# Retrospective analysis of the correlation between the facial biotype and the inclination of the upper canine cusp axis to the occlusal plane

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**SUMMARY**

Permanent maxillary canines are the second most frequently impacted teeth and the prevalence of this clinical condition is estimated to be 1-2% in the general population. The diagnosis of maxillary canine impaction should be based on both clinical and radiographic examinations. The aim of this study was to evaluate the presence of a correlation between the facial biotype and the inclination of the upper cusp axis. A correlation between the total radicular length of the lateral incisors was also evaluated, by comparing the side of impaction with the healthy side. Twenty three patients with a diagnosis of unilateral upper cusp impaction were recruited. For each patient, dental casts and radiographic material (panoramic radiographs and lateral cephalograms) were examined. Statistical analyses were done with Spearman's rank correlation coefficient or Spearman's rho (ρ).

X-ray examinations demonstrated that canine impaction was associated to other dental anomalies (32% of the sample). The mean α angle measurements were 22.9° ± 4.1°, and mean values of the β angle were 34.7°± 4.0°. The mean distance "d" value was 14.6 mm ± 1.2 mm.

The mean values of the angle between the upper cusp axis and the perpendicular-to-Fh plane were 20.8 °± 2.6°. Among the 23 subjects recruited, 5 showed values included in the range 25°- 45° and 1 an inclination > 45°.

The results obtained in the present study demonstrate a significant inverse correlation between the MM angle and the inclination of the upper cusp axis to the perpendicular-to-Fh plane.

**Key words:** facial biotype, tooth impaction, upper canine, gnatology.

## Introduction

Permanent maxillary canines are the second most frequently impacted teeth and the prevalence of this clinical condition is estimated to be 1-2% in the general population (1).

Females are twice as frequently affected (1.17%) as males (0.51%) (2).

This atypical limited eruption is most likely due to an extended tooth development period and to a long, difficult path of eruption because of anatomic limitations (3).

Palatally displaced canines are three times more frequent than the buccal displacements (2).

There are many possible etiologic factors associated with canine impaction. Bishara (4) lists the most common causes as the result of any one or a combination of the following factors: tooth size, arch length discrepancies, prolonged retention or early loss of the deciduous canine, abnormal position of the tooth bud, the presence of an alveolar cleft, ankylosis, cystic or

neoplastic formation, dilaceration of the root, iatrogenic injury, and an idiopathic condition with no apparent cause.
During their development, the crowns of the maxillary canines are closely related to the roots of the lateral incisors. For this reason, developmental absence of the maxillary lateral incisor, as well as variation in root size and timing of root formation, have also been implicated as important etiologic factors (5).
The diagnosis of maxillary canine impaction should be based on both clinical and radiographic examinations.
The crown of the developing canine is detectable as a "bulge", high in the buccal sulcus normally by the age of 10 years.
If the canine is palatally displaced, it may press on the root of the lateral incisor and push the root buccally, while the crown will move palatally.
Routine radiographic techniques adopted for orthodontic diagnosis should include:

a) orthopanoramic radiography: Chaushu et al. (6) suggested that if the relationship between the sizes of the canine to the central incisors is sized 1.15 or greater, this prompts a palatal displacement;
b) two periapical radiographies, according to Clark (7);
c) maxillary occlusal X-ray;
d) lateral and frontal cephalograms (8);
e) a three-dimensional cone beam computed tomography (CT) scan can help to localize the canine, providing additional information regarding its relationship with neighboring teeth and any bony pathologic features associated with the impacted tooth (9).

Both the frequency and the complexity of treatment permit extensive study of possible interceptive approaches, with the aim to preventing a definitive impaction of the initially displaced canines.
The aim of this study was to evaluate the existence of a statistically significant correlation between the facial biotype, measured according to the intermaxillary angle (MM) (10) and α angle (11), MM and β angle, (12) MM and the inclination of the upper cusp axis to the perpendicular-to-Fh plane (13), MM angle and distance "d" of the canine cusp to the occlusal plane (11).
A correlation between the total radicular length of the lateral incisors was also evaluated, by comparing the side of impaction with the healthy side.

