linear measures (N-Me, ANS-Me, S-Go) were evaluated maxillary and mandibular horizontal and vertical dental and skeletal movements (ANS, PNS, U1, U6, Co, Go, Pog, L1, L6). **Results and conclusions:** The treatment produced significantly greater decreases in the palatal plane to mandibular angle of the treated group, due primarily to increases of the palatal plane angle. The ANB, SNA and SN.ANS angles decreased significantly more in the treated patients than in the controls. PNS remodeled superiorly in the treated group and inferiorly in the control group. Lower face height (ANS-Me) decreased in the treated group and increased in the control group. The modified Thurow appliance controls the vertical and horizontal displacements of the maxilla, rotates the maxilla to improve open-bite malocclusion, and decreases lower facial height.

KEYWORDS: Class II; Open-bite; Thurow appliance;cephalometrics

INTRODUCTION

Class II malocclusion can be due to skeletal or dental maxillary protrusion, mandibular retrusion or a combination of factors.[1-3] While Class II malocclusion can be addressed in a number of different ways (i.e. dentoalveolar changes, orthopedic forces to inhibit maxillary growth or stimulate mandibular growth, or surgical repositioning of the mandible in nongrowing patients), protrusive maxillas are usually treated with orthopedic forces produced by headgear appliances.[3-5] Headgears can be inserted into bands bonded onto the upper molars or into removable appliances. Whether or not headgear therapy causes skeletal maxillary changes in humans remains controversial.[6-9]

When associated with hyperdivergence and an anterior open-bite, Class II malocclusions have proven to be extremely challenging for orthodontists. Finger, thumb, and tongue habits are perhaps the best known physical factors that produce open-bite malocclusions.[10] Hyperdivergent open-bite subjects have anterior and posterior dentoalveolar heights that tend to be excessive, palatal plane angles that are flatter, and increased mandibular plane and gonial angles.[11] To treat such malocclusion in growing patients, it is necessary to limit maxillary displacement and intrude the molars in order to rotate the mandible upwards and forwards.[12,13]

The Thurow appliance was developed to apply distal and vertical forces, while controlling the molar rotation and tipping produced by forces directed through buccal molar tubes. The original appliance, which incorporates a high-pull headgear and a maxillary acrylic splint that serves as a bite block, has been shown to restrain maxillary growth, tip and displace the maxillary teeth distally, and restrain the eruption of the posterior maxillary teeth.[14,15] Because the splint precisely engaging the entire maxillary dentition, higher force levels that dissipate over a larger surface area can be used. Its smooth acrylic surface disoccludes the teeth and effectively eliminates occlusal interferences during force application, which facilitates maxillary tooth movement and allows the mandible to grow unimpeded by the maxilla. The Thurow appliance is thought to be particularly well suited for Class II patients with maxillary prognatism, steep mandibular plane angles and open-bites.[16]

It has been reported that the Thurow appliance can be used to decrease the ANB angle, inhibit maxillary horizontal growth, control vertical growth of the maxilla, maintain the mandibular plane angle, move the upper first molars distally, and improve lip relationships.[12,13,16-19] However, these claims have been based on case reports and a clinical study that did not have matched untreated controls. Existing case-control studies were not able to distinguish between the dentoalveolar and basal changes produced by the appliance because mandibular and, especially, maxillary superimpositions were not performed.[14,20,21]

The ability to distinguish the skeletal and dental contributions of correction is important in order to ensure that treatment objectives can be met and to further improve appliance therapy. Clinically, understanding the effects of Thurow high-pull headgear is vital for understanding Class II correction in growing hyperdivergent patients. The aim of this retrospective study was to evaluate dental and skeletal changes produced by a Thurow high-pull headgear modified appliance for hyperdivergent open-bite Class II division 1 malocclusion treatment using cephalometric radiographs.

SUBJECTS AND METHODS

Sample

Fifteen children participated in this retrospective clinical study. Recruitment was conducted at the orthodontic clinic at Araraquara Dental School, Sao Paulo State University. During the treatment 2 patients moved from the city.

