Original article

Are Noffel's danger signs pathognomonic of class II division 2? A retrospective comparative study

Les signes d'alarme de Noffel sont-ils pathognomoniques de la classe II division 2? Etude comparative rétrospective

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Abstract

Introduction: The 3 Noffel signs, "Ramal height", "Smiling chin", and "B-line space", often present in class II division 2, are called "danger signs" for aesthetics, when they are strongly marked and absolutely need to be taken into account in the therapeutic strategy. The main objective was to assess whether the three measurements associated with Noffel signs (Gonion/Articulare distance, Cutaneous Pogonion/Na-B, and B-line space) were pathognomonic of class II division 2. The secondary objective was to determine whether there was a correlation between the severity of Noffel signs and the sagittal and/or vertical skeletal severity of class II division 2.

Materials and methods: In this comparative, mono-centric study based on a retrospective cohort, lateral cephalograms of all the growing patients who were treated at the CSERD between 2012 and 2018 and had normodivergent and hypodivergent profiles, were analysed. **Results:** The logistic regression analysis showed that only "Total chin" and "B-line space" were significantly related to class II division 2 ($p = 0.00199$; $p = 0.00778$, respectively). The three signs were related to the severity of the hypodivergence, but not to the severity of skeletal class II.

Conclusion: Only "Total chin" and "B-line space" are pathognomonic of class II division 2. The correlation between the severity of Noffel's three signs and skeletal severity exists only in the vertical dimension.

Keywords

- Class II division 2
- Chin
- Ramal height
- Concavity of the profile
- Hypodivergence

Résumé

Introduction : Les 3 signes de Noffel, « Hauteur ramale », « Smiling chin », « B-line space », souvent présents dans la classe II division 2 sont dits « d'alarme » du point de vue esthétique, quand ils sont marqués et primordiaux à considérer dans la stratégie thérapeutique. L'objectif

principal était d'évaluer si les trois mesures associées aux signes de Noffel (distance Gonion/Articulaire, Pogonion cutané/Na-B, et aire « B-line space ») étaient pathognomoniques de la classe II division 2. L'objectif secondaire était de savoir s'il existait une corrélation entre la sévérité des signes de Noffel et la sévérité squelettique sagittale et/ou verticale des classes II division 2.

Matériels et méthodes : Dans cette étude comparative, mono-centrique réalisée à partir d'une cohorte rétrospective, les téléradiographies de profil de tous les patients du CSERD, en cours de croissance, traités entre 2012 et 2018, normo et hypodivergents, ont été analysées. **Résultats :** L'analyse de régression logistique a montré que seuls « Total chin » et « B-line space » étaient significativement liés à la classe II division 2, ($p = 0,00199$; $p = 0,00778$, respectivement). Les trois signes étaient liés à la sévérité de l'hypodivergence, mais pas à la sévérité de la classe II squelettique.

Conclusion : Seuls « Total chin » et « B-line space » sont pathognomoniques de la classe II division 2. La corrélation entre sévérité des 3 signes de Noffel et sévérité squelettique n'existe que dans la dimension verticale.

Mots-clés

- Classe II division 2 d'Angle
- Menton
- Hauteur ramale
- Concavité du profil
- Hypodivergence

Introduction

Class II division 2 should be considered as a muscle syndrome [1-6]. But the definition of this malocclusion has not always been so holistic. Angle EH classified it, from the dento-alveolar point of view, as a mandibular arch distocclusion, a palato-version of the maxillary incisors, an incisor supraclulsion and normal nasal and labial functions [7]. This classification was clinical but did not take into account the dysfunctional envelope or the cephalometric reference points. If most authors studied class II division 2 from a cephalometric point of view, they were nevertheless divided over it [8-16]. An aetiological distinction between primary and secondary class II division 2 was established by Darqué [17]. Two clinical forms were then distinguished: genetic-hereditary class II division 2 and dysfunctional-acquired class II division 2. The study by Peck *et al.* identified the notion of "a heritable pattern of small teeth in well-developed jaws." characterized by an increased ramal height, a normal mandible with an important projection of the symphysis without sagittal skeletal discrepancy [2]. According to Noffel [18], when the symphysis is prominent and the profile concave with a particular muscular context, the clinical picture is similar to that of an "occlusion face", whose aesthetic prognosis is linked to the importance of three danger signs: the "B-line space", the ramal height and the "Smiling chin" (*Fig. 1*).

