3

Are the Orthodontic Basis Wrong? Revisiting Two of the Keys to Normal Oclusion (Crown Inclination and Crown Angulation) in the Andrews Series

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1. Introduction

In the second half of the last century, Lawrence F. Andrews studied a series of 120 casts, of non-orthodontic subjects with ideal patterns of dental occlusion, and established "*The six keys to normal occlusion*". These were the basis to program the tooth movement directly on the bracket and not in wire bending, and were also the origin of the straight-wire, or preadjusted, appliance of current use in orthodontics. However, until now, the postulates of Andrews never have been contrasted using the scientific method and a proper statistical analysis. Moreover, some orthodontists have the suspect that the criteria of Andrews are not universal and applicable to the whole population since he do not distinguished age-dependent changes, ethnical group, sex, or left-right asymmetry. The critical analysis of the Andrews' work is the goal of this Chapter, but we have centered our efforts in the date related to Crown angulation (the mesiodistal "tip") and Crown inclination (labiolingual or buccolingual inclination) which are of capital importance to perform accurately functional and aesthetic orthodontic treatments.

2. Background: Historical context

The use of the fixed appliance in orthodontic is directly linked to the proposal and guides of Edward H. Angle to move the teeth to the so-called "occlusion line", defined as "*the line, shape and position, must be teeth in balance if there is a normal occlusion*". Angle described in detail the relationships between maxillary and mandible, and maxillary-mandible and teeth, and especially the teeth among them, in order to achieve an ideal occlusion (Angle, 1929b; see the Special Edition of 1981).

These recommendations required the designing of special devices for three-dimensional control of teeth in order to reach the occlusion line and allow teeth to be correctly aligned in both the maxillary and mandible. Furthermore, according to Angle the alignment of the teeth, both crown and root, would result in the expansion of both the maxillary and mandible arches. This was also one of the main objectives to design the Angle's devices. Nevertheless, these postulates are still under discussion (Canut, 2000; Peck, 2008).

In 1887, Angle developed the "E" arch appliance formed by a thick gold wire placed for labial and some stainless steel tape on the first molar adjusted at pressure. This type of arch expanded both maxillary and mandible arches sagittally and transversely, and allowed a movement of simple inclination of the crown through a few ligatures that surrounded the tooth and conformed to the arch.

In the early 20th century with the development of metallurgy emerged the possibility of banding all the teeth and welding devices for the control of rotations. In 1910, Angle introduced the first appliance with individual tooth action and fullbanding, the so-called "pin and tube appliance", which welded small vertical tubes in the bands to introduce a stem attached to the wire. This device facilitated the labiolingual as mesiodistal expansion of the maxillary, and its drawback was the requirement for adjustment and accuracy in addition to the skill by the clinician (Bravo, 2007). Unfortunately one of the problems posed by this device was its inestability (Graber and Vanarsdall, 1994). Later, in 1916, Angle designed a bracket, called "ribbon arch appliance wire-band", containing a rectangular wire fixed by a few pins and placing the wider side on the tooth. This device properly controlled the labiolingual as well as vertical placement of teeth, by facilitating the correction of giroversions. However, it was difficult to place on the cusp and the looseness of the wire in the slot prevented mesiodistal control. Another substantial contribution of Angle was the frontal slot bracket, as opposed to the ribbon arch appliance of vertical opening, which featured great advantages, especially the ease to introduce the wire and the possibility to control the premolars and the adjustment of mesiodistal movement. In 1926 he presented the "bracket 447" with a horizontal slot .022 "x.028" which served to introduce a rectangular wire of the same thickness through the more narrow are, i.e. edgewise. It was made in gold and was called "soft bracket", as it opened easily and distorting (see for a review the Special Edition of Angle's work, 1981).

Over the basis of this model Steiner developed the "bracket 452" (hard bracket), more resistant to deformation which allowed to control teeth movement at the three levels through bends as tip, torque and in-out. This would become the prototype of the contemporary brackets.