The final sample included 13 (1 male and 12 female) children Class II division 1 malocclusion open-bites who were treated for 12 months before their growth spurts (Table1). The maxillary splint high pull headgear was composed of an acrylic plate, a vestibular arch, an extraoral arch fixed to the acrylic, a palatal cribs, and an expansion screw at the level of the second deciduous molars (Figure1). The acrylic plate extended laterally and occlusally, covering the cusps and approximately one-third of the molars' bucal surfaces. It was based on the appliance introduced by Thurow[16] and modified by Santos-Pinto.[18] If expansion was needed, the screw was activated once a week (0.25mm) for as long as needed. The outer bow of the extraoral arch was adjusted so that the elastics' line of force passed slight posterior through the first and second deciduous molars anteroposteriorly and between the lower margin of the orbitale and apex of the first molar vertically, which is slight posterior to be the maxilla's center of resistance.[22,23] The high-pull headgear delivered approximately 400g of force per side and was worn 14 hours a day. After correction was achieved, the patients used the headgear for 8 to 10 hours during sleep. They were seen monthly so that the splint could be adjusted if necessary.

The untreated control group included children who were followed longitudinally at the Human Growth Research Center, University of Montreal, Canada. They were from 3 school districts in Montreal representing various socioeconomic strata of the larger population.[24] The control group sample size consisted of 22 (2 males and 20 females) Class II division 1 who presented the same age, sex, and mandible plane angle when compared to the treated sample.

Table 1- Pre-treatment and follow-up ages of the treated (Thurow appliance) and untreated (control) groups.					
Group		**Sample size**	**Mean**	**SD**	**Prob**
Initial	**Treated**	13	8.85	0.73	0.912
	Untreated	22	8.82	0.73	
Final	**Treated**	13	9.84	0.70	0.933
	Untreated	22	9.82	0.73	

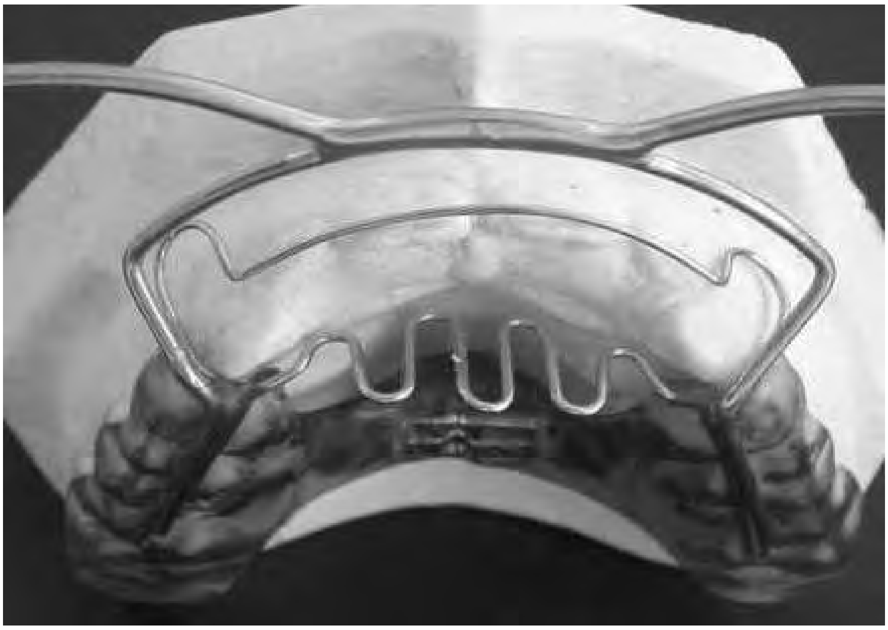

Figure 1- Partial view of the modified Thurow appliance

Cephalometric methods

Lateral cephalograms were obtained at the beginning of the treatment (T1) and at the follow-up appointment (T2) in the treatment group and in the control group the lateral cephalograms were obtained at one year of interval at least fifteen days before or after the birthday. The cephalograms were taken with the head positioned according to the Camper Plane parallel to the ground and standardized source-subject and subject-film distances. Lateral cephalometric tracings were performed on acetate paper. The tracings were digitized and analyzed with Viewbox 3.1-Cephalometric

Software, version 3.1.1.14 (Dhal Software, Athens, Hellas, Greece) by one investigator. The linear measurements were adjusted to eliminate magnification. The analyses describe growth and treatment changes of fourteen skeletal landmarks (Figure 2).

