LOWER INCISOR INCLINATION REGARDING DIFFERENT REFERENCE PLANES

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ABSTRACT

The purpose of this study was to assess the degree of lower incisor inclination with respect to different reference planes. It was an observational, analytical, longitudinal, prospective study conducted on 100 lateral cephalograms which were corrected according to the photograph in natural head position in order to draw the true vertical plane (TVP). The incisor mandibular plane angle (IMPA) was compensated to eliminate the variation of the mandibular plane growth type with the formula "FMApx.– 25 (FMA) + IMPApx. = compensated IMPA (IMPACOM)". As the data followed normal distribution determined by the Kolmogorov-Smirnov test, parametric tests were used for the statistical analysis, T-test, ANOVA and Pearson coefficient correlation test. Statistical analysis was performed using a statistical significance of p<0.05. There is correlation between TVP and NB line (NB) (0.8614), Frankfort mandibular incisor angle (FMIA) (0.8894), IMPA (0.6351), A-po line (Apo) (0.609), IMPACOM (0.8895) and McHorris angle (MH) (0.7769). ANOVA showed statistically significant differences between the means for the 7 variables with 95% confidence level, P=0.0001. The multiple range test showed no significant difference among means: APo-NB (-0.88), IMPA-MH (0.36), IMPA-NB (-0.65), FMIA-IMPACOM (0.01), FMIA-TVP (0.18), TVP-IMPACOM (0.17).
There was correlation among all reference planes. There were statistically significant differences among the means of the planes measured, except for IMPACOM, FMIA and TVP. The IMPA differed significantly from the IMPACOM. The compensated IMPA and the FMIA did not differ significantly from the TVP. The true horizontal plane was mismatched with Frankfort plane in 84% of the sample with a range of 19°. The true vertical plane is adequate for measuring lower incisor inclination.

Key words: *Orthodontics, Incisor, reference standards.*

INCLINACIÓN DEL INCISIVO INFERIOR RESPECTO A DIFERENTES PLANOS DE REFERENCIA

RESUMEN

El propósito del estudio fue concordar el grado de inclinación del incisivo inferior medido con los diferentes planos de referencia. Estudio observacional, analítico, longitudinal y prospectivo en 100 radiografías laterales que fueron corregidas con base en la fotografía en posición natural de la cabeza, para trazar el plano vertical verdadero (PVV). Se compensó el ángulo del plano incisivo mandibular (IMPA) para eliminar la variación del plano mandibular respecto al tipo de crecimiento con la fórmula "FMApx. – 25 (FMA) + IMPApx. = IMPA compensado (IMPACOM)". Los datos tuvieron una distribución normal de acuerdo a la prueba Kolmogorov-Smirnov, por lo tanto se aplicaron pruebas paramétricas, T para medias de una muestra, coeficiente R de Pearson y ANOVA. El análisis estadístico fue realizado con una significancia estadística de p<0.05.
Existe correlación entre el PVV con la línea NB (NB) (0.8614), ángulo de Frankfort incisivo mandibular (FMIA) (0.8894), IMPA (0.6351), línea Apo (APo) (0.609), IMPACOM (0.8895) y ángulo de McHorris (MH) (0.7769). De acuerdo al análisis de ANOVA existen diferencias estadísticamente significativas entre las medias de las 7 variables con un nivel de 95% de confianza p=0.0001. Mediante la prueba de múltiples rangos para determinar diferencias entre medias, se demostró que no existen diferencias significativas entre: APo-NB (-0.88), IMPA-MH (0.36), IMPA-NB (-0.65), FMIA-IMPACOM (0.01), FMIA-PVV (0.18), PVV-IMPACOM (0.17).
Todos los planos de referencia presentaron correlación entre ellos. Las mediciones derivadas de éstos tuvieron diferencias estadísticamente significativas, a excepción de FMIA, IMPACOM Y PVV. Existen diferencias estadísticamente significativas entre el ángulo IMPA y éste con su compensación. No se encontraron diferencias significativas entre el IMPACOM y PVV. El plano de Frankfort y el PHV no son coincidentes en un 84%, con un rango de 19 grados.