## Materials and methods

The study was conducted in accordance with the provisions of the Declaration of Helsinki and each patient gave written, informed consent to participate.
An initial sample of 23 patients (12 males and 11 females) aged between 18 and 32 years (mean age 20.9±3.8), with a diagnosis of unilateral upper cusp impaction, was recruited.
All subjects underwent complete work-up prior to orthodontic treatment.
For each patient, dental casts and radiographic material (panoramic radiographs and lateral cephalograms) were examined.
All the records meeting the following entry criteria were included in the study:

1) unilateral impaction of the maxillary canine: the spontaneously erupted canines on the opposite sides served as control teeth;
2) a fully formed apex of the root of the impacted canine (Stage H of tooth development assessed by Demirjian analysis) (14).

For these reasons, we excluded from the study 3 patients with bilateral impactions and 3 others lacking some of the required records.
The final sample, therefore, consisted of 20 patients, 10 males and 10 females.
In the frontal view (orthopantomogram), for each patient, the following parameters were evaluated:

- α angle: the angle between the long axis of the impacted canine and the midline;
- β angle: the angle between the long axis of the impacted canine and the long axis of the lateral incisor;
- distance "d" of the cusp tip to the occlusal plane;
- canine medial crown position in sectors 1-3, according to Crescini (12).

On the sagittal plane (lateral head film) evaluations were made of:

- the vertical skeletal relationships expressed by the intermaxillary angle (MM), according to McLau-

ghlin cephalometric analysis (10);
- the angle between the upper cusp axis and the perpendicular-to-Fh plane (13).

All the examined patients underwent the appropriate orthodontic treatment.

## Statistical analysis

Statistical analyses were done with Spearman's rank correlation coefficient or Spearman's rho (ρ).

## Results

X-ray examinations demonstrated that canine impaction was associated to other dental anomalies (32% of the sample).

Figures from 1 to 6 illustrate ρ values for the analyzed variable pairs.

The mean α angle measurements were 22.9° ± 4.1°, and mean values of the β angle were 34.7° ± 4.0°. The mean distance "d" value was 14.6 mm ± 1.2 mm.

In the evaluation of the canine medial crown position in sectors 1-3 according to Crescini (12) we found a higher percentage of canines in sector 3 (60%), *versus* 24% in sector 2 and 16% in sector 1.

The mean values of the angle between the upper cusp axis and the perpendicular-to-Fh plane were 20.8° ± 2.6°.

Among the 23 subjects recruited, 5 showed values included in the range 25°- 45° and 1 an inclination > 45°.

Finally, we evaluated the correlation between canine impaction, assessed according to the method described by Ericson and Kurol (11) and Orton (13), and the facial biotype according to McLaughlin's (MM: 28° ± 3°) cephalometric analysis (10).

There was a prevalence of normodivergence (52%) and hypodivergence (32%), whereas only 16% of patients with impacted canines showed hyperdivergence.

A more detailed analysis demonstrated that patients with buccal impaction showed normodivergence (9 patients), hyperdivergence (3 patients) and hypodivergence (3 cases).

On the other hand, patients with palatally displaced canines showed largely normodivergence (4 subjects) and hypodivergence (5 patients), while only one patient showed hyperdivergence.

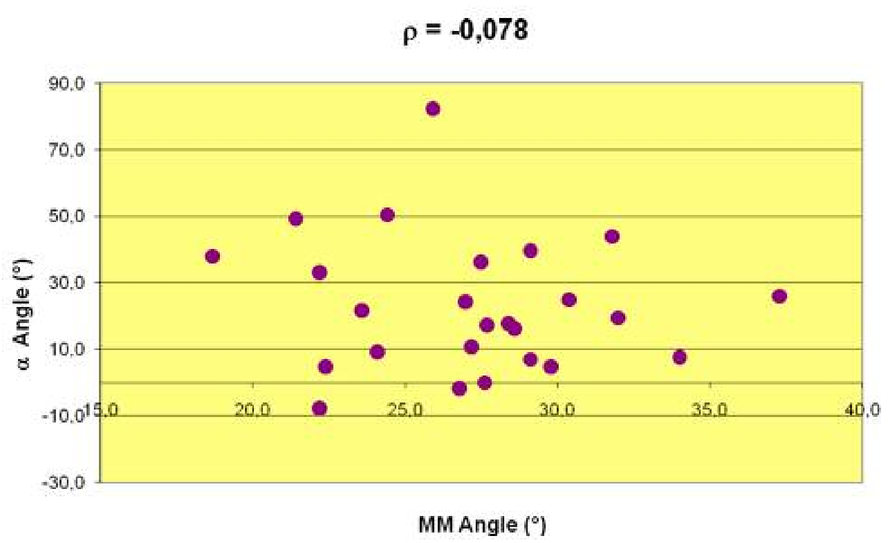


**Figure 1**
Correlation between MM and α angle. The obtained coefficient ρ = -0.078 is not statistically significant either in the two-tailed (ρ = 0.337) or one-tailed test (ρ = 0.265), with a confidence interval of α = 0.10.