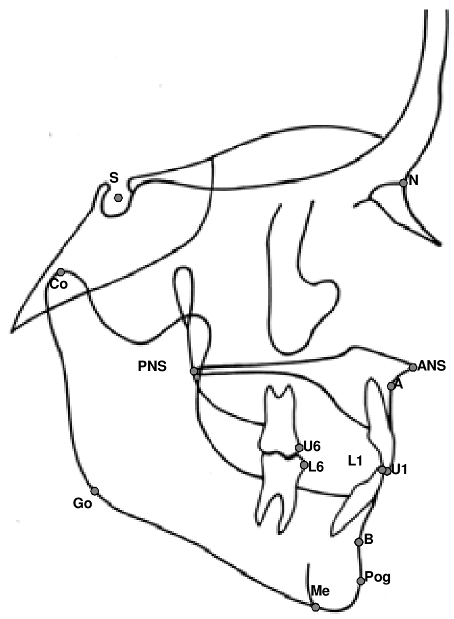

Figure 2- Cephalometric landmarks digitized; (S) sella, (N) nasion, (PNS) posterior nasal spine, (ANS) anterior nasal spine, (A) A-point, (Co) condylion, (Go) gonion, (Me) menton, (Pog) pogonion, (B) B-point, (U6) maxillary mesial molar, (U1) maxillary incisor tip, (L6) mandible mesial molar, (L1) mandible incisor tip.

The horizontal and vertical movements of selected landmarks were described based on a horizontal reference line (RL), which was oriented based on the T1 sella-nasion plane minus 7 degrees. For example, the horizontal change in the position of pogonion was measured parallel to the RL (distance between the pogonion projection to a reference point fixed 100 mm behind the sella) and the vertical change was measured perpendicular to the RL (Figure 3). Overall tooth movements were calculated based on the tracings superimposed on the stable cranial base structures, as described by Björk and Skieller.[25] To determine the actual movements of the incisors and the molars, maxillary and mandibular superimpositions were performed as describe by Björk and Skieller.[25,26] Tooth movements were subtracted from the overall tooth movements to estimate the movement of the skeletal bases. Horizontally, an anterior change was recorded as positive, and a posterior change was recorded as negative. Vertically, a superior change was recorded as negative, and an inferior change was recorded as positive (Figure 3).

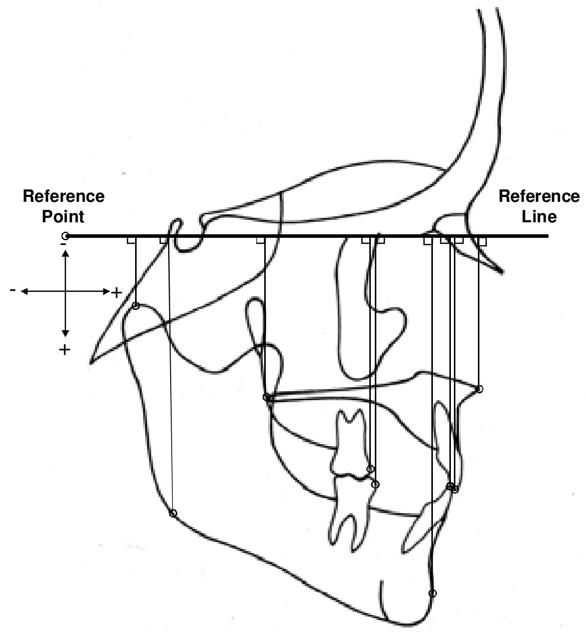

Figure 3- Horizontal and vertical cephalometric landmarks positions; the variables were measured parallel and perpendicular to reference line (SN -7°).

Replicate analysis of 26 subjects showed small but statistically significant systematic errors for the ANS horizontal (0.31 mm) and Go vertical (-0.21 mm). Random method errors[27] ranged from0.15-0.46mm with PNS horizontal showing the largest random error.

Statistical methods

The measurements were transferred to SPSS software (version 15.0, SPSS, Chicago, IL) for evaluation. Based on skewness and kurtosis, the variables were judged to be normally distributed. T-tests were used to compare the groups. A probability level of 0.05 was used to determine statistical significance.