Palabras clave: *Ortodoncia, incisivo, estándares de referencia*

INTRODUCTION

In orthodontics, the position of the lower incisor is considered essential to reaching an appropriate diagnosis and designing a treatment plan. It even defines certain aspects such as whether extractions are needed and what type of anchorage should be used.[1-3] Lower incisor position has a significant functional effect. It must resist incisal overeruption

and provide harmony and functionality to the temporomandibular joint, providing an appropriate anterior guide and protrusive movements, which are crucial to mutually protected organic occlusion.[4] It also affects stability, because when the incisors are within the cortical bone, rather than outside it or at the biological limit, there is less risk of relapse.[5]

Tweed advocated placing the mandibular incisors upright to achieve balance and harmony in the lower facial third[6] Angle held that lower lip curvature is determined by incisor position[7], and many authors have emphasized that the effect of lower incisor position is crucial to dental and facial aesthetics.[8-10]

Lower incisor position was formerly considered so important that the course of the treatment plan was based only on its initial and final position, considered the key to successful treatment.[8-13]

Although it is currently known that a correct diagnosis must consider multiple factors in addition to the lower incisor, there is no doubt regarding its major effect in terms of function, stability and aesthetics. [1-3, 9, 14]

It is important to assess the position of the lower incisor not only on all three planes of space in relation to the mandibular alveolar bone and chin, but also in relation to the vertical and horizontal composition of the face.[15] Unlike the vertical and transversal plane, the anteroposterior plane has a very restricted field anatomically, therefore, in order to achieve optimal incisor position, it is important to assess its angulation. Excessive inclination can cause recession of the gingival margin or bone dehiscence, and insufficient angulation can cause fenestration.[16-18]

The lower incisor has thus been the object of much attention for many years. Many authors have tried to establish an optimal position, taking as reference different planes involving both hard and soft tissues.

With the implementation of radiography in the dental field, several cephalometric analyses have emerged. They have been extraordinarily useful to diagnostic procedures by enabling accurate assessments of skeletal and dental relationships occurring in different types of malocclusion.[19] For cephalometric study, the vertical and horizontal true planes have also been implemented, which are obtained from the Natural Head Position (NHP).[20-23]

There are currently multiple reference planes to measure incisor angulation; however, they are all affected by the other anatomical structures of each patient, so that their interpretation is highly variable. The bases of all cephalometric analysis were proposed years ago, and despite further contributions from different studies, current research establishes that a valid cephalometric reference should include the following features: reliability, intraindividual reproducibility, low inter-individual variability and average orientation close to the vertical or horizontal true plane.[20]

Tweed first highlighted the importance of the lower incisors, emphasizing the need to position them vertically on the medullary bone of the mandible body in order to achieve balance and harmony in the inferior facial third.[6, 24-26] After many years of observing the changes accomplished with respect to tooth position and their effects on facial aesthetics, he introduced his concept of "diagnosis triangle".[24]

Downs related incisor inclination to its upper antagonist, the mandibular plane and the occlusal plane. In addition to the use of the Frankfort mandibular plane, he introduced the A-Po line as a reference. However, unlike Tweed, he highlighted the importance of positioning the incisors in relation to the occlusal plane, and not necessarily in relation to the mandibular plane.[27-29] Schudy confirmed this and reported that the lower incisor is more consistently related to the occlusal than the mandibular plane in all types of facial morphology[30]. Knösel et al. found that third order angulation of fixed orthodontic appliances dictates incisal inclination, which refers to a perpendicular to the occlusal plane, and incisor inclination presents no correlation with craniofacial cephalometric measurements. [31, 32]

Steiner's cephalometric analysis associated the lower incisor to the middle facial third, and suggested individualizing the position of the lower incisor according to the relative prominence of the chin and the patient's maxillary-mandibular discrepancy. To this end, he proposed the line NB, formed by the union of Nasion and point B, as a reference.[33]