Previously to the emergence of the straight wire, Angle already proposed to place the brackets to mesial or distal from the teeth to help to correct teeth rotations (Angle, 1929a), and a posterior angulation of the brackets to get proper root movements (see Meyer and Nelson, 1978). Later, Lewis (1950) joined segments ("arms") linked to the brackets, in contact with the wires for controlling rotations. Thereafter, Holdaway (1952) proposed that the buccal aspect of the brackets could be angulated depending on the degree of severity of the malocclusion. Twenty years later the original idea of Lewis, with some modifications, was adapted by Gottlieb et al. (1972). On the other hand Jarabak and Fizell (1963) minted the well-known phrase "*building treatment into the appliance*" which proposed to incorporate angles within the bracket, and these authors presented at the meeting of the American Association of Orthodontist in 1960 the first bracket model combining crown angulation and crown inclination (Wahl, 2008).

All together the work of all these authors consisted in eliminating bends in the wire to be incorporated into the bracket. All this led to the evolution of the bracket of edgewise to the bracket of straight wire incorporating the information in the slot of the bracket (Figure 1).

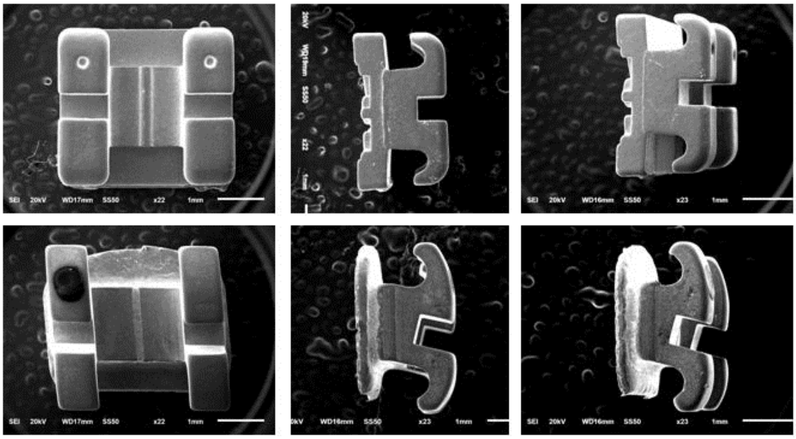


Fig. 1. Top line: Scanning electron microscopy of one bracket of standard edgewise appliance from a frontal (A), lateral (B), and oblique (C) view. Bottom line: Scanning electron microscopy of one straight wire bracket from a frontal (D), lateral (E), and oblique (F) view. The absence of information in the slot of the bracket of standard edgewise appliance in comparison with the bracket of the straight-wire appliance can be observed.

2.1 The work of L.F. Andrews

From 1960 Andrews published a series of five studies, which resulted in the development of a new concept for the orthodontic treatment: the straight wire appliance.

The **First study** had as purpose the completion of a thesis for obtaining the certification of the American Board of Orthodontics. It consisted of the static analysis of the occlusion in post-orthodontic treatment casts. He found that there were features common to all them: absence of rotations in the incisors, no cross-bites, and Class I molar relationship of Angle, except in cases of extractions in a single maxillary. However, other parameters were not common at all. He deduced that the optimal positioning of the teeth should sustain in studies of optimal natural dentures (see Andrews, 1989).

In order to perform the **Second study**, Andrews selected 120 casts of non-orthodontic, untreated, patients with supposedly ideal occlusions, from which arose a few assumptions that should determine the occlusal objectives after orthodontic treatment. The compilation of the cases was carried out between 1960 and 1964 with the help of various Orthodontists, among them Brodie (Andrews, 1989). These casts have in common, in addition to lack of orthodontic treatment, a correct teeth alignment and positioning as well as a seemingly an "excellent" occlusion. The concept was, in essence, that if it is know what is right it can identify and quantify what's wrong in a direct and methodical manner. Over the casts Andrews conducted a series of marks: the facial axis (axial) of the clinical crowns, the most prominent portion of incisors, canines and pre-molars, as well as the projection of the medial groove in molars, and the midpoint of the height of each clinical crown.

