Compensation in Class III Malocclusions: Analysis of Tooth Crown Inclination on Digital Dental Casts

Compensação da Má Oclusão de Classe III: Análise da Inclinação das Coroas dos Dentes em Modelos Digitais

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Abstract

The objective of this study was to evaluate the tooth crown inclination in maxillary and mandibular arches in Class III malocclusion individuals, to identify the presence and magnitude of compensation. The study was conducted on 46 plaster casts of individuals with Class III malocclusion, of both genders (25 males and 21 females), with mean age 21 years and 1 month, with indication for compensatory orthodontic treatment. The dental casts models were scanned and the tooth crown inclinations were measured and compared with standard values by the independent t test. All tests considered a significance level of 5% (p<0.05). According to the results there was extensive variation in tooth inclination in Class III malocclusions. Values distribution for incisors highlighted the significant concentration of maxillary incisors in the area of positive values, compared with a very expressive concentration of mandibular incisors in the area of negative values. Compared with normal standards, in Class III malocclusions, the maxillary posterior teeth exhibited smaller palatal inclination than normal, while the mandibular incisors and second molars presented greater lingual inclination. It was concluded that the analysis of inclinations of all crowns of both dental arches in Class III malocclusions, compared with normal standards, evidenced the presence of natural compensation for maxillary posterior teeth, with reduced palatal inclination, as well as increased lingual inclination in mandibular incisors. The parameters of compensation naturally present in Class III malocclusions described, especially in lower incisors, would help clinicians when compensatory treatment is considered.

Keywords: Angle Class III Malocclusion. Dentoalveolar Compensation. Digital Model.

Resumo

O objetivo deste estudo foi avaliar a inclinação das coroas dentárias nas arcadas superior e inferior em indivíduos com má oclusão de Classe III, para identificar a presença e a magnitude da compensação. O estudo foi realizado em 46 modelos de gesso de indivíduos com má oclusão de Classe III, de ambos os sexos (25 homens e 21 mulheres), com média de idade de 21 anos e 1 mês, com indicação de tratamento ortodôntico compensatório. Os modelos de gesso foram digitalizados e as inclinações da coroa dos dentes foram medidas e comparadas com os valores de normalidade pelo teste t independente. Todos os testes estatísticos adotaram um nível de significância de 5% (p <0,05). De acordo com os resultados, houve grande variação na inclinação dentária nas más oclusões de Classe III. A distribuição dos valores para os incisivos destacou a concentração significativa de incisivos superiores na área de valores positivos, em comparação com uma concentração muito expressiva de incisivos inferiores na área de valores negativos. Comparados aos padrões de normalidade, nas más oclusões de Classe III, os dentes posteriores superiores exibiram inclinação palatina menor que o normal, enquanto os incisivos e segundos molares inferiores apresentaram inclinação lingual maior. Concluiu-se que a análise das inclinações de todas as coroas de ambas as arcadas dentárias nas más oclusões de Classe III, comparadas aos padrões de normalidade, evidenciou a presença de compensação natural para os dentes posteriores superiores, com diminuição da inclinação palatina, bem como aumento da inclinação lingual dos incisivos inferiores. Os parâmetros de compensação naturalmente presentes nas más oclusões de Classe III descritos, especialmente nos incisivos inferiores, podem auxiliar o clínico quando o tratamento compensatório é considerado.

Palavras-chave: *Má oclusão de Classe III de Angle. Compensação Dentoalveolar. Modelos Digitais.*

1 Introduction

Class III malocclusion has been characterized by skeletal, functional, and dental discrepancies, which may or may not be associated with each other. In 63% of the cases the maxilla is involved in the sagittal skeletal discrepancy[1-3] and the adoption of interceptive treatment is encouraged. The limited and controversial outcomes of treatment focused on the mandible, such as chincup[4], may lead for orthopedic approach with rapid maxillary expansion (RME) and maxillary protraction (MP), when facial features could benefit from this protocol[5-10].