Tweed reaffirmed the standards of the proposed angles in his diagnostic triangle, and took the FMA angle variation (formed by the mandibular plane and the Frankfort horizontal plane) from 16 to 35 degrees with a standard value of 25; the IMPA angle (lower incisor with respect to mandibular plane)

from 80-85 with norm of 90, and the FMIA angle (lower incisor with regard to Frankfort Horizontal plane) ideally as 65, though in rare cases it requires 75 degrees to achieve better facial balance.[34,35]

An important consideration when applying these measurements is the compensation that IMPA requires with regard to FMA. As the inclination of the mandibular plane with regard to Frankfort plane increases or decreases, the measure of lower incisor with respect to the mandibular plane will also vary but in the opposite direction. In other words, for each degree by which the FMA exceeds the norm of 25°, the mandibular incisors must be positioned a lower number of the norm of 90°, and vice versa, in case of a decrease of FMA, the mandibular incisors must be positioned a higher number of the IMPA's norm of 90°.[35]

Another outstanding author, Ricketts, established that the APo line represents a relationship of bony bases which can be affected by movements of the lower incisor, the APo line itself, or both, which should be considered when estimating the direction and degrees of desired movement in order to functionally place anterior teeth. His norm of incisal inclination differs from Downs', which is 21±5 degrees.[36-38]

McHorris proposed using the CI angle, formed by the radius of the mandibular hinge axis and the longitudinal axis of the lower incisor, at the intersection with the incisal edge of the latter. He acknowledged that the CI line was not affected by the mandibular position relative to the maxilla or the cranial base. He also pointed out the importance of condylar position in harmony with the teeth, because since they are at the service of the condyles in both static and dynamic relationship, there is more harmonious occlusion.[39, 40.]

In 1950 there was an important introduction: the natural head position, defined as an innate, physiological, reproducible head position, obtained when the patient is relaxed, sitting or standing, with the horizontal visual axis at eye level. It is known as the self-balance position of the head or natural orientation.[41] Also, this position offers the advantage of the cephalometric evaluation being based on the same standards as the clinical evaluation.[20- 23,42]

It is difficult to define a reference plane to set the ideal position of the lower incisor because there are multiple factors that affect and modify it. In addition, cephalometric analyses were obtained from dentures considered ideal, with the confluence of skeletal and dental features that usually do not occur in malocclusions, therefore they have been the subject of criticism and disagreement in the orthodontic field.[43]

The aim of this study was to match the degree of inclination of the lower incisor measured with different reference planes under the hypothesis that there is agreement among them. The reference planes considered were: (1) the Frankfort horizontal plane (FH) (which gives rise to FMIA angle), (2) the Nasion-Point B line (NB), (3) the Point A-Pogonion line (APo), (4) the mandibular plane (PM), (which gives rise to IMPA angle), (5) the McHorris plane (MH), and (6) the true vertical plane (TVP).

MATERIAL AND METHODS

Prior authorization was obtained from the Division of Postgraduate Studies of the School of Dentistry of the Meritorious Autonomous University of Puebla (FEBUAP) for the biological and method-ological requirements. An observational, analytic, longitudinal, prospective study was conducted. Using a non-probabilistic convenience sample, 100 lateral cephalograms were analyzed from patients who visited the orthodontic clinic in 2014 and met the selection criteria. Selection criteria were: fully erupted dentition up to first molar; with initial panoramic and cephalogram radiographs with sufficient sharpness to identify the lower incisors and other anatomical structures that are part of the reference planes; without previous orthodontic or orthopedic treatment; without supernumerary teeth, prosthetic dentures or missing teeth, and without craniofacial deformities or syndromes. A profile photograph of the patients in lateral head position (NHP) was taken in order to draw a true vertical and the radiograph was corrected based on this photograph. The lower incisor was measured taking as reference the NB, APo, IMPA, FMIA, TVP and McHorris plane. The FMA angle (Frankfort plane and mandibular plane) was also measured, to establish the patient's mandibular growth type.