Taking these three elements into account is important in the therapeutic prognosis [5,6,10, 18-21]. In particular, any anterior extraction is contraindicated at the risk of aggravating these warning signs and the indication for orthognathic surgery will become more frequent in cases of mandibular retrognathia when there is no hope of mandibular growth (*Fig. 2,3*).

According to Noffel, only two out of three signs are enough to alert the orthodontist about the aesthetic impact of his orthodontic therapy [18]. This assessment was a clinical intuition, without any real scientific evidence. We thought that it might be interesting to check whether these signs were really pathognomonic of class II division 2. Are one, two or three warning signs synonymous with aesthetic damage for class II division 2? Are they correlated with sagittal and vertical skeletal severity? Are they simply related to the growth pattern of hypodivergence? The main objective was to determine, in a normal and hypodivergent population, whether the cephalometric parameters associated with Noffel's warning signs

were pathognomonic of class II division 2. We investigated whether there was a correlation between the severity of Noffel's warning signs and the sagittal and/or vertical skeletal severity of class II division 2.

Materials and methods

A comparative, mono-centric study based on a retrospective cohort was conducted. All the records of patients undergoing orthodontic treatment at the CSERD in Montpellier between 2012 and early 2018 were collected. Among them, only files meeting the following eligibility criteria were pre-selected: age less than or equal to 15 for girls and 17 for boys, permanent teeth (visible on the dental panoramic radiographs). After cephalometric analysis, we excluded: the files in which lateral cephalograms did not have good visibility of soft tissues and were poorly framed or deformed (exclusion criteria); hyperdivergent patients ($\text{Ans-Pns} / \text{MP} > 31.5^\circ$); dental class I patients with ethnic bialveolar protrusion ($\text{Ans-Pns} / \text{I} > 115^\circ + \text{MP} / \text{i} > 95^\circ$), syndromic and surgical dysmorphisms; and patients with an interceptive treatment history. The lateral cephalographs were taken in the CSERD radiography department at 4-metre distance using the same equipment and trained technicians. They were carried out before any treatment. Measurements were made using Cephalometrics® Software for the calculations of angular and millimetric values. The entire sample was classified by malocclusion type: class I (no horizontal overjet, normal overbite: 2mm); class II division 1 (maxillary incisor proclination $\text{Ans-Pns} / \text{I} > 110^\circ$, horizontal overjet $> 4\text{mm}$); class II division 2 (maxillary and/or mandibular incisor overbite, deep bite: $\text{Ans-Pns} / \text{Ols} > 15^\circ$; $\text{MP} / \text{Oli} < 15^\circ$, maxillary incisor retroclination: $\text{Ans-Pns} / \text{I} < 105^\circ$); class III (edge-to-edge occlusion, horizontal overjet $\leq 1\text{mm}$). The sagittal and vertical severity of the different malocclusions was apprehended in a binary way: severe (1) or non-severe (0). The hypodivergence was judged severe with an angle $\text{Ans-Pns} / \text{MP} < 22^\circ$; the sagittal severity was judged severe with an AOBO distance > 2 or < 0 mm. We quantified Noffel's warning signs on lateral cephalographs by length (mm) and area (mm^2) measurements with the ImageJ® software according to the following protocol. The axes required for the various measurements were previously plotted in white on the lateral cephalographs and then the scales were calibrated (pixel equivalence in mm) using the cephalostat (40 mm). The measurements were taken by the same operator twice. The ramal height (warning sign 1) was evaluated by measuring the distance between the Gonion point (Go) and the Articulare point (Ar), which is the posterior facial height defined by Merrifield (Fig.4). The "Smiling chin" (warning sign 2) was defined by measuring the "Total Chin" of the Tweed analysis: orthogonal distance between the cutaneous Pogonion and the Na-B line (Fig.4). The "B-line space" area (warning sign 3) was determined thanks to definition given by Noffel (Fig.4). The boundaries were: the Nasion-Pogonion line (Na-Pog); the point of contact between the Pogonion (Pog) and the Na-Pog line; the free edge of the mandibular incisor (perpendicular to the Na-Pog line); the anterior dental and alveolar contour of the mandibular incisor and symphysis.

