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Original article

Reproducibility of the assessment of the Fränkel manoeuvre for the evaluation of sagittal skeletal discrepancies in Class II individuals

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Summary

Objectives: The Fränkel manoeuvre is a procedure by which the mandible of Class II individuals is postured forward in dental Class I relationship. The evaluation of the resulting facial profile provides information concerning the components determining the sagittal discrepancy. Data concerning the reproducibility of its assessment are not available. This study aimed to evaluate the intra-observer and inter-observer reproducibility of the assessment of the manoeuvre and to assess whether the amount of clinical experience affects its reproducibility.

Methods: Two lateral photographs, one in centric occlusion, and the other with the mandible postured forward (Fränkel manoeuvre) of 100 Angle Class II individuals aged between 9 and 13 years were evaluated by six orthodontists (T0). Each examiner was asked whether the facial profile worsen or not with the manoeuvre after being trained by an expert orthodontist. The test was repeated after 2 weeks interval (T1). Intra-observer and inter-observer agreement were evaluated by computing the Cohen's *K*.

Results: The agreement (*K* values) between observations (T0 versus T1) for each examiner ranged from 0.49 to 0.72. The overall agreement was 0.65 [95% confidence interval (CI) = 0.54–0.75]. The agreement in the group with less clinical experience was 0.61 (95% CI = 0.46–0.76), while it was 0.68 (95% CI = 0.53–0.83) in the more experienced group. The amount of clinical experience did not affect intra-observer agreement ($P = 0.50$). The overall agreement between the examiners and the trainer was 0.74 (95% CI = 0.65–0.83) and 0.73 (95% CI = 0.64–0.83) at T0 and T1 respectively.

Conclusion: The assessment of the Fränkel manoeuvre is reproducible and it is not influenced by the amount of clinical experience.

Introduction

Angle Class II is the most frequent malocclusion in growing individuals. Previous studies have shown that it is mostly associated to mandibular retrusion (1–4) and to a convex facial profile.

The diagnostic process for the evaluation of sagittal skeletal discrepancies in growing individuals includes both cephalometric and aesthetic assessments. The cephalometric analyses available for the evaluation of sagittal discrepancies still rely on angular and linear measurements.

Nonetheless, a number of studies have questioned several of these indicators. For instance, the use of A point -Nasion -B point (ANB) angle has been criticized (5, 6), since it is sensitive to the position of the anterior cranial base, and may vary according to the divergence of the jaws (7). Similarly, the Wits appraisal is questionable (8, 9), being also sensitive to a correct identification of the occlusal plane, and to its variations due to tooth eruption, and to the effect of orthodontic treatment. Linear measurements of the mandible and maxilla as well have limited significance because of the large individual variation and due to secular trends effect on norm cephalometric linear and angular measurements (10). Hence, not surprisingly, cephalometric outcomes are only partly considered for a proper diagnosis of sagittal skeletal discrepancies in clinical setting (11).

The evaluation of the facial profile has increased the awareness of the limitations of cephalometric norms for the assessment of sagittal discrepancies. According to Arnett and Bergman (12), the aesthetic assessment of the facial profile is a good diagnostic indicator of sagittal skeletal discrepancies. Hence, they developed a soft-tissue cephalometric analysis. Nonetheless, this instrument uses norms from a limited sample of adult individuals and does not report measurements for growing patients.

To our knowledge, a set of soft-tissue cephalometric norms in growing individuals is lacking, probably because it could be awkward due to the well-known inter-individual differences in soft-tissue trait changes with growth (13).

Useful clinical information for the aesthetic evaluation of individuals with mandibular retrusion derives from the observation of the chin position and of the lip philtrum. In Class I individuals, the latter should exhibit a forward and downward slope when the patient assumes a natural head posture. Forward projection of the upper lip could be indicative of a protruding maxilla, while a backward projection of the lower lip may indicate a retruded mandible (14).

The Fränkel manoeuvre is a clinical procedure by which the lower jaw of individuals affected with Class II malocclusion is postured forward until molars and canines are in Class I relationship. Once the position is reached, the patient has to keep the lips in contact, without excessive contraction of the perioral muscles. The aesthetic evaluation of the manoeuvre provides additional information concerning the components determining the sagittal discrepancy (15). According to the authors, a worsening of the profile with the Fränkel manoeuvre, with biprotruded appearance, could indicate a forward positioning of the upper jaw and that the mandible has adapted to this forward position. On the contrary, aesthetic improvement of the facial profile, with orthognatic appearance, may indicate a retruded mandible (15) Although this tool is largely used in clinical practice, and partly for research purposes (16, 17), data concerning the reproducibility of its assessment are not available. Reproducibility refers to the variation in measurements made on a subject under changing conditions (18) and is an indicator of the quality of a diagnostic test. Testing the reproducibility of a diagnostic tool could increase the relevance of the interpretation of the clinical outcome.