To standardize the researchers, 10 radiographs were taken randomly and retraced two weeks later to avoid memory bias. The measurements were compared to those from the first trace and Pearson's R coefficient test was performed to determine measurement error. No statistically

significant difference was found between the two measurements.

Subsequently, all radiographs were measured using cephalometric paper, 0.05mm pencil and an Ormco brand protractor.

IMPA compensation was performed as described by Tweed[34,35] with the formula proposed by the researchers (Fig 1). Statistical analysis was conducted using SPSS version 20 and STATGRAPHICS Centurion XVI.II, with a statistical significance of p< 0.05. The data had normal distribution, which was determined with the Kolmogorov-Smirnov test, therefore parametric tests were applied, *T* test for sample means, Pearson's R coefficient and ANOVA.

RESULTS

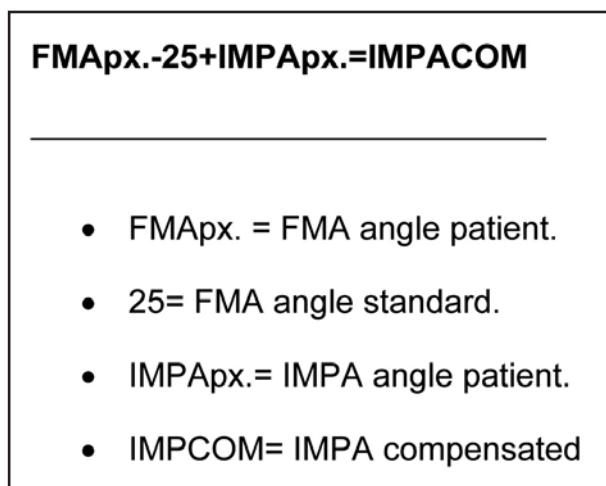A total 100 lateral cephalograms were included. Pearson's R coefficient test showed correlation between lower incisor inclination and all planes studied, including the true vertical plane (Table 1). Comparison of the 7 variables with ANOVA showed statistically significant differences between means with a 95% level of confidence p=0.0001 (Table 2). A multiple range test was used to determine in which groups these differences are significant. It is important to mention that there were no differences between the TVP, IMPACOM and FMIA (Table 3). The Student-T test for means was applied to determine the differences between the means of the studied planes and the TVV, finding no statistically significant difference between the TVP and the FMIA and IMPACOM planes (Table 4). Finally, Student-T test for means
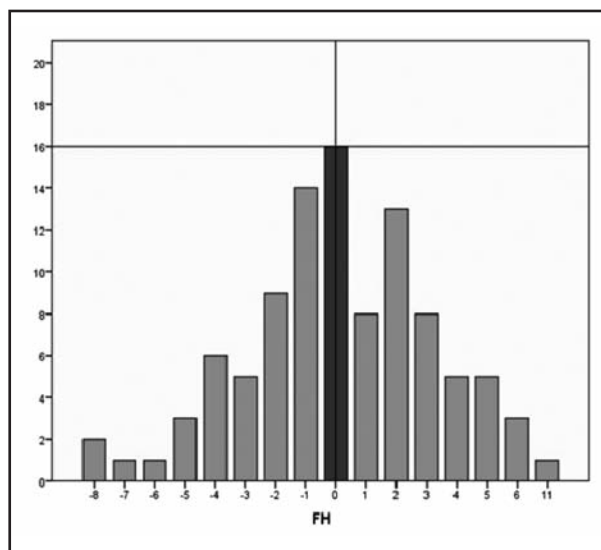

FMApx.-25+IMPApx.=IMPACOM

- FMApx. = FMA angle patient.
- 25= FMA angle standard.
- IMPApx.= IMPA angle patient.
- IMPCOM= IMPA compensated

Fig. 1: Formula to compensate the IMPA.