RESULTS

T-tests showed significant ($p<.05$) group differences prior to treatment for five of the 11 traditional variables measured (Table 2). In comparison to the untreated controls, the treated group initially had larger ANB angles, smaller palatal plane angles, and greater anterior and posterior facial heights. Analyses of covariance showed that none of the traditional pretreatment variables were related to the treatment changes.

Table 2 – Comparison of pretreatment values between treated and untreated groups

Variable		Treated		Untreated		Difference Prob
		Mean	SD	Mean	SD	
SN.ANS	deg	87.45	5.88	86.38	2.62	0.548
SNA	deg	82.37	5.93	81.27	3.19	0.550
PPA	deg	3.99	3.40	6.91	2.79	0.016
SN.Pog	deg	77.25	5.14	77.28	3.02	0.981
SNB	deg	77.21	5.45	77.50	3.10	0.862
MPA	deg	35.97	5.30	36.27	3.60	0.855
PP/MPA	deg	31.96	4.62	29.19	3.41	0.076
ANB	deg	5.16	1.90	3.72	2.00	0.046
N-Me	mm	96.58	4.58	92.03	4.02	0.007
ANS-Me	mm	58.23	3.99	53.02	2.66	0.001
S-Go	mm	60.82	5.25	57.27	3.90	0.047

Independent of the pretreatment measures, the treatment produced significant group differences (Table 3). The palatal plane angle increased in the treated group and remained unchanged in the controls. This difference, together with the slighter greater, although not statistically significant, decrease in the MPA, resulted in a significantly greater decrease in the PP/MPA of the treated group. The ANB angle decreased significantly more in the treated patients than in the controls, due primarily to a significant treatment decrease of the SNA angle. The SN.ANS angle decreased significantly ($p<.001$) more than the SNA angle in the treated group. While lower face height increased significantly in the controls, it decreased significantly in the treated group.

Table 3- Comparison of changes between treated and untreated groups.

Variable		Treated		Untreated		Prob
		Mean	SD	Mean	SD	
SN.ANS	deg	-2.75	1.20	0.08	1.45	<0.001
SNA	deg	-0.94	0.80	0.03	1.15	0.007
PPA	deg	2.14	1.59	0.07	0.85	<0.001
SN.Pog	deg	0.27	1.12	0.33	0.66	0.871
SNB	deg	0.16	0.95	0.22	0.59	0.846
MPA	deg	-0.61	1.63	-0.17	0.99	0.392
PP/MPA	deg	-2.73	1.92	-0.23	1.12	0.001
ANB	deg	-1.10	0.88	-0.12	1.15	0.010
N-Me	mm	1.64	1.55	2.36	1.52	0.198
ANS-Me	mm	-0.92	1.44	1.14	1.26	<0.001
S-Go	mm	1.68	1.68	1.64	0.89	0.938

In comparison to the treated group, which showed no statistically significant horizontal displacement, the maxillas and maxillary teeth of the control group were displaced anteriorly approximately 0.7 mm over the year long observation period (Table 4). Although the treated group showed anterior displacement of the mandible, the changes were not statistically significant. With the exception of condylion, all of the mandibular landmarks of the untreated controls showed significant anterior displacement. None of the group differences in horizontal displacement were statistically significant.

Based on the maxillary superimpositions, the treated group demonstrated no statistically significant horizontal remodeling or tooth migration; the untreated controls showed anterior and posterior remodeling of ANS and PNS, respectively, and mesial drift of the incisors and molars. With the except of gonion for the untreated controls, which drifted posteriorly, and the lower molar of the treated group, which moved mesially, none of the mandibular measures showed statistically significant horizontal changes. While several of the group comparisons approached significance level, none of the differences were statistically significant.

Both groups showed statistically significant inferior displacement, with no significant group differences (Table 5). The maxilla was displaced inferiorly approximately 1 mm. The posterior and anterior aspects of the mandible were displaced inferiorly approximately 2.9-3.4 mm and 1.5-2.3 mm, respectively. While ANS showed no significant remodeling changes, PNS showed slight superior drift in the treated group and inferior drift in the control group, with the difference being statistically significant. The maxillary molar of the treated group also show no vertical change, whereas the control molars erupted approximately 0.8 mm. There was little or no group difference in mandibular remodeling and tooth movements. Condylion showed the most growth (2.6-2.8 mm), gonion drifted superiorly, the incisors erupted 0.8-1.2 mm and the mandibular molars erupted 0.8-0.9 mm.