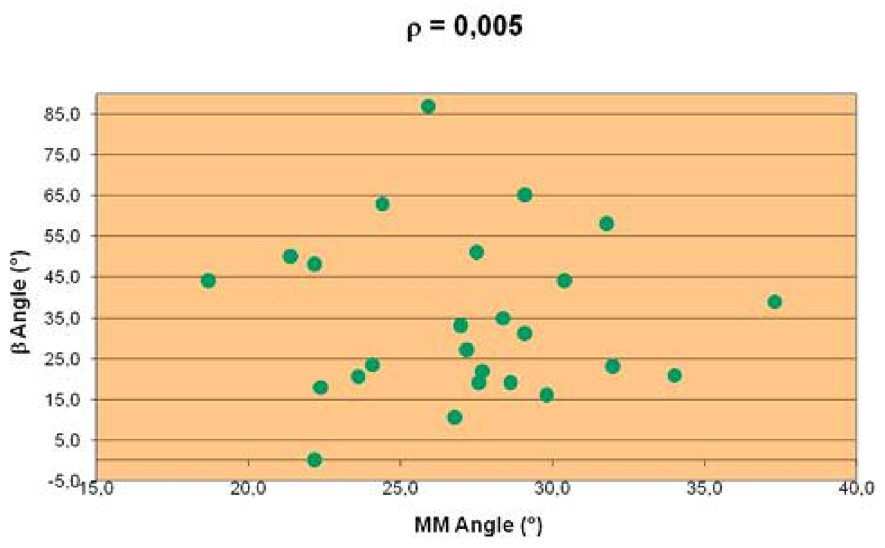


**Figure 2**
Correlation between MM and β angle. The obtained coefficient ρ = 0.005, is not statistically significant either in the two-tailed (ρ = 0.337) or one-tailed test (ρ = 0.265), with a confidence interval of α = 0.10.

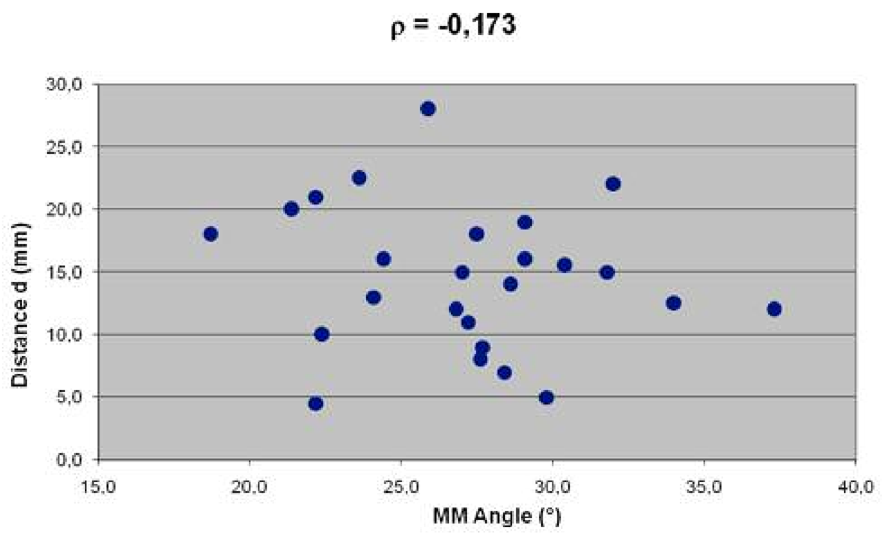


**Figure 3**
Correlation between MM and distance d. The obtained coefficient (ρ = -0,173 is not statistically significant either in the two-tailed (ρ = 0.337) or one-tailed test (ρ = 0.265), with a confidence interval of α = 0.10.