Fig. 2: The Frankfort plane matches the Horizontal True correlation.

Table 1.

	NB	FMIA	IMPA	APo	PVV	IMPACOM	MH
NB	1	.880**	.783**	.797**	.861**	.879**	.841**
FMIA	.880**	1	.683**	.587**	.889**	1.000**	.839**
IMPA	.783**	.683**	1	.644**	.635**	.684**	.800**
APo	.797**	.587**	.644**	1	.609**	.587**	.633**
PVV	.861**	.889**	.635**	.609**	1	.889**	.777**
IMPACOM	.879**	1.000**	.684**	.587**	.889**	1	.839**
MH	.841**	.839**	.800*	.633**	.777**	.839**	1

** The correlation is significant at the 0.01 level (bilateral). n = 100, FMIA: Frankfort horizontal plane – inferior incisive, NB: Nasion line to point B, APo: Point A- Pogonion, IMPA: mandibular plane – inferior incisive, true vertical plane (TVP), IMPACOM: IMPA compensated and MH: McHorris plane.

Table 2.

	Sum of squares	Gl	Mean square	F-ratio	P-value
Between groups	5545.98	6	924.33	20.56	0.0001*
Within groups	31158.5	693	44.9617		
Total (Corr.)	36704.4	699			

* Statistically significant differences (p< 0.05). n = 100.

comparing IMPA to IMPACOM found statistically significant differences with p<0.0001 (Table 5). The Frankfort plane matches the Horizontal True only in 16% of the cases, and the measurements obtained vary between -8 and 11 (Fig 2).

DISCUSSION

With the development of orthodontic science, diagnostic accuracy and treatment plan detail have both increased, resulting in the need to evaluate the methods used. In order to apply cephalometric measurements properly, it is important to determine their specificity and sensitivity with regard to the position of teeth and their bony bases, and the relationship between them, the jaws and other cranial structures. If cephalometric measurements are interpreted inappropriately, they can lead in the wrong direction.[44]

Similarly, the literature has emphasized the importance of timely, accurate diagnosis of the lower

Table 3.

Contrast	Sig.	Differences
NB - FMIA	*	-4.76
NB - IMPA		1.65
NB - APo		-0.88
NB – IMPACOM	*	-4.75
NB - MH	*	2.01
NB - PVV	*	-4.58
FMIA - IMPA	*	6.41
FMIA - APo	*	3.88
FMIA – IMPACOM		0.01
FMIA - MH	*	6.77
FMIA - PVV		0.18
IMPA – Apo	*	-2.53
IMPA – IMPACOM	*	-6.4
IMPA – MH		0.36
IMPA – PVV	*	-6.23
APo - IMPACOM	*	-3.87
APo - MH	*	2.89
APo - PVV	*	-3.7
IMPACOM - MH	*	6.76
IMPACOM - PVV		0.17
MH - PVV	*	-6.59

* Statistically significant differences, (p< 0.05). FMIA: Frankfort Horizontal Plane – inferior incisive, NB: Nasion line to point B, APo: point line A-Pogonion, IMPA: mandibular plane – inferior incisive, True Vertical Plane (TVP), IMPACOM: IMPA compensated and MH: McHorris plane.

Table 4.

	t	Gl.	Sig. (bilateral)	Mean differences	Lower	Upper
NB	12.826	99	.001*	4.58000	3.8715	5.2885
FMIA	-.555	99	.580	-.18000	-.8240	.4640
IMPA	10.375	99	.001*	6.23000	5.0385	7.4215
MH	14.127	99	.001*	6.59000	5.6644	7.5156
APo	6.499	99	.001*	3.70000	2.5703	4.8297
IMPACOM	-.524	99	.601	1.17000	-.8138	.4738

* Statistically significant differences, (p< 0.05). n = 100, FMIA: Frankfort Horizontal Plane– Inferior incisive, NB: Nasion line to point B, APo: Point line A- Pogonion, IMPA: Mandibular Plane – Inferior incisive, MH: McHorris plane and IMPACOM: IMPA compensated.