The incisors compensation is often present on the initial evaluation of Class III malocclusion and tends to increase during treatment[11], which allows to consider this therapeutic process as *compensatory*. In the presence of more severe skeletal discrepancies, with indication for orthognathic surgery, the compensation, which is usually more severe in mandibular incisors, must be removed[11,12]. This treatment stage is called decompensation and, if inadequately performed, it may impair the quality of surgical treatment.[11]

The compensatory evidences from a cephalometric point of view, present in upper teeth and more intense and

frequent in lower incisors are reported.[13-15] On the other hand, investigation in dental casts in patients with normal occlusion were conducted and greater range of inclination for lower incisors were described, mean of -1.71° with variation of 33° (from +16° to -17°).[16] Other studies also verified the tooth inclination and angulation in patients with normal occlusion.[17,18] The measurements were performed in dental casts using a special device developed to increase the accuracy of evaluations and the mean values were not very different from those reported by Andrews,[18] indicating an extensive variation of values also representing normality. Considering this wide variation, this sample was re-assessed for critical analysis of the presence of the six keys to normal occlusion[19], specifically for inclination, the variation was greater than previously described,[16] indicating values that ruled out the presence of this key.

Based on the available literature, there is an evident need to describe the compensation naturally present in Class III malocclusions. The literature also clearly presents the remarkable variation in tooth crown inclinations, without crossing the normal standards, which significantly validates the option for compensatory treatment. Thus, this study analyzed the compensation beyond the inclination of incisors, analyzing all teeth in the maxillary and mandibular arches of individuals with Class III malocclusions, with indication for compensatory treatment.

2 Material and Methods

This study was approved by the Institutional Review Board of Sagrado Coração University (protocol n. 500.012).

The sample of this retrospective study was composed of dental casts of individuals with Class III malocclusions, with indication for compensatory orthodontic treatment, collected from the orthodontic records from a private clinic and selected among 3,000 patients. Pretreatment dental casts were obtained from 46 individuals, of both genders (25 males, 21 females), with mean age of 21 years and 1 month (maximum age 44 years and 3 months and minimum age 12 years), with ¼ to full Class III molar relationship.

Sample size calculation was based on the measurement of inclination from the study of Zanelato.[18] The standard deviation of the inclination of mandibular canine was 4.73°. Considering a confidence interval of 95% and a margin of error of 1.5°, the calculated sample size was 41 individuals.

The following inclusion criteria were considered for sample selection: presence of bilateral Class III malocclusion; absence of hypodontia or permanent teeth loss, except for the third molars; absence of supernumerary or impacted teeth, or syndromes. Ethnicity was also considered, selecting only Caucasian individuals, due to probable differences in tooth positioning in Class III malocclusions between Caucasian individuals and those from Asian or African descent.[1,4]

The dental casts were scanned for achievement of digital casts (3D), using the scanner 3Shape r700 (3Shape A/S, Copenhagen, Denmark) (Figure 1).

Figure 1 – Three-dimensional model obtained by scanning and manipulated on the software Ortho Viewer (3Shape)

Source: The authors.

After that, they were manipulated (*3Shape Ortho Viewer* software) and positioned considering the maxillary and mandibular occlusal line and the tooth to be measured. The occlusal line was defined considering the mesiobuccal cusp of the first molar and a point between the two central incisors; if the incisors presented severe mispositioning, the canine cusp tip would be taken as reference. The present study analyzed the inclination, which required profile view of the tooth to be measured. After positioning the dental cast, a "print screen" was obtained for achievement of a JPEG file (Figure 2).

Figure 2 – Print screen of dental cast correctly positioned for achievement of measurements (respectively, teeth 11/16)
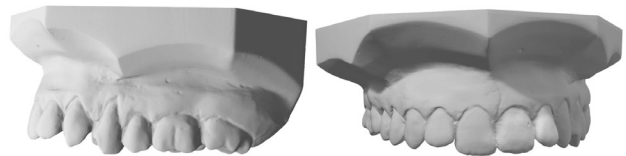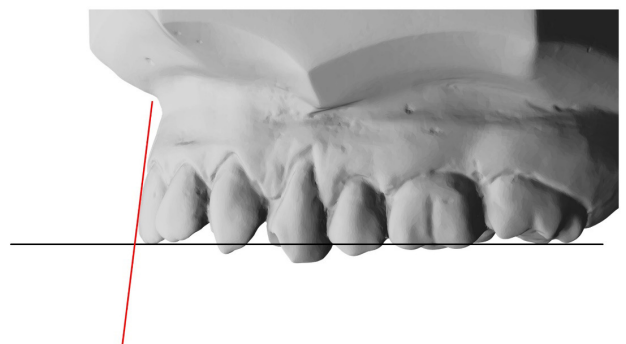

Source: The authors.