Hence, the aim of this study was to evaluate the intra-observer and inter-observer reproducibility of the assessment of the manoeuvre and to assess whether the amount of clinical experience might influence its reproducibility. The null hypothesis to be tested was that the assessment of the manoeuvre presents a scarce intra-rater and inter-rater reproducibility.

Subjects and methods

Study sample

Consecutive patients seeking for an orthodontic consultation were screened by two specialists in orthodontics (RM and AG) at two orthodontic divisions. Patients were considered eligible when they presented a full Class II molar relationship, overjet greater than 6 mm, an age range of 10–13 years for boys and of 9–12 years for girls. The Fränkel manoeuvre (15) was used to evaluate the sagittal jaw discrepancy based on an aesthetic evaluation, as done in previous research reports (16, 17). Patients were asked to posture the mandible forward until a Class I molar and canine relationship was achieved. The manoeuvre was then repeated at least three times while coaching the patients to keep the lips in contact without an excessive contraction of the perioral muscles. The following conditions were considered as exclusion criteria: lack of parent's willingness to sign an informed consent form, orofacial inflammatory conditions, tooth agenesis, congenital syndromes, facial asymmetries, and previous orthodontic treatment. The study protocol complied fully with the principles of the Helsinki Declaration and was approved by the Local Ethics Committee (reference number: 13704).

One hundred individuals (56 males, 44 females, mean age ± std deviation = 10.8 ± 1.5) were recruited.

Two lateral photographs of the right facial profile of each patient were taken using a black background panel, in order to eliminate shadows, while in natural head position (NHP): one photo with the mandible in Class II relationship (centric occlusion) and another with the mandible positioned according to the Fränkel manoeuvre (Figure 1). Subjects were asked to keep their head and shoulders erect with both arms hanging free at their sides. A plumbline cable was photographed together with the patient to resemble the true vertical line. The camera was mounted at a distance of 2.5 m on an adjustable tripod. Cepahalometric sella -nasion -A point angle (SNA) and sella -nasion -B point angle (SNB) measurements were collected by a single operator over digitized lateral cephalograms using a software (Dolphin Imaging

Figure 1. Sample pictures of two individuals assessed for the study. Left: facial profile in centric occlusion; Right: facial profile with Fränkel manoeuvre. The manoeuvre causes an improvement of the facial profile in subject A, while a worsening of the facial profile with the manoeuvre is evident in case B (biprotruded appearance).

System 11.0, Chatsworth, CA). The method error was computed using the Dahlberg formula over repeated measurements collected over 30 lateral radiographs and was 0.4 ± 1.2 for SNA and 0.2 ± 0.6 for SNB.

Examiners

Six orthodontists randomly selected among two groups of clinicians with different clinical experience (more than 10 years versus less than 5 years), each including 10 clinicians of the School of Orthodontics at the Section of Orthodontics, University of Naples, Italy, were invited to assess the outcome of the Fränkel manoeuvre for each recruited patient. Before the assessment, all the examiners were submitted to a training session lasting 1 hour, in which an operator (RM) expert in the usage of the manoeuvre trained all the examiners for a proper execution and evaluation of the manoeuvre. A set of clinical cases was shown during the presentation, and the interpretation of the Fränkel manoeuvre outcomes were critically discussed with all the examiners.

One hundred power-point slides (Microsoft, Redmond, WA), each including the previously described two facial profile photographs, were submitted to each examiner, who was invited to answer to the question 'Does the facial profile worsen with the Fränkel manoeuvre?', with a dichotomous response (yes/no). Each examiner was invited to assess the pictures in a quiet room, without time limit (time T0). After 15 days interval, all the examiners were invited to repeat the assessments with the same patients' pictures placed in a different order (time T1).

Statistical analysis

A sample size of 96 subjects was required to estimate kappa, assuming a 95% CI, a margin of error of 0.2, a positive test in about 20%, and without assumption about the value of kappa.

Cohen's kappa value and 95% CIs were calculated for single examiners and overall to evaluate the intra-rater agreement between observations (T0 versus T1 condition). The agreement between observations (T0 versus T1) was also computed for each group (experience less than 5 years versus experience more than 10 years). A test for equal kappa values among strata was also performed. The training was evaluated by computing the Cohen's kappa between the examiners and the trainer (RM) at the different observations (T0 and T1).