After the plotting and calibration of the scale, we transformed the shades of grey into black and white for better contrast in order to isolate the "B-line space" area (Fig. 5).

Statistical analysis

Analysis of variance (ANOVA) and χ^2 tests were performed to initially compare the means and percentages of variables in the various groups. For the analysis of the main objective, a logistic regression was used to assess the pathognomoncity of Noffel's criteria in the assessment of class II division 2. A decision tree was used to complement the logistic regression: it showed to what extent Noffel signs were indicative of class II division 2. For the analysis of the secondary objectives, a multifactorial ANOVA with Bonferroni correction was used. The various statistical tests were conducted with the Mypstat / Systat® software and RapidMiner® (decision tree).

Results

Out of the 421 files meeting age inclusion criteria, 173 cephalographs were not included after cephalometric analysis because they represented hyperdivergent patients with class I bialveolar protrusion. Out of the remaining 248 files, 117 files were excluded for technical reasons: the images were blurred, distorted and incomplete or did not allow soft tissue analysis. This was considered independent of the patient or the type of malocclusion but dependent on the way the picture had been taken. The remaining and usable sample at the end of inclusion was composed of 131 lateral cephalographs with 46 class I cases, 37 class II division 1 cases, 38 class II division 2 cases and 10 class III cases (*Figure 6*).

The results of the logistic regression analysis showed that only the "B-line space" and "Total Chin" factors were significantly related to class II division 2, with $p=0.00199$ and $p=0.00778$ respectively. The ramal height was not significantly related to class II division 2 with $p=0.15364$ (*Table I*).

For the two factors considered significant, "B-line space" and "Total Chin", an analysis of the Odds Ratio was carried out. If "B-line space" increased by 1, the risks of class II division 2 were multiplied by 1.05038 and if "Total Chin" increased by 1, the risks of class II division 2 were multiplied by 1.420097 (*Table II*).

A covariance analysis was carried out for each warning sign to investigate its relationship to each of the factors: age, sex and skeletal severity by adjusting the others (*Table III*). The "B-line space" parameter showed a significant correlation with the vertical severity $p=0.01$. Ramal height had significant correlations with vertical severity, age and sex ($p=0.00164$, $p=0.0000173$, $p=0.00365$ respectively). This was also the case for the "Total Chin" parameter, which was significantly correlated with vertical severity, age and gender ($p=0.000366$, $p=0.04$, $p=0.05$ respectively). However, the results did not show a correlation of Noffel signs with sagittal severity, nor with the three factors combined "Vertical severity, Sagittal severity, Sex".

A decision tree with a depth of 4 was calculated with RapidMiner® software to predict whether the patient had a class II division 2 malocclusion or not by considering "Noffel's criteria". It was a mathematical predictive model that produced a class II division 2 prognostic guide. Two Noffel signs ("Total Chin" and "B-line space") were retained in the tree: an increased "Total Chin" ($> 17,890$) predicted a class II division 2. Similarly, a "Total Chin" $\leq 17,890$, a "B-line space" and an increased ramal height (respectively $> 26,840$ and $> 33,475$) predicted a class II division 2 (*Figure 7*, *Table IV*). This tree was selected from a random sample of 70% of previous files. The remaining 30% tested its predictive power: but among the 39 patients tested, 5 false positives and 5 false negatives were found and as a result, it is difficult to have a prediction that establishes the pathognomonic nature of Noffel signs.

