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EFEITO DO TRATAMENTO COMPENSATÓRIO DA CLASSE II ESQUELÉTICA NA PROFUNDIDADE ANTERIOR DOS ARCOS E NA RELAÇÃO DOS CANINOS

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Linha de Pesquisa:

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Orientador: Prof. Dr. Sérgio Estelita Cavalcante Barros.

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RESUMO

Introdução: O objetivo desse estudo clínico foi avaliar a influência das inclinações compensatórias dos incisivos superiores e inferiores na relação do comprimento do arco anterior e na relação entre os caninos no tratamento compensatório da má oclusão de Classe II com discrepância esquelética. **Material e método:** O estudo baseou-se em telerradiografias e modelos de gesso finais de 88 pacientes. A amostra foi dividida em grupo Classe II (32 pacientes com ANB≥5º) e grupo Classe I (56 pacientes com 1º≤ANB≤2,5º). As medidas obtidas para o comprimento e a largura dos arcos na região anterior, a discrepância de Bolton, a relação dos caninos, o padrão de crescimento e a posição dos incisivos foram comparadas entre os grupos (teste *t*) e correlacionadas (teste de correlação de Pearson - $P<0.05$). **Resultados:** A média do ângulo ANB foi de 6,21° e 1,78° para os grupos Classe II e I, respectivamente. O grupo Classe II apresentou o comprimento da região anterior do arco inferior significantemente maior, afetando a relação de comprimento entre os arcos. No grupo Classe II, a relação dos caninos estava significantemente mais desviada em direção à má oclusão de Classe II. Os incisivos inferiores estavam mais vestibularizados, enquanto os superiores estavam mais lingualizados, no grupo Classe II. Os grupos foram similares em relação ao overjet, overbite e padrão vertical de crescimento da face. Existiu correlação significante entre a relação dos caninos, o comprimento dos arcos, a posição dos incisivos inferiores e a discrepância de Bolton. **Conclusão:** Pode-se concluir que a excessiva vestibularização dos incisivos inferiores está significantemente relacionada ao aumento do comprimento do arco inferior, influenciando negativamente a relação final dos caninos em pacientes com Classe II esquelética.

Palavras-chave: Má oclusão de Angle Classe II. Ortodontia corretiva. Resultado do tratamento.

ABSTRACT

Objective: This retrospective study's goal was to evaluate the influence of compensatory inclinations of maxillary and mandibular incisor on the anterior relation of anterior arch length and on the relation between canines in the compensatory treatment of Class II malocclusion with skeletal discrepancy. **Matherial and method:** The study was based on posttreatment lateral head films and dental casts of 88 patients. Sample was divided into Class II group (32 patients with ANB≥5º) and Class I group (56 patients with 1º≤ANB≤2.5º). Measurements obtained for anterior arch length and width, Bolton discrepancy, canine relation, growth pattern and incisor position were compared between groups (*t* test) and correlated (Pearson's correlation test – $P<0.05$). **Results:** Average ANB angle was 6.21º and 1.78º for the Class II and Class I groups, respectively. Class II group presents significantly lower anterior arch length, affecting the length relationship between the arches. In Class II group, canine relation was significantly shifted towards Class II occlusion. Mandibular incisors were more buccal, while maxillary incisors were more lingualized in Class II group. Both groups were similar regarding overjet, overbite and vertical pattern of face growth. There is a significant correlation between canine relation, arch length, incisors position and Bolton discrepancy. **Conclusion:** It can be concluded that excessive proclination of mandibular incisors are significantly related to increase of lower arch length, negatively influencing the final relationship of canines in skeletal Class II patients.

Keywords: Malocclusion, Angle Class II. Orthodontics, Corrective. Treatment outcome.

SUMÁRIO

1. INTRODUÇÃO

Durante o crescimento craniofacial, a relação maxilomandibular pode apresentar seu desenvolvimento de forma não harmônica. Entretanto, mesmo ocorrendo variações significativas nesta relação, uma oclusão normal pode ser alcançada e mantida durante o crescimento.(1) Para que haja uma boa relação entre os arcos dentários superiores e inferiores, em casos de discrepâncias esqueléticas, ocorrem mecanismos compensatórios no posicionamento dos dentes em relação ao seu osso basal.(2, 3) A compensação dentoalveolar para discrepâncias suaves a moderadas, no sentido sagital entre maxila e mandíbula, pode ser observada em casos de relação esquelética de Classe II, nos quais as compensações se dão principalmente pela modificação na inclinação dos incisivos: os superiores mais verticalizados e os inferiores mais proclinados.(4)

Em geral, a compensação dentoalveolar natural é insuficiente para alcançar uma oclusão normal quando discrepâncias esqueléticas severas estão associadas.(4) Nestes casos, o tratamento ortopédico é frequentemente indicado na busca pela normalização da relação esquelética maxilomandibular se o paciente ainda apresenta um bom potencial de crescimento. Entretanto, sabe-se que o tratamento ortopédico das más oclusões esqueléticas apresenta efeitos predominantemente dentoalveolares,(5) ou seja, são as compensações dentoalveolares que corrigem as más oclusões sem, contudo, resolver totalmente a discrepância das bases ósseas.

Por outro lado, em pacientes adultos, a cirurgia ortognática é o tratamento indicado para a correção do problema esquelético.(1, 6) Apesar do tratamento ortodôntico-cirúrgico ser indicado para pacientes adultos com discrepância esquelética moderada a acentuada, sabe-se que esta modalidade de tratamento nem sempre é bem aceita pelo paciente devido ao seu alto custo financeiro e biológico, além dos desconfortos e riscos inerentes ao procedimento.(7) Deve-se ainda levar em conta que a autoestima e a auto percepção do paciente sobre seu problema são fatores que influenciam o grau de mudança que o paciente busca no tratamento ortodôntico, (7, 8) podendo a queixa do paciente ficar restrita à má posição dentária ou se estender às desarmonias faciais associadas à discrepância esquelética. Todas estas questões que envolvem o tratamento ortodôntico-cirúrgico ajudam a explicar a razão pela qual o tratamento ortodôntico compensatório é, por

vezes, utilizado para corrigir más oclusões cujas discrepâncias esqueléticas apresentam indicação para correção cirúrgica.(9)

Estas constatações acerca dos efeitos do tratamento ortopédico e da aceitação do tratamento ortodôntico-cirúrgico tornam as compensações dentoalveolares um procedimento frequentemente presente nos tratamentos ortodônticos das mais diferentes faixas etárias.(9, 10) Porém, as compensações dentárias dos problemas esqueléticos levam a mudanças significativas na inclinação dos incisivos que podem interferir na finalização do tratamento ortodôntico, haja vista que o comprimento da região anterior dos arcos dentários pode ser afetado por estas mudanças de posicionamento dos incisivos,(11) produzindo uma dificuldade de normalização da relação anteroposterior dos arcos.

Vários estudos enfatizaram a influência da inclinação dos incisivos superiores no comprimento do arco superior e na relação molar,(11-14) mas apenas alguns estudos têm se preocupado com o impacto dos incisivos inferiores nos resultados oclusais do tratamento de compensação da Classe II.(4, 12) No entanto, a vestibularização inicial excessiva dos incisivos inferiores é uma característica comum da Classe II esquelética(15-18) e não pode ser facilmente corrigida durante o tratamento de compensação dessa maloclusão,(19-21) especialmente porque a extração de pré-molares inferiores é frequentemente evitada devido ao seu impacto negativo nos resultados oclusais.(22-24) Além disso, a mecânica ortodôntica necessária para corrigir a sobremordida, frequentemente associada ao trespasse horizontal da Classe II, tem um efeito de vestibularização conhecido nos incisivos.(25-29) Por fim, todos os estudos que correlacionaram a influencia das inclinações dos incisivos sobre os resultados oclusais foram baseados em modelos laboratoriais, sem suporte clínico.(4, 11-14) Assim, este estudo clínico retrospectivo foi focado no impacto da posição compensatória dos incisivos superiores e inferiores na relação de comprimento do arco na região anterior e na relação ântero-posterior dos caninos ao final do tratamento compensatório da má oclusão esquelética de Classe II.