In our study the Spearman's rank correlation coefficient between the MM angle and the α angle was = -0.078, which was not significant either in the two-tailed (critical value ρ = 0.337) or one-tailed test (ρ= 0.265).
This demonstrates the absence of a correlation between the MM and α angular values; this finding was confirmed by the fact that the average α angle in normodivergence is α = 21.3° ± 6.2°, *versus* α = 24.7°±7.6° in hypodivergence and α = 24.3°±7.6° in hyperdivergence.

The study of the correlation between the MM angle and β angle yielded ρ values = -0.005, again not significant either in the two-tailed (ρ = 0.337), or one-tailed test (ρ= 0.265) [confidence interval (CI) α= 0.10].
This indicates the absence of any correlations between these parameters, since ρ is below the critical values. This hypothesis seems to be supported by the mean β angle values as compared to groups with the same biotype (normodivergence: β = 35.3°± 6.0°; hy-

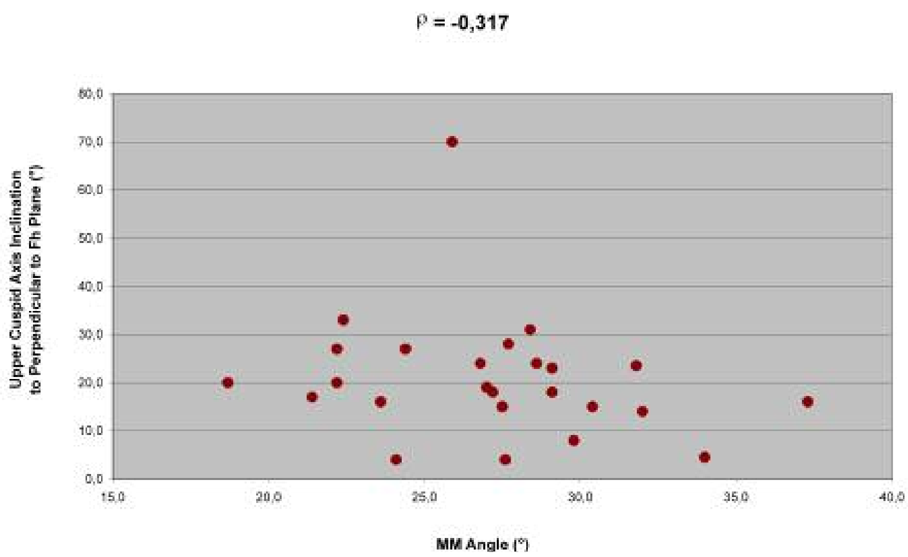


**Figure 4**
Correlation between MM and the inclination of the upper cusp axis to the perpendicular-to-Fh plane. The obtained coefficient ρ = -0.317 is not statistically significant in the two-tailed test (ρ = 0.337), but is statistically significant in the one-tailed test (ρ = 0.265), with a confidence interval of α = 0.10.

podivergence: β = 33.4° ±7.4°; hyperdivergence: β = 35.3°±8.6°).

The study of the correlation between the MM angle and the distance "d" yielded a ρ value = -0.173, which is not significant either in the two-tailed (ρ= 0.337) or one-tailed test (ρ = 0.265) (CI α = 0.10).

Therefore, neither a direct nor an inverse correlation seems to be present between the two parameters.

The correlation coefficient between the values of the MM angle and the inclination of the upper cusp axis to the perpendicular-to-Fh plane was ρ= -0.317, which is significant in the one-tailed test (ρ= 0.265) but not in the two-tailed test (ρ= 0.337) (CI α= 0.10).

Therefore, there is a statistically significant inverse correlation between the two angle measurements. In fact, as the MM angle increases, the inclination of the upper cusp axis to the perpendicular-to-Fh plane decreases.

This hypothesis seems to be confirmed by the mean values of inclination of the upper cusp axis to the perpendicular-to-Fh plane according to the divergency group (normodivergence: 22.8°±4.4°; hypodivergence: 20.5° ±3.1°; hyperdivergence: 14.5° ± 3.9°). This result suggests that the higher the divergence the more favorable the eruption path of the cusp axis.

In the statistical evaluation of a correlation between the upper lateral incisor root length on the side of impaction and the length on the healthy side, a ρ coefficient equal to 0.570 was obtained, which was highly significant both in the two-tailed test (ρ = 0.551) and one-tailed test (ρ= 0.511), with CI α = 0.005.

This finding indicates the existence of a direct correlation between the radicular length of the upper lateral incisors on the side of the impacted canine and on the healthy side (average measurements: side of impaction = 16.6± 0.4 mm; unaffected side = 16.2 ± 0.5 mm). The graphic in Figure 5 shows a more linear trend (lower dispersion of data).