Table 5.

	t	Gl.	Sig. (bilateral)	Mean differences	Lower	Upper
IMPA-IMPACOM	-11.549	99	0.001*	-6.40000	-7.4995	-5.3005

* Statistically significant differences, (p< 0.05). n = 100, FMIA IMPA: Mandibular plane – Inferior incisive, IMPACOM: IMPA compensated.

incisor by analyzing its position and inclination, as well as of other structures that influence and affect its measurement.[24, 27-29, 34-38] This information influences decisions for the treatment plan, such as whether extractions or stripping will be performed and what anchorage type and biomechanics will be used, among other aspects. [1-3]

It is also relevant in pre-surgical orthodontics because the measurements used are often based on surgically repositioned structures. Cephalometric analysis should therefore be objective and consider each factor that may change or influence the measurement result.[44]

Based on the reference planes used in the present study, the lower incisor had an average proclination of 4.8°, lower than reported by Gütermann[16] (6.6°) and Asad[45] (7.7°), in similar samples. However, the variations among the means obtained for each plane were considerable, with the McHorris and FMIA angles indicating the lowest and highest proclination, respectively (1.2° ± 7 y 8°± 6). This shows how altered incisor measurement can depend on the reference plane used.[44]

There was correlation among all the reference planes analyzed. Aldreeset al.[46] reported similar results in terms of correlation between the mandibular plane and NB line, contrary to what was reported by Linder and Cornelius.[47]

The weakest correlation was observed for the APo line with regard to other planes, including FMIA (.587), IMPA (.644) and TVP (.609). Another low correlation was for IMPA with regard to FMIA (.683) and TVP (.644). This is due to the great influence of the horizontal and vertical position of the jaw on the APo line[38,44] and IMPA angle, highlighting the need for appropriate compensation in the latter in order to eliminate this variability factor.[34, 35]

The FMIA angle derives from the Frankfort plane, and is therefore strongly influenced by it. Ideally, the position of the Frankfort plane should be as close as possible to a true horizontal, however, in the present study this only occurred in 16% of the samples, with a minimum value of -8°, maximum of 11° and a broad range of 19°, similar to values reported by Madsen[20] and Shetty[21], at 23° and 16°, respectively.

The low correlation between FMIA and the other planes and its large difference with measurements of other groups is due to the fact that it is also affected by the position and rotation of the mandible, as stated by Williams[48,49] (1969, 1985).

The IMPA measurement was compensated following Tweed (1952, 1964), to remove the variation of the vertical and horizontal position of the jaw. The following formula is proposed:

$$FMApx - 25 + IMPApx = compensated\ IMPA$$

i.e., for each degree by which the FMA angle exceeds the norm of 25°, the mandibular incisors must be positioned a lower number of the IMPA's norm of 90°, and vice versa, in case of a decrease in FMA, the mandibular incisors must be positioned a higher number of the IMPA's norm of 90°.[34, 35]

The true vertical plane has not been used previously to measure lower incisor inclination. However, in the sample analyzed in our study, the true vertical plane showed correlation with the other reference planes, and measurements of incisal inclination did not differ significantly from the FMIA angle and IMPACOM.

The planes with greatest differences in the proclination or retroclination degrees were the McHorris plane with regard to TVP (-6.59) and FMIA (-6.77), and the IMPA angle with regard to TVP (-6.23), FMIA (-6.41) and IMPACOM (-6.4). It is thus feasible to state that the most consistent measurements are derived from the true vertical planes, FMIA and IMPA with its compensation, since without it the differences are heightened considerably.

CONCLUSION

There was correlation among all reference planes. The differences were statistically significant except for FMIA, IMPACOM and TVP. There were statistically significant differences between the IMPA angle and the compensated angle. No significant difference was found between the IMPACOM and the incisive measurement derived from the TVP. The Frankfort horizontal plane and the true horizontal plane are mismatched in 84% of the sample population, with a range of 19°.

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