2. OBJETIVO

Essa sessão está destinada ao Objetivo Geral e aos Objetivos Específicos desse estudo.

2.1. OBJETIVO GERAL

Avaliar a influência das inclinações compensatórias dos incisivos superiores e inferiores na relação de comprimento dos arcos após o tratamento compensatório da Classe II esquelética.

2.2. OBJETIVO ESPECÍFICO

a) Comparar o comprimento da região anterior dos arcos superior e inferior de pacientes com e sem discrepância esquelética ao final do tratamento ortodôntico.
b) Comparar a relação entre o comprimento dos arcos superior e inferior, na região anterior, em pacientes com e sem discrepância esquelética ao final do tratamento ortodôntico.
c) Comparar a relação ântero-posterior dos caninos em pacientes com e sem discrepância esquelética ao final do tratamento ortodôntico.
c) Avaliar a influência da relação entre o comprimento dos arcos na região anterior na relação ântero-posterior dos caninos ao final do tratamento compensatório da má oclusão de Classe II esquelética.

3. ARTIGO

Esse Trabalho de Dissertação é composto pelo artigo "***Effect of skeletal Class II camouflage treatment on anterior arch length ratio and canine relationship"***.

Será enviado para publicação no periódico *American Journal of Orthodontics and Dentofacial Orthopedics*. O manuscrito, na formatação exigida pelo periódico correspondente, encontra-se a seguir:

3.1 ARTIGO

Effect of skeletal Class II camouflage treatment on anterior arch length ratio and canine relationship.

ABSTRACT

Objective: This retrospective study's goal was to evaluate the influence of compensatory inclinations of maxillary and mandibular incisor on the anterior relation of anterior arch length and on the relation between canines in the compensatory treatment of Class II malocclusion with skeletal discrepancy. **Matherial and method:** The study was based on posttreatment lateral head films and dental casts of 88 patients. Sample was divided into Class II group (32 patients with ANB≥5º) and Class I group (56 patients with 1º≤ANB≤2.5º). Measurements obtained for anterior arch length and width, Bolton discrepancy, canine relation, growth pattern and incisor position were compared between groups (*t* test) and correlated (Pearson's correlation test – P<0.05). **Results:** Average ANB angle was 6.21º and 1.78º for the Class II and Class I groups, respectively. Class II group presents significantly lower anterior arch length, affecting the length relationship between the arches. In Class II group, canine relation was significantly shifted towards Class II occlusion. Mandibular incisors were more buccal, while maxillary incisors were more lingualized in Class II group. Both groups were similar regarding overjet, overbite and vertical pattern of face growth. There is a significant correlation between canine relation, arch length, incisors position and Bolton discrepancy. **Conclusion:** It can be concluded that excessive proclination of mandibular incisors are significantly related to increase of lower arch length, negatively influencing the final relationship of canines in skeletal Class II patients.

Introduction

Class I canine relationship is one of the most intended orthodontic goals during the treatment of malocclusions, with the accompanying molar relationship being merely a consequence of extraction or nonextraction treatment protocol.[1,2] Class I canine relationship has a relevant esthetic and functional role, since normal overjet, overbite and anterior guidance are strongly associated with this occlusal trait.[3,4] In fact, finishing phase of the orthodontic treatment, Class I canine relationship is frequently associated with normal overjet and overbite, provided that maxillary and mandibular anterior arch length are not compromised by incisors torque, dental anomalies of number, size and shape and unbalanced Bolton's tooth-size ratio.[5]

Skeletal Class II can be treated with or without orthognathic surgery. It has been suggested that anteroposterior maxillomandibular discrepancies should be greater than 6° of ANB angle to indicate surgical correction, otherwise profile esthetics improvement may become unpredictable.[6,7] When orthodontic-surgical treatment protocol is indicated, mandibular premolar extraction may be required to decompensate the labial tipping of the mandibular incisors and allow satisfactory mandibular advancement.[8,9] In fact, patients with moderate to severe skeletal Class II frequently presents compensated mandibular incisors.[10-13] Sometimes orthodontic-surgical treatment of skeletal discrepancies is not be accepted by the patient,[14] and orthodontic camouflage may be the only way forward to achieve good occlusion. However, this treatment alternative may become even more difficult if compensatory treatment of skeletal Class II malocclusion includes mandibular premolar extraction to upright or align mandibular incisors, especially if the Class II anteroposterior discrepancy is more severe than a cusp-to-cusp relationship and the patient has no remaining growth.[15-18] On the other hand, if mandibular premolars are not extracted to benefit Class II anteroposterior malocclusion correction, excessive labial tipping of the mandibular incisors may become a hard obstacle to normalize the anteroposterior relationship,[19,20] as it is for mandibular surgical advancement,[8] creating a paradoxical situation.

Several studies has emphasized the influence of maxillary incisors tipping on the maxillary arch length and molar relationship.[20-23] Only a few studies have been concerned about the impact of mandibular incisors tipping on the occlusal results of Class II camouflage treatment.[19,20] However, excessive initial labial tipping of the mandibular incisors is a common skeletal Class II characteristic,[10-13] and it cannot be easily corrected during Class II camouflage treatment,[7,24-26] especially because mandibular premolar extraction for incisor uprighting is frequently avoided due to its negative impact on the occlusal results.[16-18,27] In addition, the orthodontic mechanics required to correct deep bite, which is frequently associated with Class II overjet,[28,29] has a known proclination effect on the incisors.[30-34] Finally, all studies that correlated incisors tipping and occlusal results were based on laboratorial models, lacking clinical support.[19-23] Thus, this clinical study was focused on the impact of the compensatory position of the maxillary and mandibular incisors on the final anterior arch length ratio and canine relationship in skeletal Class II camouflage treatment.

Material and methods

This investigation was based on retrospective data obtained from orthodontic records of patients treated at the Faculty of Dentistry, University of _____. It was approved by the corresponding institutional review board, under number 2.659.451. The sample was selected from a pool of 1050 documented treated

patients from 1976 to 2017 at Orthodontics Department. Medical records, posttreatment lateral headfilms and dental casts from patients with skeletal Class I and skeletal Class II were evaluated. Sample size calculation was performed assuming values of 5% and 20% for α (Type I error) and β (Type II error), respectively. The minimum difference to be detected in dental arch length for patients with skeletal Class I and skeletal Class II was 0.2 mm. Standard deviation was taken from a previous laboratorial study[23] and sample calculation indicated that a minimum of 28 individuals in each group were needed.

Sample selection was based on the following inclusion criteria: good quality of orthodontic records, permanent dentition including second molars, patients with skeletal Class I and 1° ≤ ANB ≤ 2.5° (Class I group), patients with skeletal Class II and ANB ≥ 5° (Class II group) and normal overjet and overbite (Fig 1). These dental characteristics were evaluated on posttreatment lateral head films and the anteroposterior maxillomandibular relationship was confirmed by measuring Wits. Exclusion criteria included dental anomalies of size, shape, or structure, extensive dental restorations involving proximal surfaces of anterior teeth and tooth loss of any tooth in the anterior segment of the dental arch. Molar relationships and orthodontic treatment protocols used to treat the patients with and without skeletal imbalance were not a selection or allocation criterion in this study. Considering these criteria, 88 patients were selected from the total number of consecutive orthodontic records from our archives. Skeletal Class I group consisted of 56 patients (16 males and 40 females) with a mean age of 19.20 years. Skeletal Class II group consisted of 32 patients (15 males and 17 females) with a mean age of 20.82 years. Class II and Class I skeletal patients treated without any interproximal stripping were posteriorly allocated into subgroups to minimize the influence of this procedure on the results.