The agreement between cephalometric diagnostic sagittal categories and the outcomes of the Fränkel manoeuvre were computed by calculating the Cohen's kappa between the trainer at T0 time and cephalometric categories of Class II discrepancies. Values outside cephalometric norms plus or minus a standard deviation for SNA and SNB were used for classifying the position of the jaws of the selected study sample. Subjects with SNA values increased of more than one deviation from the norm and with a SNB value within the normal range (19) were considered to have a forward position of the maxilla, and, therefore, the ones that should have been assessed as 'worsened' with the Fränkel manoeuvre. The statistical significance was set at $P < 0.05$. SAS version 9.2 (SAS Inc., Cary, North Carolina, USA) was used.

Results

The frequency and the distribution of the examiners' replies (outcomes of the Fränkel manoeuvre) are reported in Table 1. The agreement (*K* values) between observations (T0 versus T1) for each examiner ranged from 0.49 to 0.72. The overall agreement between the two observations was $K = 0.65$ [95% confidence interval (CI) = 0.54–0.75; Table 1]. The agreement in the group with less than 5 years clinical experience was $K = 0.61$ (95% CI = 0.46–0.76), while in the group greater than 10 years was 0.68 (95% CI = 0.53–0.83, Table 2). The amount of clinical experience did not affect the intra-observer agreement ($P = 0.50$, Table 2).

At T0, the agreement between the trainer and each examiner ranged between 0.59 and 0.71 (Table 3), while the agreement between the examiners and the trainer (T0 observation) sorted by experience (less than 5 years versus greater than 10 years) and controlled for examiner is reported in Table 4. No statistical differences were found between groups ($P = 0.34$).

At T1, the agreement between the trainer and each examiner ranged between 0.55 and 0.83 (Table 3), while the agreement between the examiners and the trainer (T1 observation) sorted by experience (less than 5 years versus greater than 10 years) and controlled for examiner is reported in Table 4. No statistical differences were found between groups ($P = 0.62$). The agreement between the trainer (T0 observation) and the cephalometric assessment was $K = 0.52$. The disagreements regarded all patients with a maxillary

Table 1. Frequencies of Fränkel manoeuvre outcomes (YES, NO, %) sorted by examiner at T0 and T1, and agreement (*K* values) between observations (T0 versus T1).

	NO		YES		*K* value*	
Examiner	T0	T1	T0	T1	T0 versus T1	95% Confidence interval
RC	90	91	10	9	0.71	0.47–0.95
GM	87	89	13	11	0.72	0.50–0.93
PF	92	94	8	6	0.54	0.21–0.86
AS	92	86	8	14	0.49	0.26–0.76
RV	91	96	9	4	0.59	0.28–0.91
AM	90	91	10	9	0.71	0.47–0.95
					P = 0.74	

*Overall agreement between observations (controlled for examiner) $K = 0.65$ (95% CI = 0.54–0.75).

Table 2. Agreement (*K* values) between observations (T0 versus T1) for each group (experience <5 years versus experience >10 years, controlled for examiner).

Group	*K* value	95% Confidence interval
<5 years	0.61	0.46–0.76
>10 years	0.68	0.53–0.83
	P = 0.50	

Table 3. Agreement (*K* values) between examiners and trainer (T0 and T1 observations).

	T0		T1	
Examiner	*K* value	95% Confidence interval	*K* value*	95% Confidence interval
RC	0.71	0.47–0.95	0.59	0.32–0.87
GM	0.69	0.47–0.92	0.84	0.66–1.00
PF	0.68	0.41–0.94	0.73	0.48–0.98
AS	0.68	0.41–0.94	0.62	0.39–0.86
RV	0.88	0.71–1.00	0.55	0.23–0.86
AM	0.59	0.31–0.86	0.83	0.63–1.00
	P = 0.50		*P = 0.36*	

*Overall agreement between examiners and trainer at T0 $K = 0.74$ (95% CI = 0.65–0.83), at T1 $K = 0.73$ (95% CI = 0.64–0.83).

Table 4. Agreement (*K* values) between examiners and trainer (T0 and T1 observations) by experience (<5 years versus >10 years, controlled for examiner).

	T0		T1	
Group	*K* value	95% Confidence interval	*K* value	95% Confidence interval
<5 years	0.69	0.54–0.83	0.76	0.63–0.88
>10 years	0.78	0.65–0.90	0.71	0.57–0.85
	P = 0.34		*P* = 0.62	

protrusion (increased SNA and SNB within the norm, 19), but rated as 'not worsened' by the trainer.