In the **Third study** he described six characteristics that were always present in the 120 casts. These features would be referred to as "*The six keys to normal occlusion*" and were published in 1972 in the American Journal of Orthodontics (Andrews, 1972). The "Six Keys" would assess the occlusal situation without using measuring instruments, as in the keys II and III (referring to the crown angulation and crown inclination, respectively), Andrews do not use units but simply the positive or negative sign (he used terms such as lightly positive, generally negative, etc). According to Andrews the "Six Keys" are interdependent components of the structural system of optimal occlusion and serve as a basis to assess the occlusion.

They consisted of a series of significant characteristics shared by all of the non-orthodontic normal teeth, and were the following: specific molar relationship (key I), crown angulation (the angulation or mesiodistal "tip" of the long axis of the crown: Key II), crown inclination (the labiolingual or buccolingual inclination of the long axis of the crown: Key III), no rotations (key IV), absence of spaces (key V), and the occlusal plane (key VI). In the own Andrews words "*The six keys to normal occlusion contribute individually and collectively to the total scheme of occlusion and, therefore, are viewed as essential to successful orthodontic treatment*".

The 120 casts analyzed by Andrews showed similarities in values of crown angulation, crown inclination, shape, and size for the different types of teeth. But this was not enough for the design of the new device. Therefore, in a further study attempted to determine the shape, size and position of each tooth in the arch.

For the **Fourth study**, Andrews made new measurements over the 120 casts (see Andrews, 1989). The measurements made in this case were: the determination of the bracket area for each teeth, vertical crown contour, crown angulation, crown inclination, offset of maxillary molars, horizontal crown contour, crown facial prominence and depth of the curve of Spee. So, he doubled the 120 casts and removed the occlusal halves of the crown. On these surfaces he defined a line that joins the portion more vestibular of contact points and the most prominent portions of each clinical crown. He denominated this line as the embrasure line. The values obtained were incorporated into the design of the bracket to eliminate the first order bends. These measurements, except bracket size and curve of Spee, were averaged for each tooth type, and the results served as norms for the design of the new appliance: the straight-wire. After describing outcomes, Andrews concludes that the study reveals essential data on the position (with the exception of the inclination of the incisors), morphology and relative vestibular prominence of each tooth in the arch. The differences in the inclination of the incisors were attributed to disharmonies between the maxillary bones.

The **Fifth**, and final, **study** consisted of comparison of 1156 casts post-treatment in terms of occlusion, with the 120 casts from non-treated subjects with optimal occlusion. This study was focused to the design of a new device able to include the "six keys". The conclusion was that very few of the analyzed casts presented all the "six keys" (Andrews, 1976a). Therefore, he considered necessary the establishment of some premises of treatment, including common objectives, coupled with a new device. The straight wire appliance of Andrews was the first completely pre-adjusted orthodontic appliance. It was designed for the treatment of cases without extraction with one less than 5^{o} ANB, avoiding the need for bends in the wire. As the closure of the spaces after premolar extractions produces undesirable side effects (rotation, inclination), Andrews subsequently introduced different brackets for cases with extractions. Moreover, when designing their brackets, Andrews differentiated between treatments in which the translation of teeth is necessary and that no, the so-called brackets of translation and standard brackets (Andrews, 1976c, 1989). In a short time the new straight-wire appliance was adopted by the American universities and most of the orthodontists (Andrews, 1976b, 1989). Some year later (Roth, 1976, 1987), designed brackets with information at the three levels, varying the characteristics described by Andrews. He developed the second generation of preprogrammed brackets, increasing the crown inclination in the canines up to 13º to achieve the "best functional occlusion".