Posttreatment dental casts were measured using a 0.01 mm precision digital caliper (Mitutoyo America, Aurora, Ill). The following measurements were performed by an experienced and trained orthodontist (___). The widest mesiodistal crown width of incisors and canines in both arches. Maxillary and mandibular intercanine widths were the distances between the cusp tips of the canines. The distance between the cusp tips of canines and the dental midline were measured on each side of both arches. This latter measurement together with the intercanine distance formed a triangle (Fig. 2). A trigonometric calculation based on Heron's formula was used to determine the height of a triangle when the length of all three sides are known (Fig. 2), allowing to determine maxillary and mandibular anterior arch length (MxAAL and MdAAL). Afterwards, maxillary and mandibular anterior arch length were divided each other to determine the anterior arch length ratio (MdAAL/MxAAL). The sum of mesiodistal width of maxillary and mandibular anterior teeth was used to evaluate the anterior tooth-size disharmony (TSD 3-3 - Bolton's ratio).[35] Canine relationship was determined by the arithmetic mean of the horizontal distance between the cusp tip of the maxillary canine and the embrasure between the mandibular first premolar molar and canine measured on the right and left sides (Fig. 2).

Lateral headfilms were obtained in centric occlusion with passive lip posture. Posttreatment lateral head films from both groups (Fig. 1) were digitized by one investigator (___) and checked for landmarks identification by a second examiner (___). The data were analyzed with Radiocef Studio 2 software (version 1.0; release 7.82; _____, _____) using were scanned. A customized cephalometric analysis including dental and skeletal measurements from known analyses Steiner,[36] Tweed,[37] Wits,[38] Ricketts,[39] and McNamara[40] was used, totaling 11 variables (7

angular, 4 linear). The lateral headfilms were obtained using a x-ray machine (Orthophos CD; Siemens Sirona, Bensheim, Germany), which produced an image magnification of the order of 10%. This enlargement was corrected on the cephalometric software to match a 0% magnification factor.
In order to evalute this method's error, 20 patients study models and initial telerradiographs were randomly selected and submitted to a second measure from the same evaluator. Intraclass correlation coefficient (ICC) was used to to assess intra-examiner reliability and reproducibility for all linear and angular measurements.

Statistical analysis

Intraclass correlation coefficient (ICC) indicated that measurements reliability and reproducibility degree ranged from satisfactory to excellent (ICC – 0.78 to 0.99).

Descriptive statistics for radiographic measurements were calculated for each group. Because several variables did not show normal distribution for all the groups, the comparisons and correlations were performed using parametric or nonparametric statistical tests according to the results of the Shapiro-Wilk normality tests. Categorical variables were compared with chi-square tests.

Comparability of the groups regarding final age, sex and interproximal stripping distribution was investigated with *t*-tests and chi-square tests.

The groups were compared with t-test and Mann Whitney U test. Dental and skeletal variables were correlated with the canine relationship using the Pearson and Spearman correlation tests.

All statistical tests were performed using the Statistica program (Version 7.0; StatSoft Inc., Tulsa, OK, USA). Results were considered statistically significant with $P < 0.05$.

Results

The groups were similar regarding the age, sex distribution and percentage of patients with interproximal stripping (Table I). Skeletal Class II patients presented the mandibular anterior arch length significantly greater (Table I). In addition, the intermaxillary anterior arch length ratio was also significantly greater in this group. Bolton's tooth-size ratio was similar between the groups. Skeletal Class II group showed a greater canine occlusal relationship deviation towards Class II than the skeletal Class I group at the end of treatment. Despite this, the groups had similar and satisfactory final overjet and overbite, showing that at the end of treatment there was no additional overjet to improve the greater residual Class II canine relationship in the skeletal Class II group (Table I). Maxillomandibular anteroposterior relationship was significantly different between the groups (Table I). Maxillary and mandibular incisors were significantly compensated in the skeletal Class II group (Table I). The skeletal Class II mandibular incisors compensation (labial tipping) was twice as intense as maxillary incisors compensation (palatal tipping) when compared to skeletal Class I group (Table I). Although the skeletal Class II group presented a slight increase of the vertical facial pattern, no statistically significant difference was found (Table I).

Although the groups were similar regarding the percentage of patients receiving anterior interproximal striping, its quantity and location was not standardized and could influence the results. Thus, skeletal Class II and Class I subgroups composed of patients treated without any interproximal stripping, were compared (Table II). Mandibular anterior arch length and intermaxillary anterior arch length ratio were about of 1.4 mm and 11% greater in the skeletal Class II subgroup,

respectively (Table II). Bolton's tooth-size ratio was slightly smaller in skeletal Class II subgroup, but this difference was not sufficient to make intermaxillary anterior arch length ratio similar between the subgroups (Table II). Overjet and overbite were normalized in both subgroups at the end of treatment. Although the skeletal Class II subgroup showed a slightly smaller overjet, the canine relationship remained significantly more deviated towards Class II in this subgroup, probably due to the greater mandibular anterior arch length and intermaxillary anterior arch length ratio in this subgroup (Table II). The mandibular incisors compensation (labial tipping) was significant and remained twice as intense as the maxillary incisors compensation (palatal tipping) in skeletal Class II subgroup (Table II). The growth pattern was similar between the subgroups (Table II).

Anterior arch lenght ratio was the most influential variable in the final canine relationship (Table III). Mandibular anterior arch length, mandibular incisors tipping and Bolton's ratio were also significantly correlated (Table III). Only skeletal variables associated with the maxillomandibular anteroposterior relationship were significantly correlated with canine relationship (Table III).

Discussion

Skeletal Class II malocclusion can be surgically or orthodontically treated.[14] When surgical treatment is planed there is a priamary concern about the need for incisors decompensation to obtain a more suitable dentoskeletal anteroposterior relationship after maxillomandibular repostioining.[8,9,41,42] However, in Class II camouflage treatment, the compensated incisors position is generally accepted at the end of treatment in order to camouflage the skeletal discrepancy.[9,13,26,42,43] Several *in vitro* studies have evaluated the impact of the maxillary incisors tipping on dental arch length and anteroposterior relationship.[20-23] However, the prediction of molar relationship based only on maxillary incisors tipping cannot be reliable when mandibular incisor to mandibular plane angulation varies significantly from 92°.[19,20] In addition, previous studies did not evaluated confounding variables such as the tooth-mass discrepancy (Bolton's ratio) and arch width.[19,20] To the extent of our knowledge, this is the first clinical study to evaluate the impact of compensated maxillary and mandibular incisor tipping on the final arch length ratio and anteroposterior occlusal relationship in orthodontically treated patients with and without skeletal Class II discrepancy.