The achieved image was then opened on the software "BI Abzil", developed by Serra Online informática LTDA (Petrópolis, RJ, Brazil), in order to evaluate the tooth crown inclinations.

For the achievement of measurements, initially a reference line of the established occlusal line was marked on the first software in which the dental cast was manipulated. Following, the middle point on the long axis of the clinical crown was marked (point EV), considering the cusp tip and the most cervical point of the crown. The long axis was defined as a line parallel to the buccal aspect of the clinical crown, passing through point EV, touching the greatest number of points close to it (Figure 3).

Figure 3 – Long axis of the clinical crown.

Source: The authors.

The angle formed between the long axis of the crown and a line perpendicular to the occlusal plane was then automatically obtained, representing the value of tooth crown inclination. Positive values indicated buccal inclination of the crown, while negative values indicated lingual inclination. This procedure was repeated in all teeth, from second molar to second molar, in both maxillary and mandibular arches (Figure 4).

Figure 4 – Angle between long axis of the crown and a line perpendicular to the occlusal line.
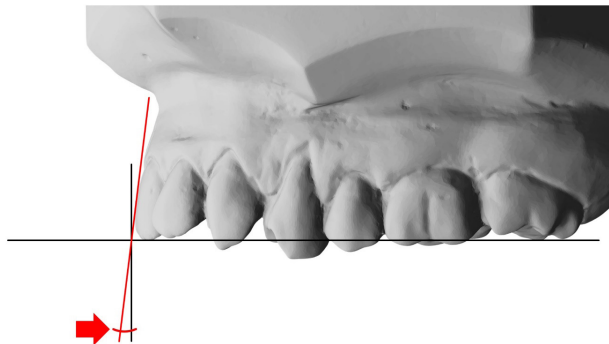
Source: The authors.

2.1 Statistical analysis

The dental casts were randomly selected and remeasured (30%) three weeks after the first mensuration to investigate the intra-examiner error. The systematic error was assessed by the paired t test. The casual error was determined by the calculation proposed by Dahlberg.[20]

Data were described by the parameters of mean, standard deviation, minimum and maximum values. All measurements passed the Kolmogorov-Smirnov normality test. Comparison between sides was performed by the paired t test. The results were compared with the findings of Zanellato[18] by the t test. All tests considered a significance level of 5% (p<0.05).

All statistical procedures were performed on the software *Statistica,* version 5.1 (StatSoft Inc., Tulsa, USA)

3 Results and Discussion

Analysis of intra-examiner systematic error revealed that only the inclination of the mandibular second molar exhibited statistical difference, although this difference between the first and second analyses did not exceed 0.85 degree.

In the analysis of casual errors, the values ranged from 0.28 for the maxillary lateral incisor to 3.09 for the mandibular first molar, with maximum difference of 1.66 degree between the first and second measurements.

The results for the inclination of maxillary teeth (Table 1), in the average, was positive for central and lateral incisors and negative for all the other teeth. Considering standard deviations with similar values for all teeth and the wide difference between the highest and lowest values, extensive variation may be inferred for tooth crown inclination in Class III malocclusions. This includes the negative inclination of

maxillary incisors.

Table 1 – Inclinations of maxillary tooth crowns in Class III malocclusions, considering the mean between sides

Tooth	Mean	SD	Minimum	Maximum
Maxillary central incisor	6.67	5.43	-3.09	19.87
Maxillary lateral incisor	4.79	5.76	-6.18	18.34
Maxillary canine	-1.67	4.52	-12.85	6.98
Maxillary first premolar	-4.51	4.09	-13.92	4.71
Maxillary second premolar	-4.81	4.27	-14.04	5.25
Maxillary first molar	-6.70	3.93	-16.21	3.56
Maxillary second molar	-5.27	6.12	-16.93	6.81

Source: Research data.