Discussion

Our sample consisted of 46 class I cases, 37 class II division 1 cases, 38 class II division 2 cases and 10 class III cases, which seems to be a natural over-representation of class II division 2 within the Montpellier dental care centre compared to the frequencies reported by the general health insurance scheme (Ameli) [22]: 5.4% of class II division cases 2, 59.9% of class II division 1 cases, 29.7% of class I cases and 5.0% of class III cases. However, it should be remembered that the sample was constructed on the basis of skeletal divergence. It was mainly represented by hypodivergent and normodivergent facial patterns, which are more frequent in class II division 2. In our study, only the "B-line space" and "Total Chin" factors were significantly related to class II division 2. Ramal height did not appear as a characteristic

sign of class II division 2. However, in many studies [11-16], the authors reported increased ramal height in this syndrome. In our sample, this increase in ramus was not only present in class II division 2 cases, it was the characteristic of the hypodivergence that we also found in class II division 1, class I and class III cases, since hypodivergence was the criterion for inclusion in the study. In addition, it would have been interesting to separate the genetic class II division 2 from the dysfunctional classes where the vertical divergence was more random, in order to know if the signs were more strongly marked, more significant in one or the other aetiopathogenic form, compared to other malocclusions (the inclusion criterion would not have reduced the sample to skeletal divergence). On the other hand, the "Total Chin" and "B-line space" parameters were characteristic of class II division 2: the shape of the particular symphysis with the projection of Pogonion, the "recessed" point B and the mandibular incisor which is most often well-positioned, represent the typical features of class II division 2. This is the finding of most studies where there is hyperdevelopment of the symphysis region: increased B-Pogonion distance for Karlsen [1]; prominent Pogonion for Brezniak [11]; increased SN-Pogonion distance for Al-Khateeb [12]; chin prominence for Dodda [14]; increased N-Pogonion/mandibular incisor distance ("IFL") for Peck [2]. This last measurement is very close to "Total Chin"/ "B-line space" used in our study and Peck's results corroborate ours. In addition, our study showed that "B-line space" showed a significant correlation with the severity of hypodivergence: indeed, the more the mandibular symphysis had a "rocking chair" shape with an increased "B-line space", the more it marked an anterior rotation with anterior vertical insufficiency. "Ramal height" and "Total Chin" also showed significant correlations with vertical severity, age and sex. This seems logical since mandibular growth continues two years after the end of statural growth, anterior rotation with an important ramal height increases with age and the chin is a secondary sexual trait, which is more pronounced in males. On the other hand, there was no correlation between Noffel signs and sagittal severity, nor with the three factors combined "Vertical severity, Sagittal severity, Sex". This also corresponds to the results of Peck's study showing that the real class II division 2 cases were actually skeletal class I cases [2].

This study had the typical disadvantages of retrospective studies. We could not keep the files of patients with fuzzy radiographs (117 cephalograms or more than ¼ from the baseline sample). However, this study made it possible to integrate all the files meeting the eligibility criteria over several years. Besides, the practitioner was unable to perform blinded measurements. Yet, the use of standardized measurements (using computer tools) limited measurement bias. However, it was a two-dimensional study, not using 3D imaging. In addition, we created the measurement of the "B-line space" area, which was difficult to discuss because it was not found in the literature.

Conclusion

Our study showed that two of Noffel's factors "B-line space" and "Total Chin" were significantly related to class II division 2 while the ramal height was not. It is therefore the characteristic shape of the chin with its anterior rolling curve ("Total Chin" and "B-line space" increased), which marks class II division 2 and affects the severity of the vertical dimension more than the ramal height. "Total Chin" was more pronounced with age, in boys and in cases of severe hypodivergence. Just like "B-line space" and ramal height are related to vertical skeletal severity. However, no link was shown between Noffel signs and the sagittal skeletal discrepancy.

Declaration of interest

The authors declare that they have no conflicts of interest in relation to this article.