The groups with and without skeletal discrepancy showed similarity in age, sex distribution and patients undergoing interproximal enamel reduction, minimizing the influence of these variables on the results (Table I). It is well known that maxillary incisors tipping can influence dental arch length.[10,21-23] However, in this study, the anterior arch length in the skeletal Class II group, which had the most lingually tipped maxillary incisors, did not differ from that of the skeletal Class I group (Table I). This result may be due to the tendency of an increased anterior Bolton's ratio in Class II malocclusion compared to Class I (Table I).[44] This Class II malocclusion feature could help mitigate the occlusal effects of its longer mandibular anterior arch length and greater mandibular incisors tipping, but it was not sufficient to prevent a smaller anterior arch length ratio in this malocclusion group, which may have significantly contributed to a worse canine relationship (Table I).[19,20]

Since the selection criterion for patient allocation in each group was based only in ANB angle, the anteroposterior maxillomandibular relationship of the groups was evaluated by more than one cephalometric parameter due to the diagnostic limitations of each.[45] However, all cephalometric variables used to evaluate the

anteroposterior maxillomandibular relationship presented significant difference between the groups (Table I). Compared to Class I, the mandibular incisors tipping showed a greater contribution rate to the camouflage of skeletal Class II discrepancy and the total incisors compensation than the maxillary incisors tipping (Table I). Perhaps because mandibular incisors uprighting depends on the presence of space in the dental and Class II mechanics are prone to mesialize the mandibular arch, [26,46,47] while excessive lingual tipping of the maxillary incisors can be more easily corrected during or at the end of orthodontic treatment. Similar final values of IMPA has been reported for orthodontically treated patients presenting ANB value greater than 5°.[13,24] Although non-significant, all cephalometric measurements showed a slight excess of vertical development in skeletal Class II patients compared to Class I (Table I). This finding is in line with other studies demonstrating that a slight vertical excess is a common skeletal feature in Class II malocclusion.[10,48] However, this slight deviation in the vertical pattern does not seem to have a significant influence on the occlusal results.[49] Although the canine relationship was significantly different between the groups, the overjet and overbite were similar and within normal limits for adult patients (Table I).[50,51] Considering that the similar and normal overjet and overbite observed in both groups should be associated with a similar canine anteroposterior relationship, it was concluded that the disagreement between the incisal and canine relationship in the skeletal Class II group was due to the increased mandibular anterior arch length and the reduced anterior arch length ratio, leading to a worse anteroposterior canine relationship in this group.[19,20]

Although the patients rate presenting interproximal enamel reduction was similar between the groups (Table I), this reduction was not standardized between them and its indication was not the same for all patients. Interproximal stripping indication included anterior tooth crowding alleviation during the alignment and leveling phase and lingual tipping of the incisors during the finishing phase for overjet and overbite adjustment.[19,52] Considering that the interproximal reduction of incisors has a direct impact on anterior arch length and incisors relationship, the sample was divided into two non-stripping subgroups to eliminate any influence of this procedure on the study results. Subgroup comparisons did not present relevant changes in relation to that of the total sample (Table II). Probably, the similar rate of stripping and non-stripping patients between the groups contributed to this (Table I). Only the anterior tooth-size ratio, maxillary incisors tipping and overjet changed their statistical significance status, but maintaining the same previous trend and a threshold significance level (Tables I and II). Although the Class II group showed a smaller mean value of the anterior Bolton's ratio, the anterior arch length ratio remained significantly greater when compared to the Class I (Tables I and II). It was concluded that the anterior tooth-size ratio had smaller influence on the anterior arch length ratio than the incisors compensatory positioning had, especially the excessive labial tipping of the mandibular incisors (Fig. 3). In these cases, interproximal enamel reduction may be indicated without any imbalance in Bolton's ratio, its indication is to achieve an adequate anterior arch length ratio, which would allow normal overjet, overbite and canine relationship.[19,20] The overjet was slightly smaller in skeletal Class II subgroup, but this tiny difference was not sufficient to improve Class II canine relationship (Table II), which actually worsened in this subgroup, probably due to the impact of non-stripping protocol on the anterior arch length ratio, disturbing the expected association between normal overjet and Class I canine relationship (Table II).

Anterior arch length ratio was the most influential variable in the canine relationship (Table III), showing a high statistical significance level and a positive correlation coefficient close to 0.5 (moderate correlation). The mandibular anterior arch length and mandibular incisors tipping showed a lower correlation coefficient than that of the anterior arch length ratio, showing that the latter was a more relevant variable to explain the variation of the canine relationship. After all, it represents the contribution of both the maxillary and the mandibular arch in the canine relationship. Some sagittal skeletal variables also presented relevant correlation coefficients, probably due to the close relationship between the anteroposterior skeletal deficiency and the compensated incisors positioning.[11,53] Thus, the anterior arch length ratio can be expected to be less compromised in Class II cases with less severe skeletal imbalance. Anterior tooth-size ratio discrepancy showed a significant and positive correlation, meaning that an increase in anterior Bolton's ratio due to mandibular excess or maxillary reduction in tooth mass may increase the Class II canine relationship. However, the Bolton's ratio was the dental variable with the lowest correlation coefficient and significance level. This finding is consistent with the previous comments that a worse Class II canine relationship was more associated with an imbalance in anterior arch length ratio than a Bolton's ratio disharmony.

Clinical implications

Mandibular incisors may already be excessively proclined prior to skeletal Class II treatment or may become labially tipped during sagittal correction due to the action of Class II elastics or functional appliances.[10-13,26,46,47] Mandibular premolar extraction for incisor decompensation is more frequently performed in association with surgical correction of skeletal Class II,[41] as mandibular extractions may reduce the occlusal success rate of the compensatory treatment.[16-18] Although the compensated mandibular incisor plays an important role in achieving an adequate incisal relationship,[11,54] it can compromise the anterior arch length ratio and buccal anteroposterior relationship (Tables I, II and III).[19,20] An edge-to-edge incisor relationship, a normal overjet/overbite with residual extraction spaces remaining, and/or a poor buccal anteroposterior relationship may be clinical signals associated with excessively compensated mandibular incisors.[19] In these cases, the orthodontist should discard aggravating factors such as excessive palatal tipping of the maxillary incisors or anterior Bolton's ratio imbalance due to maxillary tooth mass deficiency before deciding on interproximal enamel reduction of the mandibular incisors.[19,55] After all, maxillary incisors proclination or reshaping can be performed without irreversible or invasive procedures and have a beneficial impact on smile esthetics.[56,57] Ultimately, if interproximal enamel reduction is really required, it should be distributed among the six mandibular anterior teeth, and interproximal spaces should be closed with a round archwire for maximum lingual incisors tipping and minimal enamel reduction.

Conclusions

- Anterior arch length ratio and canine relationship were significantly influenced by Class II camouflage treatment.
- An increased mandibular anterior arch length was the major contributing factor to the deterioration of the anterior arch length ratio.
- Mandibular incisors had a higher compensation degree than the maxillary incisors.
- Anterior arch length ratio was the most influential variable in the canine relationship.
- The need for mandibular anterior arch length reduction by interproximal stripping should be considered in Class II maloccusions with more severe skeletal imbalance.