Table 4- horizontal skeletal and dental changes in patients treated and the untreated controls (positive value = forward direction; negative value = backward direction).					
Horizontal values					
Displacement					
	Treated		**Control**		**Difference**
Variable	**Mean**	**SD**	**Mean**	**SD**	**Prob**
ANS	0.01	0.83	**0.72**	1.16	.060
PNS	0.02	0.84	**0.74**	1.21	.068
U1	0.15	1.62	**0.71**	1.56	.315
U6	0.12	1.35	**0.72**	1.41	.229
Co	-0.42	2.42	0.15	1.73	.418
Go	0.63	2.12	**0.93**	1.37	.618
Pog	1.32	2.66	**1.44**	1.84	.878
L1	0.59	2.17	**0.86**	1.38	.654
L6	0.55	2.11	**0.86**	1.37	.592
Remodeling/Migration					
	Treated		**Control**		**Difference**
Variable	**Mean**	**SD**	**Mean**	**SD**	**Prob**
ANS	0.35	1.18	**0.78**	1.36	.428
PNS	-1.14	1.93	**-0.81**	1.14	.699
U1	-0.02	1.53	**0.80**	1.14	.091
U6	0.33	1.15	**0.56**	1.16	.625
Co	0.25	2.54	-0.54	1.71	.159
Go	-0.55	1.64	**-1.45**	1.31	.053
Pog	0.02	0.13	-0.07	0.25	.271
L1	0.74	1.44	0.34	0.94	.203
L6	**0.98**	1.28	0.36	0.96	.121

Bold=significant change over time

Table 5- Vertical skeletal and dental changes in patients treated and the untreated controls (positive value = inferior direction; negative value = superior direction).					
Vertical values					
Displacement					
	Treated		**Control**		**Difference**
Variable	**Mean**	**SD**	**Mean**	**SD**	**Prob**
ANS	**0.80**	1.47	**0.98**	1.54	.740
PNS	**1.02**	1.08	**1.00**	0.69	.964
U1	**0.83**	1.42	**1.00**	1.48	.749
U6	**0.96**	0.88	**0.96**	0.89	.995
Co	**2.94**	2.30	**3.53**	2.13	.448
Go	**2.86**	2.25	**3.40**	1.95	.466
Pog	**1.51**	1.82	**2.31**	1.28	.180
L1	**1.37**	1.97	**2.23**	1.36	.181
L6	**1.89**	1.70	**2.59**	1.22	.168
Remodeling/Eruption					
	Treated		**Control**		**Difference**
Variable	**Mean**	**SD**	**Mean**	**SD**	**Prob**
ANS	0.22	0.44	0.37	1.75	.775
PNS	**-0.50**	0.57	**0.21**	0.43	**.001**
U1	**1.03**	0.91	**0.93**	1.45	.243
U6	0.33	1.15	**0.82**	0.95	.073
Co	**-2.63**	2.69	**-2.82**	1.75	.371
Go	**-1.25**	1.69	**-1.74**	1.85	.489
Pog	**0.11**	0.14	0.04	0.71	.699
L1	**-1.24**	1.49	**-0.82**	1.14	.319
L6	**-0.94**	0.86	**-0.84**	0.77	.448

Bold=significant change over time

DISCUSSION

The modified Thurow appliance clearly restricted the forward growth of the maxilla. The treated subjects showed a 2.8 degree and 0.9 degree decrease of SN.ANS and SNA, respectively. The angles decreased in the treatment group because the maxilla maintained its AP position while nasion continued to drift anteriorly. The untreated controls showed little or no change in SNA or SN.ANS because the maxilla moved forward along with nasion. This distinction is important because previous studies have reported, based solely on decreases in SNA or SN.ANS, that headgears used to correct Class II malocclusions are generally effective in redirecting the maxillary growth posteriorly.[14,16,20,21,28-31] Most studies have not evaluated the actual AP movements of the maxilla. Baumrind and co-workers,[8] who used biologically defined “best fit” of palatal structures, showed small but definite posterior movement of ANS. ANS in the present study was not displaced posteriorly, perhaps due to the more superiorly oriented forces produced by high-pull headgear.