In the mandibular arch, all tooth crowns presented negative inclination, which was more marked for the incisors (Table 2). Again, similar to the maxillary arch, the marked standard deviations with similar amplitude for all teeth, as well as the extreme values (highest and lowest), indicated extensive variation of inclination in the sample. This included the mandibular incisors with positive inclination.

Table 2 – Inclinations of mandibular tooth crowns in Class III malocclusions, considering the mean between sides

Tooth	Mean	SD	Minimum	Maximum
Mandibular central incisor	-4.59	5.22	-16.62	4.08
Mandibular lateral incisor	-6.11	5.05	-21.89	2.44
Mandibular canine	-11.95	4.70	-22.54	-2.00
Mandibular first premolar	-19.97	4.64	-30.94	-10.81
Mandibular second premolar	-21.74	7.29	-31.86	4.23
Mandibular first molar	-31.21	7.63	-48.66	-18.04
Mandibular second molar	-38.78	9.89	-58.41	-17.27

Source: Research data.

Assuming the extensive variation in inclination observed in the sample, it seemed convenient to investigate the frequency of values distribution, especially for the maxillary and mandibular incisors, because of their participation in compensation in Class III malocclusions.

Figure 5 demonstrates that the wide variation for maxillary central incisors included the area of compensation, expressed by markedly increased buccal inclination (intervals of 10 to 20 degrees) in approximately 20% of the individuals. Most individuals (70%) exhibited inclination ranging from 0 to 10 degrees, while negative inclination was an exception.

Figure 5 – Histogram of distribution of inclination values for the maxillary central incisor
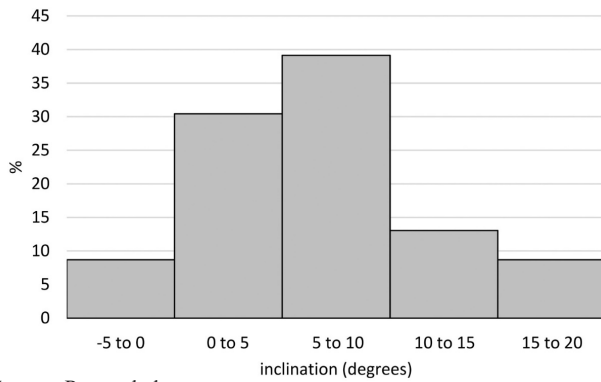
Source: Research data.

Figure 6 shows that in the mandibular arch, the values distribution of the lower central incisors was clearly condensed in the compensation area: almost 40% of the sample concentrated in the range from -20 to -5 degrees (marked lingual inclination); in addition, a significant part (> 35%) presented upright positioning or moderate lingual inclination (-5 to 0 degrees). Thus, only 20% of the sample presented an inclination from zero to 5 degrees, disagreeing with the reported tendency for lingual inclination of the lower incisors.

Figure 6 - Histogram of distribution of inclination values for the mandibular central incisor
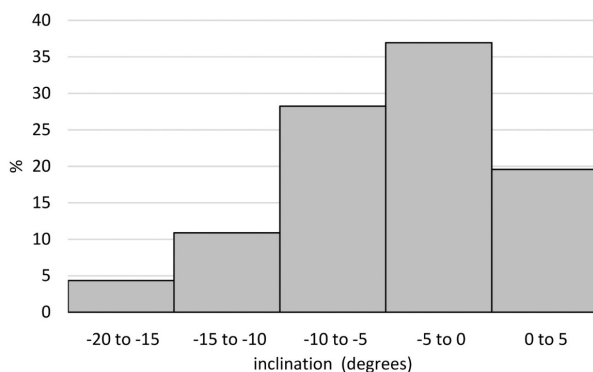
Source: Research data.

The values obtained for tooth crown inclinations in Class III malocclusions were compared with normal standards.[18] In the maxillary arch (Table 3), the tooth crown inclination of maxillary central and lateral incisors in Class III malocclusions was similar to normal occlusion. However, for all the maxillary posterior teeth, including the canines, inclination was smaller and statistically significant. There was a tendency of progressive anteroposterior palatal inclination in this segment, initiating with a palatal inclination smaller than normal of canines and then maintaining it, expressing a transverse compensation for the entire maxillary posterior tooth segment.