The third generation of brackets was developed by McLaughlin, Bennett and Trevisi (MBT™, McLaughlin et al., 1997; see also McLaughlin and Bennett, 1989). It is based on light forces and sliding mechanics maintaining the advantages of the prescriptions of Andrews and Roth, but eliminating certain limitations.

The introduction of straight-wire appliance in orthodontics led to a great controversy initially, but soon was accepted by all American orthodontic companies since it easily consent to control dental positions with the placement of brackets. Since then, others have developed new appliances, also fully programmed pre-adjusted (see for a review and references Proffit et al., 2008).

3. The Andrew's series: The values for crown angulation and crown inclination revisited

The first step of our work was to collect the individual values for crown angulation and crown inclination contained in the text and annex from Andrews' book "Straight-Wire, The Concept and Appliance" (Andrews, 1989), confirm that the descriptive statistical are exact, and apply to them a descriptive statistical analysis using the actual current methods.

When we try to validate the Andrews' statistical design the following questions and methodological troubles emerge when analyze the series of 120 casts that are the basis of the Andrews' work:

1. The origin of the sample: the author does not indicate how was selected the sample and what were the selection criteria;
2. The type of clustering of the data: he reports data from 240 casts instead of 120, because he evaluated together teeth from left and right side without checking whether or not there are differences between hemi-arch;
3. The variability between the data in the same group: the data are presented as a tabulation of centralization and dispersion of the maxillary and mandibular angles measures as did Andrews, with 240 data as if they were separate measures.

Therefore, our second step was the verification of the validity of the Andrew's design by contrast of hypothesis. It was carried out a Student t test of paired data to know whether or not there are significant differences in the crown angulation and crown inclination between the right and left hemi-arch with respect of their average values. The null hypothesis was that there are no significant differences in the crown angulation or crown inclination of teeth with respect to the side ($p \geq 0.05$) and the study hypothesis was that there are significant differences in the crown angulation or crown inclination of teeth with respect to the side ($p \leq 0.05$).

Descriptive statistics in the Andrew's series

Surprisingly, several errors in the basic descriptive statistics (count, average, standard deviation, minimum and maximum values) were detected for crown angulation but not for crown inclination (Tables 1 and 2). Thus, there is an error between the source (single) data and statistic results appearing in his publication. Moreover, in comparing these basic descriptive statistics with those obtained by us, applying the some probes on the Andrews data, it can be observed again that do not match for crown angulation (Table 1). Thus, there is an error between the source (single) data and statistic results appearing in his publication, and the statistics are no well calculated.

	Maxillary			Mandible		
Tooth	n	Range min/max	mean±SD	n	Range min/max	mean±SD
Andrews data/Our data						
1L+1R	240	-3/9	3.59±1.65	240	-4/3	0.53±1.29
1L+1R	240	-3/9	3.59±**1.70**	240	-4/3	0.53±1.29
2L+2R	240	**-2**/15	**8.04**±2.80	240	-5/3	0.38±1.47
2L+2R	240	-26/15	**7.90±3.53**	240	-5/3	0.38±1.48
3L+3R	239	**1**/17	**8.40**±2.97	240	-11/12	2.48±3.28
3L+3R	240	0/17	**8.13±3.21**	240	-11/12	2.48±3.29
4L+4R	240	-2/**12**	**2.65**±1.69	240	-10/10	1.28±1.90
4L+4R	240	-2/14	**2.90±2.29**	240	-10/10	1.28±1.90
5L+5R	240	0/12	**2.82**±1.52	240	-5/7	1.54±1.35
5L+5R	240	0/12	**2.86±1.54**	240	-5/7	1.54±1.36
6L+6R	240	-7/16	**5.73**±1.90	240	-2/6	2.03±1.14
6L+6R	240	-7/16	**5.69±1.97**	240	-2/6	2.03±1.14

Table 1. **Crown angulation**. Basic descriptive statistics of Andrews' data after revisited by us (black), and after the descriptive statistical study we have carried out (red). Values are expressed in degrees, and the observed differences are highlighted in bold.