The modified Thurow appliance produced a 2.1 degree posterior or backward rotation of the palatal plane. In contrast controls showed no significant change of the palatal plane angle, as expected for untreated subjects over a similar time period.[33-36] Others studies evaluating the effects of high-pull forces have all shown backward rotation of the palatal plane.[14,20,30,37,38] In some treatment situation the orthodontist wants to prevent maxillary rotation, then the high-pull forces should have been directed through the maxilla’s center of resistance.

In this study, the headgear forces were purposely directed slight behind the dental and maxillary centers of resistance in order to help correct the open bites. The rotation of the palatal plane also largely explains the decrease observed in lower anterior face height of the treated group.[20,31] Lower anterior face height of the untreated control increased, as expected during the growth in untreated subjects.[33,34,36]

The modified Thurow appliance used in the present study had no real treatment effect on the AP mandibular position. The SN.Pog and SNB angles did not change significantly, in either the treated or the control groups. Previous studies also show no change the AP position of the mandible.[14,20,21,32,39] LaHaye and coworkers,[40] who evaluated methods commonly used to correct Class II skeletal malocclusions, including headgears and Herbst appliances, found no appreciable significant improvements in AP chin position; the authors stated that the skeletal Class II correction in growing adolescents results primarily from maxillary growth restriction or inhibition.

The mandibular plane angle also did not show a statistically significant difference between the groups. Both groups showed forward rotation during the observation period. Most previous studies have shown that the mandibular plane angle it changed or was maintained during treatment.[14,20,21,32,41] With the exception of Bhatia and Leighton,[36] who reported a slight increase for males and stable relations for females, previous longitudinal studies of untreated children have also shown decreases in the MPA between 10-15 years of age, ranging from 0.8 to 3.5 degrees.[33-35]

CONCLUSION

1. The modified Thurow appliance hold the maxilla and caused a slight backward rotation of the palatal plane;
2. The maxillary molar of the treated group showed no horizontal and vertical change. The upper incisor was retroclined but no significant change over time was shown.
3. With exception of the lower molars, which moved more to mesial in the treated group, there is no treatment effect on the mandible;
4. The lower facial height decreased in treated group;

ACKNOWLEDGMENTS

The authors would like to thank Dr Demetrius Halazonetis for his intellectual expertise helping with the Viewbox 3.1-Cephalometric Software.

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CONSIDERAÇÕES FINAIS

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Este estudo foi realizado a partir de duas amostras retrospectivas, sendo uma para determinar o crescimento vertical de indivíduos e outra para determinar as modificações dento-esqueléticas induzidas pelo aparelho de Thurow modificado. Fez parte ainda uma revisão sistemática sobre aparelhos extrabucais com splint acrílico maxilar.

A primeira amostra foi coletada no Human Growth Research Center, na Universidade de Montreal, Canadá. Os indivíduos foram selecionados em 3 distritos escolares representando a sociedade socioeconômica da população geral. Essa amostra incluiu, aleatoriamente, 228 adolescentes não tratados com idades entre 10 e 15 anos. Cada indivíduo incluído na amostra apresentava ao menos 4 telerradiografias em norma lateral e, obrigatoriamente, deveria possuir uma aos 10 e outra aos 15 anos de idade. As telerradiografias foram coletadas anualmente e dentro de um período de 12 dias da data do aniversário de cada indivíduo. O tamanho da amostra possibilitou a eliminação do erro Tipo II e o cálculo dos percentis, pois os dados anteriormente existentes na literatura foram utilizando amostras pequenas.

A segunda amostra, também retrospectiva, incluiu crianças que foram tratadas no Departamento de Clínica Infantil da Faculdade de Odontologia de Araraquara. Para a seleção desses indivíduos da amostra, foram utilizados como critério de inclusão os que apresentavam um padrão de crescimento hiperdivergentel, Classe II, divisão 1, de Angle associado à mordida aberta anterior em fase de dentadura mista e permanente. O aparelho extrabucal de Thurow modificado foi utilizado para o tratamento desses indivíduos por um período de 12 meses. Um grupo controle, também retrospectivo, foi utilizado para comparação dos efeitos do tratamento. Esses indivíduos não tratados foram selecionados com as mesmas características de sexo, idade, plano mandibular e má-oclusão. Esse estudo possibilitou distinguir as modificações esqueléticas e dentais individualmente, muito embora a amostra apresentasse um número reduzido de indivíduos.