References

1. Behbehani F, Roy R, Al-Jame B. Prevalence of asymmetric molar and canine relationship. Eur J Orthod 2012;34:686-692.
2. Behbehani F, Artun J, Al-Jame B, Kerosuo H. Prevalence and severity of malocclusion in adolescent Kuwaitis. Med Princ Pract 2005;14:390-395.
3. Al-Nimri KS, Bataineh AB, Abo-Farha S. Functional occlusal patterns and their relationship to static occlusion. Angle Orthod 2010;80:65-71.
4. Cheng HC, Cheng PC. Factors affecting smile esthetics in adults with different types of anterior overjet malocclusion. Korean J Orthod 2017;47:31-38.
5. McLaughlin RP, Bennett JC. Finishing with the preadjusted orthodontic appliance. Semin Orthod 2003;9:165-183.
6. Shelly AD, Southard TE, Southard KA, Casko JS, Jakobsen JR, Fridrich KL et al. Evaluation of profile esthetic change with mandibular advancement surgery. Am J Orthod Dentofacial Orthop 2000;117:630-637.
7. Daniels S, Brady P, Daniels A, Howes S, Shin K, Elangovan S et al. Comparison of surgical and non-surgical orthodontic treatment approaches on occlusal and cephalometric outcomes in patients with Class II Division I malocclusions. Prog Orthod 2017;18:16.
8. Potts B, Shanker S, Fields HW, Vig KW, Beck FM. Dental and skeletal changes associated with Class II surgical-orthodontic treatment. Am J Orthod Dentofacial Orthop 2009;135:566 e561-567; discussion 566-567.
9. Kabbur KJ, Hemanth M, Patil GS, Sathyadeep V, Shamnur N, Harieesha KB et al. An esthetic treatment outcome of orthognathic surgery and dentofacial orthopedics in class II treatment: a cephalometric study. J Contemp Dent Pract 2012;13:602-606.
10. Al-Khateeb EA, Al-Khateeb SN. Anteroposterior and vertical components of class II division 1 and division 2 malocclusion. Angle Orthod 2009;79:859-866.
11. Casko JS, Shepherd WB. Dental and skeletal variation within the range of normal. Angle Orthod 1984;54:5-17.
12. Bibby RE. Incisor relationships in different skeletofacial patterns. Angle Orthod 1980;50:41-44.
13. Mihalik CA, Proffit WR, Phillips C. Long-term follow-up of Class II adults treated with orthodontic camouflage: a comparison with orthognathic surgery outcomes. Am J Orthod Dentofacial Orthop 2003;123:266-278.
14. Bailey LJ, Haltiwanger LH, Blakey GH, Proffit WR. Who seeks surgical-orthodontic treatment: a current review. Int J Adult Orthodon Orthognath Surg 2001;16:280-292.

15. Johnston LE, Jr. Growth and the Class II patient: rendering unto Caesar. Semin Orthod 1998;4:59-62.

16. Bryk C, White LW. The geometry of Class II correction with extractions. J Clin Orthod 2001;35:570-579.

17. Janson G, Brambilla Ada C, Henriques JF, de Freitas MR, Neves LS. Class II treatment success rate in 2- and 4-premolar extraction protocols. Am J Orthod Dentofacial Orthop 2004;125:472-479.

18. Janson G, Maria FR, Barros SE, Freitas MR, Henriques JF. Orthodontic treatment time in 2- and 4-premolar-extraction protocols. Am J Orthod Dentofacial Orthop 2006;129:666-671.

19. Sangcharearn Y, Ho C. Effect of Incisor Angulation on Overjet and Overbite in Class II Camouflage Treatment. A typodont study. Angle Orthod 2007;77:1011-1018.

20. Sangcharearn Y, Ho C. Maxillary incisor angulation and its effect on molar relationships. Angle Orthod 2007;77:221-225.

21. Hussels W, Nanda RS. Effect of maxillary incisor angulation and inclination on arch length. Am J Orthod Dentofacial Orthop 1987;91:233-239.

22. Jain M, Vyas M, Singh JR. Effect of Crown Angulation of Maxillary Incisor on Effective Arch Perimeter. J Clin Diagn Res 2017;11:ZC92-ZC96.

23. O'Higgins EA, Kirschen RH, Lee RT. The influence of maxillary incisor inclination on arch length. Br J Orthod 1999;26:97-102.

24. Chhibber A, Upadhyay M, Uribe F, Nanda R. Long-term surgical versus functional Class II correction: a comparison of identical twins. Angle Orthod 2015;85:142-156.

25. Jang JC, Fields HW, Vig KWL, Beck FM. Controversies in the timing of orthodontic treatment. Semin Orthod 2005;11:111-118.

26. Janson G, Sathler R, Fernandes TM, Branco NC, Freitas MR. Correction of Class II malocclusion with Class II elastics: a systematic review. Am J Orthod Dentofacial Orthop 2013;143:383-392.

27. Janson G, Janson MR, Cruz KS, Henriques JF, de Freitas MR. Unusual orthodontic retreatment. Am J Orthod Dentofacial Orthop 2003;123:468-475.

28. Goldstein MS, Stanton FL. Various types of occlusion and amounts of overbite in normal and abnormal occlusion between two and twelve years. International Journal of Orthodontia and Oral Surgery 1936;22:549-569.

29. Marques LS, Armond MC, Ramos-Jorge ML, Andrade RG, Bolognese AM. Correlations between dentoskeletal variables and deep bite in Class II Division 1 individuals. Braz Oral Res 2011;25:56-62.

30. Weiland FJ, Bantleon HP, Droschl H. Evaluation of continuous arch and segmented arch leveling techniques in adult patients--a clinical study. Am J Orthod Dentofacial Orthop 1996;110:647-652.

31. Parker CD, Nanda RS, Currier GF. Skeletal and dental changes associated with the treatment of deep bite malocclusion. Am J Orthod Dentofacial Orthop 1995;107:382-393.

32. Dake ML, Sinclair PM. A comparison of the Ricketts and Tweed-type arch leveling techniques. Am J Orthod Dentofacial Orthop 1989;95:72-78.

33. El Namrawy MM, Sharaby FE, Bushnak M. Intrusive Arch versus Miniscrew-Supported Intrusion for Deep Bite Correction. Open Access Maced J Med Sci 2019;7:1841-1846.

34. Sifakakis I, Pandis N, Makou M, Eliades T, Bourauel C. Forces and moments generated with various incisor intrusion systems on maxillary and mandibular anterior teeth. Angle Orthod 2009;79:928-933.

35. Bolton WA. Disharmony in tooth size and its relationship to the analysis and treatment of malocclusion. Angle Orthod 1958;28:113-130.

36. Steiner CC. Cephalometrics for you and me. Am J Orthod 1953;39:729-755.

37. Tweed CH. The Frankfort-mandibular incisor angle (FMIA) in orthodontic diagnosis, treatment planning and prognosis. Angle Orthod 1954;24:121-169.

38. Jacobson A. The "Wits" appraisal of jaw disharmony. Am J Orthod 1975;67:125-138.

39. Ricketts RM. Cephalometric analysis and synthesis. Angle Orthod 1961;1:141-156.

40. McNamara JA, Jr. A method of cephalometric evaluation. Am J Orthod 1984;86:449-469.

41. Larson BE. Orthodontic preparation for orthognathic surgery. Oral Maxillofac Surg Clin North Am 2014;26:441-458.

42. Raposo R, Peleteiro B, Paco M, Pinho T. Orthodontic camouflage versus orthodontic-orthognathic surgical treatment in class II malocclusion: a systematic review and meta-analysis. Int J Oral Maxillofac Surg 2018;47:445-455.

43. Allais D, Melsen B. Does labial movement of lower incisors influence the level of the gingival margin? A case-control study of adult orthodontic patients. Eur J Orthod 2003;25:343-352.

44. Fattahi HR, Pakshir HR, Hedayati Z. Comparison of tooth size discrepancies among different malocclusion groups. Eur J Orthod 2006;28:491-495.

45. Ishikawa H, Nakamura S, Iwasaki H, Kitazawa S. Seven parameters describing anteroposterior jaw relationships: postpubertal prediction accuracy and interchangeability. Am J Orthod Dentofacial Orthop 2000;117:714-720.

46. Ardeshna A, Bogdan F, Jiang S. Class II correction in orthodontic patients utilizing the Mandibular Anterior Repositioning Appliance (MARA). Angle Orthod 2019;89:404-410.

47. Eissa O, El-Shennawy M, Gaballah S, El-Meehy G, El Bialy T. Treatment outcomes of Class II malocclusion cases treated with miniscrew-anchored Forsus Fatigue Resistant Device: A randomized controlled trial. Angle Orthod 2017;87:824-833.