Discussion

To the best of our knowledge, this is the first study that assessed the reproducibility of the Fränkel manoeuvre and the effect of clinical experience on this clinical diagnostic tool. According to the authors (15), the manoeuvre is completed while the patient is positioned in molar and canine Class I. A positive response to the question 'does the facial profile worsen with the Fränkel manoeuvre?' may be an indication of a biprotruded facial profile (while the manoeuvre is executed), suggesting that the subject has adapted the mandible to a forward position of the upper jaw. On the contrary a negative reply may indicate a more harmonious facial profile (while the manoeuvre is executed), pointing to a normal position of the upper jaw and a retruded position of the mandible (Figure 1).

In agreement with McNamara and Vasquez (1, 3), it was found that the facial profiles of the greater part of the study sample improved with the manoeuvre, thus suggesting the diagnosis of mandibular retrusion. This resembles the normal distribution of skeletal Class II phenotypes into the Caucasian population. Also, the results of the current study have revealed that, although the assessment of the manoeuvre may look very subjective at a first sight, it presents a substantial reproducibility (20, 21) which is not significantly influenced by the amount of clinical experience. This result makes the manoeuvre a useful diagnostic tool to be used by orthodontic practitioners for the sagittal evaluation of the facial profile in addition to the conventional diagnostic tools (i.e. cephalometric norms). Moreover, the agreement between the assessment of the manoeuvre and the cephalometric diagnosis was moderate and all the disagreements regarded patients with cephalometric diagnosis of maxilla protrusion, but considered 'not worsened' with the Fränkel manoeuvre. One of the disagreement was the case A of Figure 1, who presented a SNA = 94° and a SNB = 89°. This suggests that cepahlometric variables and the assessment of Fränkel manoeuvre could give in some cases different results. As a consequence of this, the manoeuvre should be considered an additional clinical test for evaluating sagittal Class II discrepancies, other than cephalometrics.

Although cephalometric analysis has still to be considered a keystone tool for treatment planning, more recently it has been shown to influence only partially the treatment approach (11, 22, 23). At the same time, the aesthetic evaluation of soft tissues and facial profile seems nowadays to be crucial for an adequate treatment planning (12) which should consider a possible improvement of facial attractiveness. Hence, the manoeuvre can be considered a simple and useful tool, able to detect skeletal Class II due to mandibular retrusion, and to help the choice among different and rather opposite treatment modalities (i.e. functional therapy for obtaining a forward position of the mandible versus orthopedic control of the upper jaw). The question 'does the facial profile worsen with the Fränkel manoeuvre?' was constructed to interpret easily the outcome of the manoeuvre. Indeed, a worsening of the profile, mainly due to a biprotruded appearance, in most cases could indicate that the lower jaw should not be positioned forward with treatment. On the contrary, an improvement of the aesthetics of the profile with the manoeuvre would suggest that a mandibular advancement should be pursued to achieve a more harmonious facial profile.

It might be questioned whether all the examiners monitored properly the execution of the Fränkel manoeuvre and assessed it correctly. The substantial agreement found between the examiners and the clinical trainer, at both T0 and T1 time points, shows that the training of the examiner was good.

This study suffers of some limitations. First, it does not provide information about the validity of the manoeuvre. Indeed, validity refers to the degree in which a diagnostic tool is truly measuring what is intended to measure. However, since a gold standard for the evaluation of sagittal discrepancies is lacking, the validity cannot be tested. Instead, our data confirm that the examiners evaluated the outcome of the manoeuvre similarly. Second, the examiners were randomly selected among the staff of the same School of Orthodontics. As a consequence of this, they had similar orthodontic training, other than the training executed for the experiment. Third, it has been suggested that although NHP is highly reproducible (24), it may be sensitive to the type of malocclusion. Finally, no conclusion about the possibility of obtaining similar results between the outcome of the manoeuvre and treatment outcome can be drawn with this research design.

In conclusion, this study has shown that the Fränkel manoeuvre is highly reproducible and can be used in addition to the cephalometric assessment for the evaluation of sagittal skeletal discrepancies.

Clinical relevance

Orthodontic diagnosis is often a very difficult challenge. Different diagnostic tools should be considered in order to be more critical and tailored to the patient. The Fränkel manoeuvre is a diagnostic tool frequently used in clinical setting. This study has tested its reproducibility, which was shown to be moderate to high. This result could increase the relevance of the interpretation of the clinical outcome of the manoeuvre when evaluating sagittal skeletal discrepancies in Class II individuals.

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