Considerando as particularidades de cada objetivo especifico do trabalho, foram eles tratados em capítulos distintos de forma a facilitar a análise e compreensão dos resultados inerentes à proposição inicial do trabalho como um todo.

No capítulo 1 foram descritas as mudanças de crescimento vertical que ocorrem em adolescentes entre os 10 e 15 anos de idade. Os resultados dos modelos de *multilevels* mostraram mudanças de crescimento significante e diferença entre os sexos para as cinco medidas propostas no estudo. O ângulo do Plano Palatino (PPA) aumentou tanto para indivíduos do gênero feminino como masculino com valor total maior para o primeiro gênero. O ângulo do Plano Mandibular (MPA) foi maior no gênero feminino mas diminuiu mais significantemente no masculino. O ângulo entre os Plano Palatino e Plano Mandibular (PP/MPA) diminuiu linearmente no gênero masculino e curvilineamente no feminino (diminuindo mais após os 12.5 anos de idade). A proporção entre a Altura Posterior Facial e a Altura Anterior Facial (PFH:AFH) foi significantemente maior e aumenta mais no gênero masculino quando comparado ao feminino. A proporção entre a Altura Superior Facial e a Altura Inferior Facial (UFH:LFH) aumentou entre os 10 e 12 anos mas decresceu entre os 13 e 15 anos, resultando em pouca ou nenhuma mudança entre os 10 e 15 anos de idade. De uma maneira geral os indivíduos classificados como hipodivergente, dentro dos limites de normalidade ou hiperdivergentes mantiveram sua classificação inicial (75-86%). Os adolescentes masculinos exibiram menos hiperdivergência e maiores diminuições de hiperdivergência no período de observação que os femininos. Baseado na classificação aos 15 anos de idade, todas as medidas verticais mostraram significante diferença entre grupos nas mudanças de crescimento que ocorreram entre os 10 e 15 anos de idade. Os indivíduos classificados como hiperdivergentes aos 15 anos de idade mostraram as maiores mudanças no período de observação, especialmente para a proporção PFH:AFH. Dessa forma, baseado em uma amostra franco-canadense de 228 adolescentes avaliados entre os 10 e 15 anos de idade, verificou-se que as cinco medidas utilizadas não são por si só, atributos para determinar o fenótipo do individuo.

No capítulo 2 foi feita uma revisão sistemática mostrando evidências científicas da efetividade do tratamento da Classe II com aparelho extrabucal com puxada alta e cobertura de acrílico. Quatro artigos foram selecionados de acordo com os critérios de inclusão. Os estudos mostraram claramente que o aparelho extrabucal melhora a relação esquelética e dentária. As mudanças dentoalveolares foram grandemente responsáveis pela correção da Classe II onde os molares maxilares foram movidos e inclinados para distal. Verticalmente, o aparelho extrabucal pode ser usado para um controle de movimentos verticais dos molares superiores podendo, inclusive, intruí-los suavemente. Os incisivos maxilares apresentaram uma retroinclinação. O aparelho extrabucal pareceu produzir uma suave rotação horária do plano palatino, contudo esse efeito foi muito pequeno e inconsistente através da literatura e depende diretamente da resultante da linha de ação de força da puxada em relação ao arco externo do aparelho. Baseado no plano mandibular, a relação esquelética vertical foi geralmente mantida. Em relação à posição ântero-posterior da mandíbula o aparelho extrabucal não mostrou ter influência em seu posicionamento. Com respeito aos movimentos dentais, os estudos mostraram retroinclinação dos incisivos inferiores e, na região de molar, houve uma suave extrusão dos molares inferiores, quando os molares superiores apresentaram intrusão, e uma manutenção em sua posição ântero-posterior.