48. McNamara JA, Jr. Components of class II malocclusion in children 8-10 years of age. Angle Orthod 1981;51:177-202.

49. Janson G, Janson M, Nakamura A, de Freitas MR, Henriques JF, Pinzan A. Influence of cephalometric characteristics on the occlusal success rate of Class II malocclusions treated with 2- and 4-premolar extraction protocols. Am J Orthod Dentofacial Orthop 2008;133:861-868.

50. Massaro C, Miranda F, Janson G, Rodrigues de Almeida R, Pinzan A, Martins DR et al. Maturational changes of the normal occlusion: A 40-year follow-up. Am J Orthod Dentofacial Orthop 2018;154:188-200.

51. Heikinheimo K, Nystrom M, Heikinheimo T, Pirttiniemi P, Pirinen S. Dental arch width, overbite, and overjet in a Finnish population with normal occlusion between the ages of 7 and 32 years. Eur J Orthod 2012;34:418-426.

52. Lapenaite E, Lopatiene K. Interproximal enamel reduction as a part of orthodontic treatment. Stomatologija 2014;16:19-24.

53. Ishikawa H, Nakamura S, Iwasaki H, Kitazawa S, Tsukada H, Sato Y. Dentoalveolar compensation related to variations in sagittal jaw relationships. Angle Orthod 1999;69:534-538.

54. Kim JY, Lee SJ, Kim TW, Nahm DS, Chang YI. Classification of the skeletal variation in normal occlusion. Angle Orthod 2005;75:311-319.

55. Hanna A, Ellis E, 3rd. Tooth-Size Discrepancies in Patients Requiring Mandibular Advancement Surgery. J Oral Maxillofac Surg 2016;74:2481-2486.

56. Cao L, Zhang K, Bai D, Jing Y, Tian Y, Guo Y. Effect of maxillary incisor labiolingual inclination and anteroposterior position on smiling profile esthetics. Angle Orthod 2011;81:121-129.

57. Kumar S, Gandhi S, Valiathan A. Perception of smile esthetics among Indian dental professionals and laypersons. Indian J Dent Res 2012;23:295.

Legend to figures

Figure 1- Class I (A) and Class II (B) skeletal pattern.

Figure 2 - Dental cast measurements. **A.** Trigonometric calculation based on Heron's formula and used to determine the anterior arch length (AAL). **B.** Measurement of canine anteroposterior relationship.

Figure 3 - Influence of incisor inclination on arch length.

Tables

Table I – Comparison between the groups with and without skeletal Class II discrepancy.

Variables	Skeletal Class II N=32		Skeletal Class I N=56		P
	Mean	**SD**	**Mean**	**SD**	
Age (years)	20.82	7.67	19.20	5.04	0.184‡
Sex (%)	M (46.87%)		M (28.57%)		0.083§
	F (53.13%)		F (71.43%)		
Interproximal stripping (%)	Yes (46.88%)		Yes (42.86%)		0.715§
	No (53.12%)		No (57.14%)		
Dental cast measurements					
MxAAL (mm)	9.30	1.11	8.85	1.40	0.119†
MdAAL (mm)	6.11	1.07	5.16	1.25	<0.001‡*
MdAAL/MxAAL	0.66	0.12	0.58	0.10	0.019‡*
Mx3-3 (mm)	36.16	1.83	35.64	2.04	0.235†
Md3-3 (mm)	27.63	1.57	27.57	1.62	0.869†
TSD 3-3 (Bolton's ratio)	0.77	0.02	0.78	0.02	0.109†
Canines relationship (mm)	1.74	0.91	1.03	0.56	<0.001†*
Cephalometric measurements					
ANB (°)	6.21	1.12	1.78	0.52	<0.001‡*
Wits (mm)	3.39	1.08	-0.40	1.58	<0.001‡*
Convexity (NAP) (°)	11.25	4.15	1.16	3.01	<0.001†*
FH.MP (°)	28.07	5.26	26.66	5.53	0.245†
SN.GoGn (°)	35.58	5.31	33.79	6.06	0.165†
NSGn (°)	70.62	3.37	69.07	4.26	0.082†
LAFH (mm)	66.58	7.08	65.15	5.47	0.291†
Mx1.PP (°)	107.75	6.98	111.40	6.57	0.016†*
Md1.MP (°)	100.24	7.24	92.76	7.68	<0.001†*
Overjet (mm)	2.31	0.64	2.52	0.54	0.056‡
Overbite (mm)	1.71	0.67	1.76	0.88	0.818†

† *t*-test

‡Mann-Whitney U Test

§Chi-square test

*Statistically significant at P<0.05

Table II – Comparison between non-stripping subgroups with and without skeletal Class II discrepancy.

Variables	**Skeletal Class II N=17**		**Skeletal Class I N=32**		**P**
	Mean	**SD**	**Mean**	**SD**	
Age (years)	20.15	5.99	19.43	4.80	0.488‡
Sex (%)	M (52.94%)		M (31.25%)		0.137§
	F (47.06%)		F (68.75%)		
Dental cast measurements					
MxAAL (mm)	9.29	1.30	8.60	1.37	0.096†
MdAAL (mm)	6.47	1.24	5.08	1.19	<0.001‡*
MdAAL/MxAAL	0.70	0.13	0.59	0.12	0.011‡*
Mx3-3 (mm)	36.60	1.76	35.46	2.09	0.061†
Md3-3 (mm)	27.74	1.54	27.45	1.56	0.540†
TSD 3-3 (Bolton's ratio)	0.77	0.02	0.78	0.02	0.033†*
Canines relationship (mm)	2.09	1.1	1.08	0.55	<0.001†*
Cephalometric measurements					
ANB (°)	6.07	1.00	1.72	0.52	<0.001‡*
Wits (mm)	3.12	1.15	-0.57	1.59	<0.001‡*
Convexity (NAP) (°)	10.88	4.58	0.53	2.94	<0.001†*
FH.MP (°)	27.55	6.10	26.28	5.45	0.463†
SN.GoGn (°)	34.54	5.96	33.10	5.87	0.421†
NSGn (°)	69.49	3.54	68.23	4.07	0.286†
LAFH (mm)	67.27	6.34	64.26	5.89	0.092‡
Mx1.PP (°)	107.51	5.96	111.01	7.18	0.092†
Md1.MP (°)	99.27	8.06	91.39	7.91	0.001†*
Overjet (mm)	2.25	0.63	2.50	0.54	0.037‡*
Overbite (mm)	1.72	0.55	1.68	0.88	0.366‡

† *t*-test

‡Mann-Whitney U Test

§Chi-square test

*Statistically significant at P<0.05

Table III – Correlation between dental and skeletal variables and canine relationship.