Finally, the comparison between the root length of the right upper lateral incisors and that of the left upper lateral incisors showed a correlation coefficient ρ= 0.567, which is strongly indicative both in the two-tailed (ρ= 0.551) and one-tailed test (ρ = 0.511), with CI α= 0.005.

In short, there is no difference between the incisors radicular measurements on the two sides of the dental arches.

The graphic in Figure 6 and the mean values provide further confirmation of this finding (RS: 16.4 mm ±0.5 mm; LS: 16.5 ±0.4 mm).

## Discussion

Impaction of an upper canine is an important topic in the literature. The clinical and radiographic findings

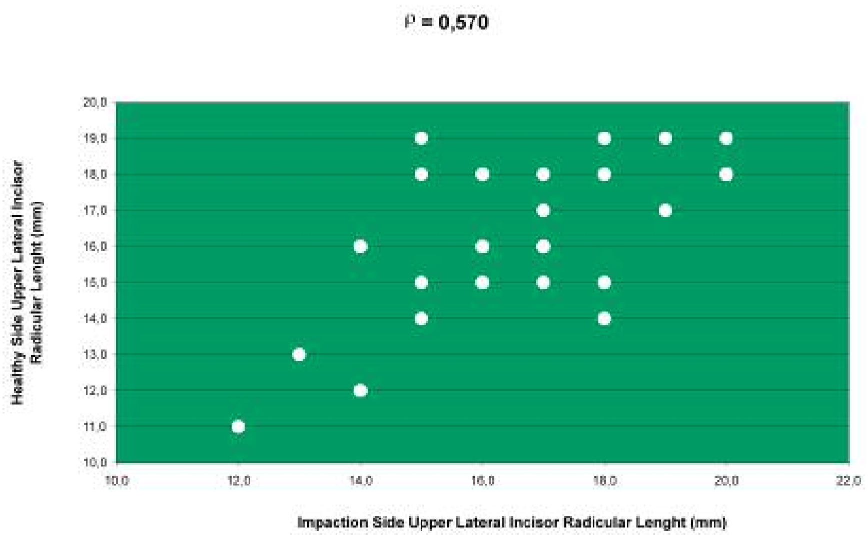


**Figure 5**
Correlation between lateral incisors radicular lengths of impaction side and “control” side. The obtained coefficient ρ = 0.570 is statistically significant both in the two-tailed (ρ = 0.551) and one-tailed test (ρ = 0.511), with a confidence interval of α = 0.005.

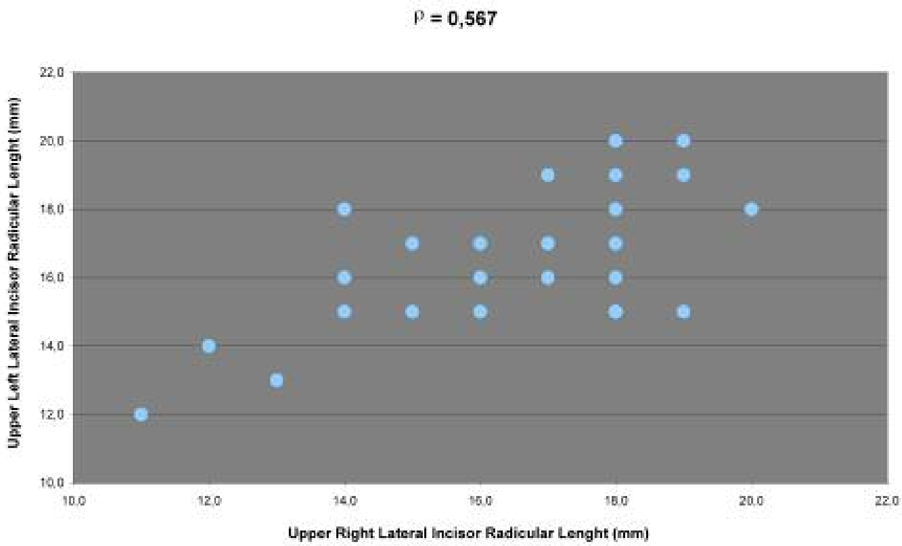


**Figure 6**
Correlation between upper right and left lateral incisors radicular lengths. The obtained coefficient ρ = 0.567 is statistically significant both in the two-tailed (ρ = 0.551) and one-tailed test (ρ = 0.511), with a confidence interval of α = 0.005.

in this retrospective study are in agreement with those of previous studies about the prevalence of this phenomenon in female subjects (2) as compared to males (F/M: 1.5/1).