No capitulo 3 foram avaliados as mudanças esqueléticas e dentais induzidas pelo aparelho de Thurow modificado. Independente das medidas pré-tratamento, o tratamento com o aparelho produziu diferenças significativas entre os grupos experimental e controle. O plano palatino aumentou no grupo tratado e manteve inalterado no grupo controle. Essa diferença, junto com um suave, mas não estatisticamente significância, diminuição do plano mandibular, resultou em uma grande diminuição do PP/MPA do grupo tratado. O ângulo S-N-ANS diminuiu significantemente mais que o ângulo S-N-A no grupo tratado mas ambos mostram o efeito de restrição do crescimento horizontal da maxila. A altura facial inferior diminuiu significantemente no grupo controle. Nenhuma das medidas entre grupos no deslocamento horizontal da mandíbula foi estatisticamente significante. Baseado na superposição maxilar, o grupo tratado demonstrou não haver remodelação ou migração dentaria. Houve pequena ou nenhuma diferença na remodelação mandibular e movimentos dentais mandibulares, mostrando que o aparelho age, quase que exclusivamente, na maxila.

Com os resultados obtidos podemos prover dados de referência para as mudanças de crescimento vertical que ocorrem na adolescência, aprofundando um pouco mais o conhecimento do crescimento vertical natural do ser humano. Já o tratamento com extrabucal com cobertura de acrílico e com o Thurow modificado mostraram ser efetivos no tratamento da correção da má-oclusão Classe II, embora seus efeitos sejam mais significativos na maxila.

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ANEXO

UNIVERSIDADE ESTADUAL PAULISTA " JÚLIO DE MESQUITA FILHO"

FACULDADE DE ODONTOLOGIA DE ARARAQUARA

Comitê de Ética em Pesquisa

Certificado

Certificamos que o projeto de pesquisa intitulado *"MUDANÇAS VERTICAIS NO CRESCIMENTO CRANIOFACIAL DE FRANCO-CANADANSES ENTRE 10 E 15 ANOS DE IDADE"*, sob o protocolo nº **29/10**, de responsabilidade do Pesquisador (a) *ARY DOS SANTOS PINTO* está de acordo com a Resolução 196/96 do Conselho Nacional de Saúde/MS, de 10/10/96, tendo sido aprovado pelo Comitê de Ética em Pesquisa–FOAr, com validade de 01 (um) ano, quando será avaliado o relatório final da pesquisa.

Certify that the research project titled *"VERTICAL CRANIOFACIAL GROWTH CHANGES FRENCH-CANADADIANS BETWEEN 10 TO 15 YEARS OF AGE"*, protocol number **29/10**, under *Dr ARY DOS SANTOS PINTO* responsability, is under the terms of Conselho Nacional de Saúde/MS resolution # 196/96, published on May 10, 1996. This research has been approved by Research Ethic Committee, FOAr-UNESP. Approval is granted for 01 (one) year when the final review of this study will occur.

Araraquara, 4 de novembro de 2010.

Prof. Dr. Maurício Meirelles Nagle
Coordenador

UNIVERSIDADE ESTADUAL PAULISTA " JÚLIO DE MESQUITA FILHO"

FACULDADE DE ODONTOLOGIA DE ARARAQUARA

Comitê de Ética em Pesquisa

Certificado

Certificamos que o projeto de pesquisa intitulado *"COMPONENTES DENTAIS E ESQUELÉTICOS DA CLASSE II COM MORDIDA ABERTA TRATADA COM O APARELHO DE THUROW MODIFICADO"*, sob o protocolo nº **28/10**, de responsabilidade do Pesquisador (a) ***ARY DOS SANTOS PINTO***, está de acordo com a Resolução 196/96 do Conselho Nacional de Saúde/MS, de 10/10/96, tendo sido aprovado pelo Comitê de Ética em Pesquisa–FOAr, com validade de 1 (um) ano, quando será avaliado o relatório final da pesquisa.

Certify that the research project titled *"DENTAL AND SKELETAL COMPONENTS OF CLASS II OPEN-BITE TREATMENT WITH A MODIFIED THUROW APPLIANCE"* protocol number **28/10**, under Dr. ***ARY DOS SANTOS PINTO***, responsability, is under the terms of Conselho Nacional de Saúde/MS resolution # 196/96, published on May 10, 1996. This research has been approved by Research Ethic Committee, FOAr-UNESP. Approval is granted for 1 (one) year when the final review of this study will occur.

Araraquara, 23 de junho de 2010.

Prof. Dr. Maurício Meirelles Nagle
Coordenador

Araraquara, 25 de março de 2011.

HELDER BALDI JACOB