Variables	**Canine relationship**	
Dental cast measurements	**R**	**P**
MxAAL (mm)	-0.119	0.268†
MdAAL (mm)	0.338	0.001‡*
MdAAL/MxAAL	0.462	<0.001‡*
Mx3-3 (mm)	-0.007	0.947†
Md3-3 (mm)	0.096	0.370†
TSD 3-3 (Bolton's ratio)	0.266	0.012†*
Cephalometric measurements		
ANB (°)	0.283	0.007‡*
Wits (mm)	0.397	<0.001‡*
Convexity (NAP) (°)	0.253	0.017†*
FH.MP (°)	0.026	0.803†
SN.GoGn (°)	-0.050	0.639†
NSGn (°)	0.004	0.967†
LAFH (mm)	0.092	0.392†
Mx1.PP (°)	-0.154	0.150†
Md1.MP (°)	0.285	0.007†*
Overjet (mm)	-0.094	0.378‡
Overbite (mm)	0.0178	0.869†

†Pearson correlation test

‡Spearman correlation test

*Statistically significant at P<0.05

Figures

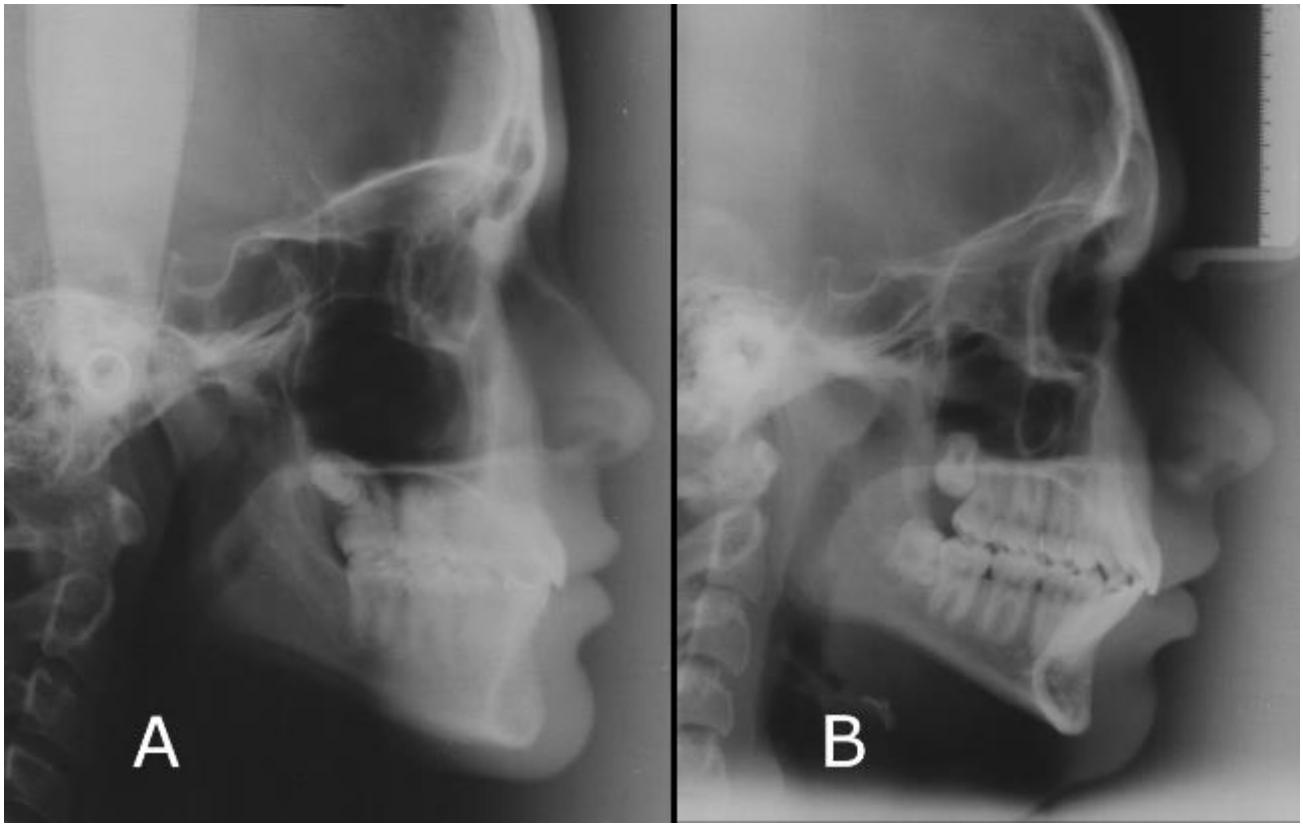

Fig 1

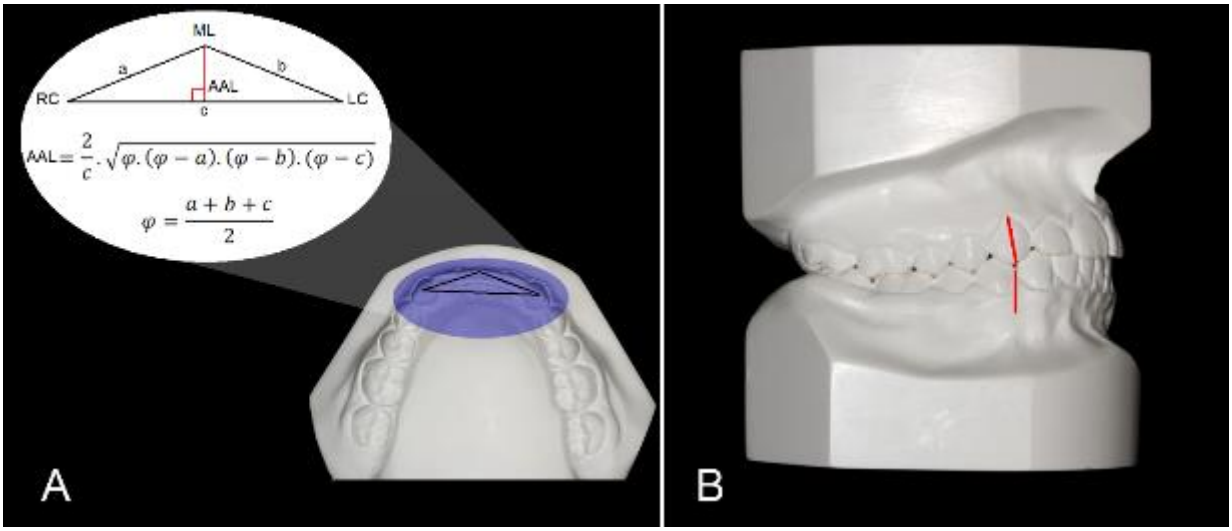
ML
a
b
RC
AAL
LC
c
$AAL = \frac{2}{c} \cdot \sqrt{\varphi.(\varphi - a).(\varphi - b).(\varphi - c)}$
$\varphi = \frac{a + b + c}{2}$
A
B