In the mandibular arch, compared with normal standards,[18] there was greater lingual inclination with statistical significance for the central and lateral incisors in Class III malocclusions,

indicating compensation (Table 4). The mandibular posterior segment exhibited progressive lingual inclination from anterior to posterior direction, although with statistically significant difference only for the second premolars and second molars. For the second premolar, lingual inclination was smaller than in normal occlusion and the second molar exhibited greater lingual inclination.

The concept of compensation in Class III malocclusions is consistently established for the incisors, as evidenced in cephalometric studies showing greater frequency and intensity of buccal inclination of upper incisors and lingual inclination of lower incisors.[11-14]

Since the advent of orthognathic surgery, with the need to remove the camouflage promoted by tooth positioning by orthodontic treatment, the concept of compensation was widened three-dimensionally and demanded information that were not sufficiently available. Thus, in order to contribute to the literature regarding this topic, this study was carried out to investigate, by digital casts analysis, the compensatory tooth crown inclination in Class III malocclusions individuals.

The results of this studh showed a significant variation in the tooth crown inclination values in both arches (Table 1). In the average, the inclination was positive for upper central and lateral incisors, and negative for posterior teeth, including the canines. In the lower arch, even though all crowns exhibited negative inclination, it was more pronounced in the incisors (Table 2). Considering the similar values of standard deviations for all teeth in both arches and the wide difference between the lowest and highest values, greater variation in tooth crown inclination may be assumed in Class III malocclusions, as also described for normal occlusions.[16,18]

For this reason, the frequency of values distribution obtained for the incisors was analyzed by histograms. The wide array of values obtained for the inclination of maxillary incisors (Figure 5) included the range of positive values (70%), even though only 20% exhibited values that clearly indicated compensation (between 10 and 20 degrees). This partially disagrees with the tendency of buccal inclination of incisors described in the literature[11,12,14].

According to the values for the inclination of lower central incisors (Figure 6), nearly 40% of the sample presented inclination values from -20 to -5 degrees (significant lingual inclination), and around 35% of patients showed upright positioning or lingual inclination (-5 to 0 degree). Thus, only 20% of the sample exhibited positioning from zero to 5 degrees. These data agree with the lingual inclination of mandibular incisors described by cephalometric analysis.[11-14]

The values obtained for tooth crown inclination in the upper arch in Class III malocclusions, compared with normal standards[21], demonstrated similarity for the incisors (Table 3). This disagrees with cephalometric results reported in the literature.[11,12,14] Thus, buccal inclination of upper incisors, though present, would not be a natural tendency in Class III

malocclusions and should be maintained when present, or implemented by treatment when absent. The usefulness of this procedure is evidenced in the literature.[11,15,22] The achievement of normal overjet and overbite requires adjustment of incisors inclinations when treatment of Class II and III malocclusions is performed only with orthodontic resources.[22]

Table 3 - Results of tooth crown inclination in the maxillary arch in Class III malocclusions compared with normal standards (Zanellato 2003).

Arch	Measurement	Capelozza (2015)		Zanelato (2003)		dif.	P
		Mean	**SD**	**Mean**	**SD**		
Maxillary	Mandibular central incisor	6.67	5.43	5.28	4.89	1.39	0.168
	Mandibular lateral incisor	4.79	5.76	4.99	4.48	-0.20	0.838
	Mandibular canine	-1.67	4.52	-6.70	4.84	5.03	<0.001*
	Mandibular first premolar	-4.51	4.09	-10.83	5.99	6.32	<0.001*
	Mandibular second premolar	-4.81	4.27	-9.95	5.87	5.14	<0.001*
	Mandibular first molar	-6.70	3.93	-10.99	5.12	4.29	<0.001*
	Mandibular second molar	-5.27	6.12	-9.88	5.84	4.61	<0.001*

Source: Research data.