	Maxillary			Mandible		
Tooth	n	Range min/max	mean±SD	n	Range min/max	mean±SD
Andrews data/Our data						
1L+1R	240	-7/15	6.11±3.97	240	-17/16	-1.71±5.79
1L+1R	240	-7/15	6.11±3.98	240	-17/16	-1.71±5.80
2L+2R	240	-6/17	4.42±4.38	239	-19/15	-3.24±5.37
2L+2R	240	-6/17	4,42±4.39	240	-19/15	-3.24±5.38
3L+3R	240	-17/10	-7.25±4.21	239	-26/2	-12.73±4.65
3L+3R	240	-17/10	-7.25±4.22	239	-26/2	-12.73±4.66
4L+4R	240	-20/5	-8.47±4.02	240	-35/-1	-18.95±4.96
4L+4R	240	-20/5	-8.47±4.03	239	-35/-1	-18.95±4.97
5L+5R	240	-20/3	-8.78±4.13	240	-45/-8	-23.63±5.58
5L+5R	240	-20/3	-8.78±4.14	240	-45/-8	-23.63±5.60
6L+6R	240	-25/2	-11.53±3.91	240	-55/-9	-30.67±5.90
6L+6R	240	-25/2	-11.53±3.92	240	-55/-9	-30.67±5.91

Table 2. **Crown inclination**. Basic descriptive statistics of Andrews' data after revisited by us (black), and after the descriptive statistical study we have carried out (red). Values are expressed in degrees, and the observed differences are highlighted in bold.

As Andrews considered the data together then we analyzed if there are differences between left and right teeth. For crown angulation, in comparing the average values of the right side and the left side differences were found to be significant ($p<0.05$) for all maxillary and mandibular teeth, except for the lower central incisor (Table 3). On the other hand, the comparison of mean averages for crown inclination of the right and left sides significant differences ($p<0.05$) were found for all upper teeth, except for the canines and first premolars, and for all lower teeth expect for both central and lateral incisors (Table 4).

	Maxillary			Mandible		
Tooth	t	fd	p	t	df	p value
1	3.00	119	**0.003**	1.11	119	0.270
2	5.71	119	**0.000**	-1.98	119	**0.050**
3	2.39	118	**0.013**	-2.62	119	**0.010**
4	2.30	119	**0.023**	-2.52	119	**0.013**
5	2.11	119	**0.037**	-3.86	119	**0.000**
6	2.79	119	**0.006**	-3.97	119	**0.000**

df: degrees of freedom

Table 3. **Crown angulation**. Student t test for crown angulation of right vs left arch. Significant differences are highlighted in bold.

	Maxillary			Mandible		
Tooth	t	fd	p	t	df	p values
1	4.00	119	**0.000**	0.11	119	0.909
2	4.95	119	**0.000**	-0.56	119	0.830
3	-1.22	119	0.223	-3.37	118	**0.008**
4	0.65	119	0.518	-4.60	118	**0.00**
5	2.34	119	**0.021**	-5.12	119	**0.000**
6	2.99	119	**0.003**	-6.56	119	**0.000**

df: degrees of freedom

Table 4. **Crown inclination**. Student t test for crown inclination for right vs left arch. Significant differences are highlighted in bold.

These results consent to affirm that significant differences exists between the right and left sides of each arch, for the angulation of crown for all the teeth of the upper arch, and for the majority of the lower arch. Regarding the crown inclination significant differences do not occur in all the maxillary and mandibular teeth but all show any difference.