Fig 2

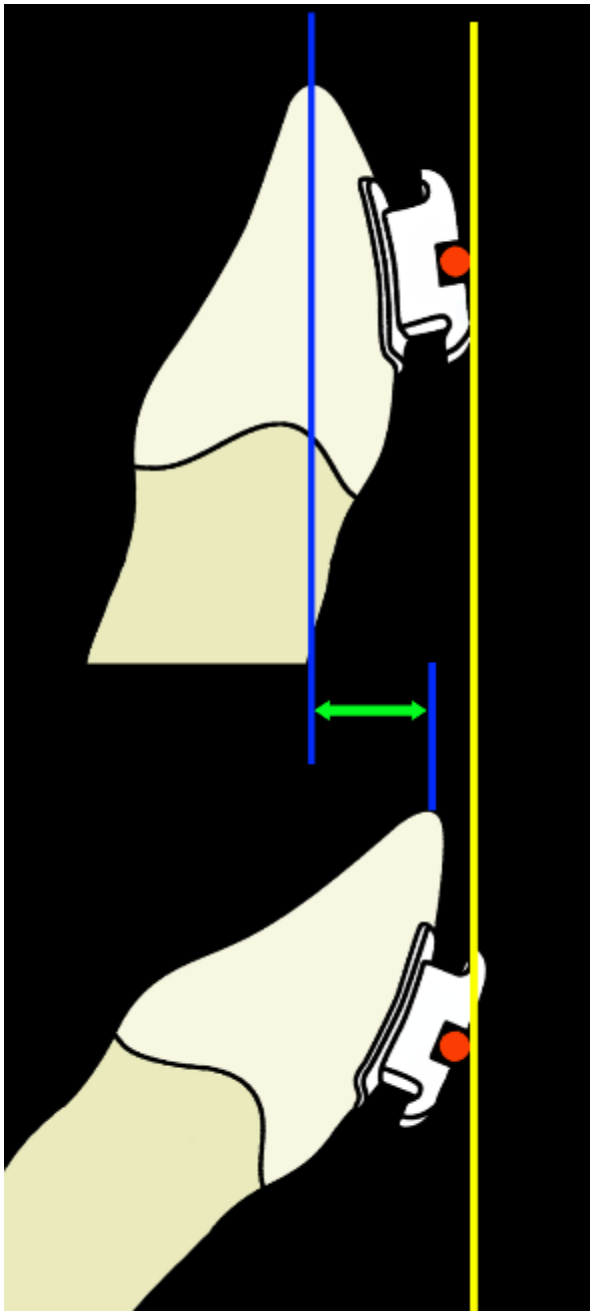

Fig 3

5. CONSIDERAÇÕES FINAIS

Com base nesse estudo podemos concluir que a relação entre o comprimento do arco anterior e a relação entre os caninos foram significativamente influenciadas pelo tratamento de compensação da Classe II. O aumento do comprimento anterior do arco inferior apresentou-se como o principal fator para a diminuição entre a razão do comprimento anterior dos arcos, e isso se deve ao posicionamento compensatório dos incisivos, sobretudo dos incisivos inferiores. A relação do comprimento do arco anterior foi a variável mais influente na relação entre os caninos, dessa forma, a necessidade de redução do comprimento do arco ântero-inferior através de desgastes interproximais deve ser considerada no tratamento compensatório das maloclusões de Classe II com desequilíbrio esquelético acentuado.

REFERÊNCIA

1. Ishikawa H, Nakamura S, Iwasaki H, Kitazawa S, Tsukada H, Chu S. Dentoalveolar compensation in negative overjet cases. Angle Orthod. 2000 Apr;70(2):145-8.

2. Ceylan I, Yavuz I, Arslan F. The effects of overjet on dentoalveolar compensation. Eur J Orthod. 2003 Jun;25(3):325-30.

3. Solow B. The dentoalveolar compensatory mechanism: background and clinical implications. Br J Orthod. 1980 Jul;7(3):145-61.

4. Sangcharearn Y, Ho C. Effect of Incisor Angulation on Overjet and Overbite in Class II Camouflage Treatment. A typodont study. Angle Orthod. 2007 Nov;77(6):1011-8.

5. Bishara SE, Ziaja RR. Functional appliances: a review. Am J Orthod Dentofacial Orthop. 1989 Mar;95(3):250-8.

6. Proffit WR, Phillips C, Dann Ct. Who seeks surgical-orthodontic treatment? Int J Adult Orthodon Orthognath Surg. 1990;5(3):153-60.
516-7

7. Berger JL, Pangrazio-Kulbersh V, George C, Kaczynski R. Long-term comparison of treatment outcome and stability of Class II patients treated with functional appliances versus bilateral sagittal split ramus osteotomy. Am J Orthod Dentofacial Orthop. 2005 Apr;127(4):451-64; quiz.

8. Maia FA, Janson G, Barros SE, Maia NG, Chiqueto K, Nakamura AY. Long-term stability of surgical-orthodontic open-bite correction. Am J Orthod Dentofacial Orthop. 2010 Sep;138(3):254 e1- e10; discussion -6.

9. Bailey LJ, Haltiwanger LH, Blakey GH, Proffit WR. Who seeks surgical-orthodontic treatment: a current review. Int J Adult Orthodon Orthognath Surg. 2001 Winter;16(4):280-92.

10. Wilmot JJ, Barber HD, Chou DG, Vig KW. Associations between severity of dentofacial deformity and motivation for orthodontic-orthognathic surgery treatment. Angle Orthod. 1993 Winter;63(4):283-8.

11. O'Higgins EA, Kirschen RH, Lee RT. The influence of maxillary incisor inclination on arch length. Br J Orthod. 1999 Jun;26(2):97-102.

12. Sangcharearn Y, Ho C. Maxillary incisor angulation and its effect on molar relationships. Angle Orthod. 2007 Mar;77(2):221-5.

13. Hussels W, Nanda RS. Effect of maxillary incisor angulation and inclination on arch length. Am J Orthod Dentofacial Orthop. 1987 Mar;91(3):233-9.

14. Jain M, Vyas M, Singh JR. Effect of Crown Angulation of Maxillary Incisor on Effective Arch Perimeter. J Clin Diagn Res. 2017 Jun;11(6):ZC92-ZC6.

15. Al-Khateeb EA, Al-Khateeb SN. Anteroposterior and vertical components of class II division 1 and division 2 malocclusion. Angle Orthod. 2009 Sep;79(5):859-66.

16. Casko JS, Shepherd WB. Dental and skeletal variation within the range of normal. Angle Orthod. 1984 Jan;54(1):5-17.

17. Bibby RE. Incisor relationships in different skeletofacial patterns. Angle Orthod. 1980 Jan;50(1):41-4.

18. Mihalik CA, Proffit WR, Phillips C. Long-term follow-up of Class II adults treated with orthodontic camouflage: a comparison with orthognathic surgery outcomes. Am J Orthod Dentofacial Orthop. 2003 Mar;123(3):266-78.

19. Daniels S, Brady P, Daniels A, Howes S, Shin K, Elangovan S, et al. Comparison of surgical and non-surgical orthodontic treatment approaches on occlusal and cephalometric outcomes in patients with Class II Division I malocclusions. Prog Orthod. 2017 Dec;18(1):16.

20. Chhibber A, Upadhyay M, Uribe F, Nanda R. Long-term surgical versus functional Class II correction: a comparison of identical twins. Angle Orthod. 2015 Jan;85(1):142-56.

21. Janson G, Sathler R, Fernandes TM, Branco NC, Freitas MR. Correction of Class II malocclusion with Class II elastics: a systematic review. Am J Orthod Dentofacial Orthop. 2013 Mar;143(3):383-92.

22. Bryk C, White LW. The geometry of Class II correction with extractions. J Clin Orthod. 2001 Sep;35(9):570-9.

23. Janson G, Maria FR, Barros SE, Freitas MR, Henriques JF. Orthodontic treatment time in 2- and 4-premolar-extraction protocols. Am J Orthod Dentofacial Orthop. 2006 May;129(5):666-71.

24. Janson G, Janson MR, Cruz KS, Henriques JF, de Freitas MR. Unusual orthodontic retreatment. Am J Orthod Dentofacial Orthop. 2003 Apr;123(4):468-75.

25. Weiland FJ, Bantleon HP, Droschl H. Evaluation of continuous arch and segmented arch leveling techniques in adult patients--a clinical study. Am J Orthod Dentofacial Orthop. 1996 Dec;110(6):647-52.

26. Parker CD, Nanda RS, Currier GF. Skeletal and dental changes associated with the treatment of deep bite malocclusion. Am J Orthod Dentofacial Orthop. 1995 Apr;107(4):382-93.

27. Dake ML, Sinclair PM. A comparison of the Ricketts and Tweed-type arch leveling techniques. Am J Orthod Dentofacial Orthop. 1989 Jan;95(1):72-8.

28. El Namrawy MM, Sharaby FE, Bushnak M. Intrusive Arch versus Miniscrew-Supported Intrusion for Deep Bite Correction. Open Access Maced J Med Sci. 2019 Jun 15;7(11):1841-6.

29. Sifakakis I, Pandis N, Makou M, Eliades T, Bourauel C. Forces and moments generated with various incisor intrusion systems on maxillary and mandibular anterior teeth. Angle Orthod. 2009 Sep;79(5):928-33.