Instead, the issue of the prevalence of the impaction on the left side rather than the right is in agreement with some Authors (15) and disagreement with others (16, 17).

There is no concordance in the literature as to the distribution of the side of canine impaction, since in our study there was a prevalence of this phenomenon on the buccal *versus* the palatal side (p/b = 1:1.5), whereas other Authors found the reverse (18).

No cases of lateral incisors root resorption were observed in the present study.

For this reason, our data evaluated on the orthopantomogram and regarding the α angle, β angle, the distance “d” and the canine medial crown position, were compared with those on a “control group” in a study by Ericson and Kurol (19, 20).

In the above-mentioned study, in fact, the Authors compared 40 patients with canine impaction and lateral incisors root resorption with a control group including 118 subjects with canine impaction but not root resorption and no periodontal inflammation (19, 21).

With regards to the α angle measurements, in our work the mean α value was 22.9° ± 4.1°, which is slightly closer to the "control group" (α = 18.6° ± 10°) of the Swedish study.

The mean values of the β angle were 34.7° ± 4.0°, again in agreement with the Swedish "control group" (β=31.1° ± 1.3°).

In concordance with the previous study, our mean values for distance "d" were 14.6 mm ± 1.2 mm, thus close to values of the "control group" (15.6 mm ± 3.8 mm) reported in the Swedish study.

Instead, in the evaluation of the canine medial crown position in sectors 1-3 according to Crescini (12) we showed a higher percentage of canines in sector 3 (60%), while the canines in sectors 2 and 1 were 24% and 16%, respectively. The long root of canines needs proper anatomical niches, so to avoid flogistic reactions on both hard and gingival tissues (22, 23).

Data we reported in our study are partially in agreement with the studies by Ericson and Kurol (19).

In fact, in the Swedish study, neither the "control group" (72%) nor the "resorption group" (34%) showed a percentage of canine crown position in sector 3 similar to the result obtained in our study.

Our data on canine impaction in sector 2 are concordant only with those showed by the "control group" (27%). Moreover, our work showed a higher percentage of canines in sector 1 than the study by Ericson and Kurol ("control group" 0.8%; "resorption group" 5%).

Our mean values for the angle between the upper cusp axis and to the perpendicular-to-Fh plane were 20.8°± 2.6°; according to Orton et al., (13) these values require orthodontic treatment to prevent canine impaction. Some modern techniques are trying to use the physiological commitment of resident stem cells to improve osteogenesis in orthodontic and orthopedic treatments (24-28).

In fact, many cases of impacted teeth recognize different causes, apart from the skeletal ones, such as syndromic conditions (29, 30), gingival overgrowth (31) or mechanical locking (32).

Among the 23 subjects recruited, 5 of them showed values included in the range 25°- 45° (indication for surgical-orthodontic treatment) and 1 showed an inclination >45° (some doubt as to surgical orthodontic treatment).

Finally, we evaluated the correlation between canine impaction, assessed according to the method by Ericson and Kurol (11) and Orton et al. (13), with the facial biotype according to McLauglin (MM: 28° ± 3°) cephalometric analysis (10).

Following the comparison between the root lengths of the right upper lateral incisors and the left upper lateral incisors, the results showed a direct correlation between the radicular lengths on both sides. Variations in radicular lengths could be related with pulp sufferings (33) that could also evolve towards pulp necrosis and inflammatory periapical cysts (34).

In conclusions, it seems to be a small variability among radicular lengths, when comparing both the left and right sides and the impaction side with the healthy side.

The results obtained in the present study demonstrate a significant inverse correlation between the MM angle and the inclination of the upper cusp axis to the perpendicular-to-Fh plane.

Therefore, the treatment of cusp impaction seems to have a more favorable prognosis in patients with hyperdivergence. Surgical treatments will have more favorable outcomes in non-smokers patients, showing a better healing of both soft and hard tissues (35).

The absence of any differences in lateral incisors radicular lengths seems to conflict with the guidance theory and to confirm a genetic component in the etiology of this tooth eruption disturbance, as well as the association of cusp impaction with gender and other dental anomalies (20).

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