3.1 Descriptive statistics of separate hemi-arch

Since significant differences between the right and left hemi-arch were found in the Andrews' series we decided to perform and basic descriptive statistical analysis of both crown angulation and crown inclination in each hemi-arch separately. At a value of the confidence interval 95% the standard deviation shows very high values in some teeth, and the variable dispersion is therefore very broad.

In the upper maxillary the greater homogeneity in crown angulation was found for the central incisor, the second premolar and first molar (Table 5; Fig. 2A). The mandible crown angulation shows a more homogeneous behavior, except for the canine (Table 5; Fig. 2B). The presence of outlier values implies a high variability, and so at a confidence interval 95% wider than would be desirable (Figs. 3A and 3C, and Figs. 3B and 3D).

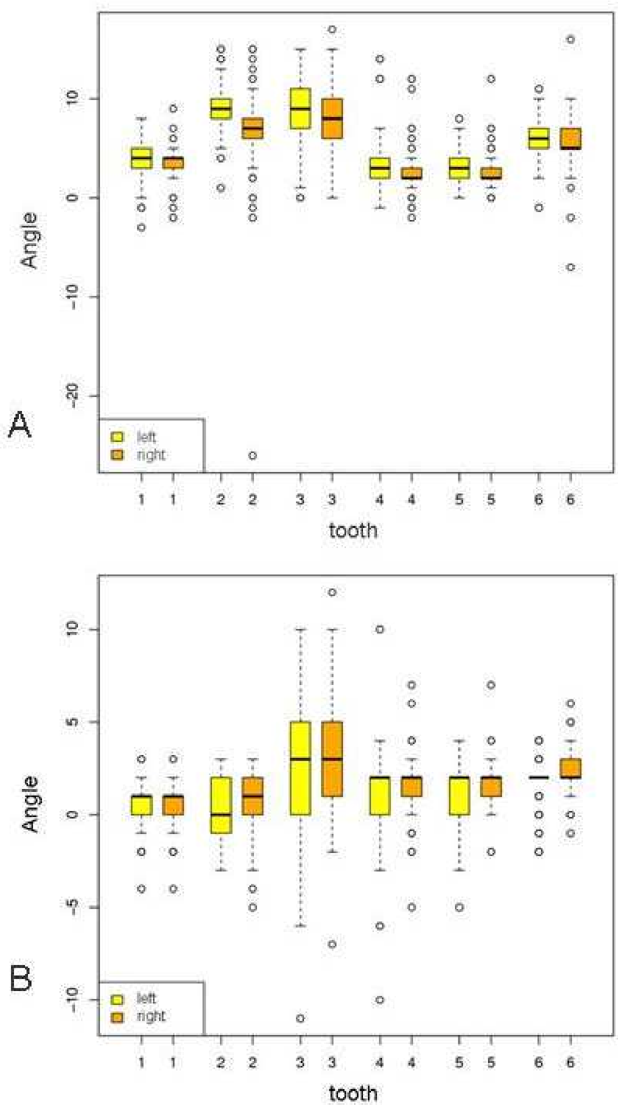


Fig. 2. Box-plot representation of the maxillary crown angulation (A) and mandibular crown angulation (B) of the data from the Andrews' series.