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Figures legends

- Fig. 1a-b: Noffel danger signs. a: 2 cephalometric signs, « B-line space » and ramal height (Ar-Go); b: clinical sign of the knobby and excessive bony chin projection when smiling, "smiling chin".
- Fig. 2 a-c: Comparison facial and cephalometric views of a child with a class II division 2 malocclusion before/after treatment carried out without anterior extractions. There is a concavity under the nose with the presence of the "Smiling chin"; anterior extractions would undoubtedly have worsened the aesthetic prognosis. Here the maxillary incisal hypertorque and the mandibular levelling allowed homothetic mandibular growth (Orthodontics: Dr Laure Frapier).
- Fig. 3a-c: Comparison facial and cephalometric views of an adult with a class II division 2 malocclusion before/after orthognathic treatment. In the absence of growth, to avoid aesthetic damage, therapeutic conduct quickly becomes surgical: here maxillary impaction, mandibular advancement (Orthodontics: Dr Laure Frapier - Orthognathic surgery: Dr Claude Garcia).
- Fig. 4: The 3 cephalometric Noffel's warning signs. 1: Ramal height defined by the Ar-Go distance; 2: « Smiling chin » defined by the straight-line distance Na-B - cutaneous Pogonion; 3: Noffel's "B-line space" area.
- Fig. 5: Selection of the orange "B-line space", zone indicated by the arrow and measurement.
- Fig. 6: Flow chart representing the distribution of selected patients.
- Fig. 7: Theoretical and diagnostic decision tree of class II division 2; the height of the rectangle is proportional to the number of subjects involved.

Tables legends

- Table I: Logistic regression for class II division 2 diagnostic factors. * $p < 0.05$ significant.
- Table I: Odds ratio for statistically significant diagnostic factors of class II division 2.
- Table III: Results of the covariance analysis showing the link with the "B-line space", the Ramal Height and the "Total Chin". X for "interaction" and * $p < 0.05$: significant.
- Table IV: Prediction quality (using the decision tree)

Fig. 1 a-b: Noffel danger signs. a: 2 cephalometric signs, « B-line space » and ramal height (Ar-Go); b: clinical sign of the knobby and excessive bony chin projection when smiling, "smiling chin".

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Fig. 4: The 3 cephalometric Noffel's warning signs. 1: Ramal height defined by the Ar-Go distance; 2: « Smiling chin » defined by the straight-line distance Na-B - cutaneous Pogonion; 3: Noffel's "B-line space" area.

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Fig. 6: Flow chart representing the distribution of selected patients.

Fig. 7: Theoretical and diagnostic decision tree of class II division 2; the height of the rectangle is proportional to the number of subjects involved

Parameter	Estimate	Standard Error	Z	p-value	95% Confidence Interval	
					Lower	Upper
1 CONSTANT	-3,1438553298	2,4473641624	-1,2845882840	0,1989361952	-7,9406009638	1,6528903042
2 B-line space	0,0491528950	0,0158952230	3,0923061028	0,0019860785*	0,0179988303	0,0803069597
3 Total Chin	0,3507254023	0,1317761317	2,6615244947	0,0077787696*	0,0924489292	0,6090018755
4 Ramus Height	-0,0908486783	0,0636743657	-1,4267700561	0,1536461849	-0,2156481424	0,0339507857

Parameter	Odds Ratio	Standard Error	95% Confidence Interval	
			Lower	Upper
2 B-line space	1,0503809365	0,0166960392	1,0181617855	1,0836196442
3 Total Chin	1,4200973170	0,1871349311	1,0968571227	1,8385953356

Source	B-line space	Ramal Height	Total Chin
Vertical Severity	0.01*	0.00164*	0.000366*
Sagittal Severity	0.85	0.09	0.68
Sex	0.61	0.00365*	0.05
Vertical Severity X Sagittal Severity	0.57	0.53	0.44
Vertical Severity X Sex	0.77	0.67	0.51
Sagittal Severity X Sex	0.84	0.66	0.72
Vertical Severity X Sagittal Severity Sex	0.32	0.46	0.60
Age	0.08	0.0000173*	0.04

	True no	True yes
Pred. no	23	5
Pred. yes	5	6