Progressive palatal inclination was observed for maxillary posterior teeth, always smaller than normal and with statistical significance (Table 3), indicating transverse compensation for the entire maxillary posterior tooth segment. With no evidence in the literature, this movement seems logically supported and has been used as a clinical resource, by expansion of the maxillary arch in interceptive[5-10] or compensatory[8] treatments. Also, within the context of esthetics and tolerance for inclination values deviating from the mean, the attractiveness of smile supports variations for the inclination of maxillary canines and premolars. Xu et al.[21] reported that esthetics was considered satisfactory by the orthodontists when the canine inclination ranged from 0° to -7° and premolars from -3º to -11º, while lay individuals accepted variations from 3º to -10º for the canines and 5º to -11º for the premolars. The authors suggested that clinicians could accept tooth positioning within this variation when performing treatment for transverse maxillary discrepancies. This can be particularly useful in compensatory treatments of Class III malocclusions.

Comparison of tooth crown inclination values for the mandibular arch in Class III malocclusions with normal standards[21] evidenced greater lingual inclination with statistical significance for the central and lateral incisors, indicating compensation (Table 4). This confirms the concept defined by cephalometric analysis for the mandibular incisors.[11-14] Thus, it seems reasonable to assume the inexorably intense presence of lingual inclination of mandibular incisors as a natural compensation, often increased during orthodontic treatment.[11,15,22]

Table 4 - Results of tooth crown inclination in the mandibular arch in Class III malocclusions compared with normal standards (Zanellato 2003)

Arch	Measurement	Capelozza (2015)		Zanelato (2003)		dif.	P
		Mean	**SD**	**Mean**	**SD**		
Mandibular	Mandibular central incisor	-4.59	5.22	0.10	5.51	-4.69	<0.001*
	Mandibular lateral incisor	-6.11	5.05	-2.03	5.18	-4.08	<0.001*
	Mandibular canine	-11.95	4.70	-10.13	4.73	-1.82	0.052
	Mandibular first premolar	-19.97	4.64	-20.74	5.26	0.77	0.432
	Mandibular second premolar	-21.74	7.29	-24.38	5.54	2.64	0.036 *
	Mandibular first molar	-31.21	7.63	-28.66	5.59	-2.55	0.050
	Mandibular second molar	-38.78	9.89	-32.10	5.93	-6.68	<0.001*

* - statistically significant difference (p<0.05)
Source: Research data.

At the mandibular posterior region, progressive lingual inclination was observed from anterior to posterior direction, although statistically significant difference was only observed for the second premolars and second molars (Table 4). For the second premolar, lingual inclination was smaller than normal, absolutely disagreeing with the context of compensation; conversely, increased lingual inclination was observed for the second molar, which has little meaning because it was limited only to that last tooth. Therefore, it must be assumed that transverse compensation expressed by the greater lingual inclination of posterior teeth is not naturally present in Class III malocclusions.

Some remarks are important and necessary after the analysis of the present results. The wide variation in values obtained for tooth crown inclination in Class III malocclusions was not greater than observed for samples with normal occlusion, including the one used in this study[18] and others of widespread importance, such as used in the description of the "six keys to normal occlusion".[16] This implies significant limitations for utilization of mean as a normal standard or to

define therapeutic goals.

Last, and not least, the literature demonstrates – by the magnitude of values described for tooth crown inclination in samples with normal occlusion and the probable tolerance of lay individuals concerning smiles built within this variation[21] – that compensatory treatments should be more qualified and considered primarily, i.e. as first option, when the skeletal discrepancies justifying the compensation do not affect the face. Specifically concerning tooth inclination, the key would be affected, notwithstanding the occlusion might still be considered as normal.[19]

4 Conclusion

Comparison of inclinations of all crowns in both dental arches of individuals with Class III malocclusions with values considered as normal standards evidenced the presence of natural compensation for maxillary posterior teeth, with reduced palatal inclination, and increased lingual inclination of mandibular incisors. This was confirmed by the significant concentration of mandibular incisors in the compensation area (negative inclination) on the histogram. Conversely, in the maxillary arch, even though most incisors presented positive inclination, the magnitude of values did not characterize compensation as a significant tendency.

The compensation parameters naturally present in Class III malocclusions described, especially in lower incisors, would help clinicians when planning compensatory Class III treatment.

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