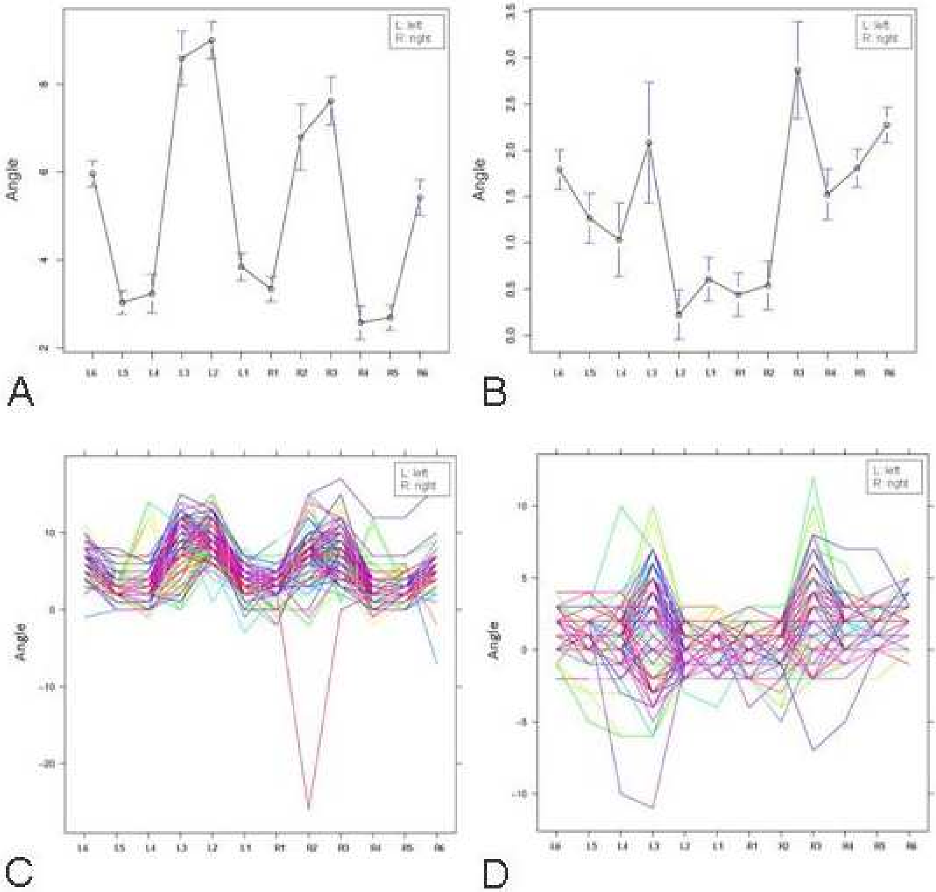


Fig. 3. Mean values of confidence interval 95% and profiles of the maxillary crown angulation (A,C) and mandibular crown angulation (B,D) of the data from the Andrews' series.

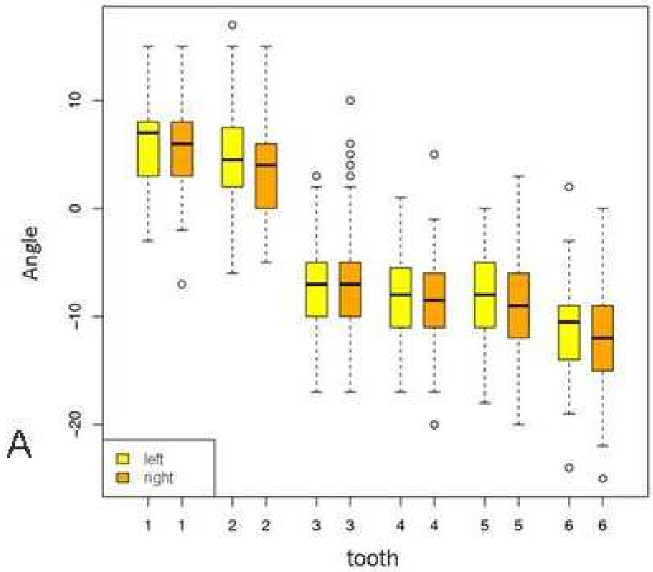
Tooth		n	mean±SD	range of confidence interval
Right hemi-arch				
1R	upper	120	3.42±1.56	3.06 – 3.62
	lower	120	0.44±1.28	0.21 – 0.67
2R	upper	120	6.79±2.85	6.04 – 7.54
	lower	120	0.54±1.46	0.28 – 0.81
3R	upper	119	7.61±2.95	7.07 – 8.16
	lower	120	2.87±2.89	2.34 – 3.39
4R	upper	120	2.57±2.13	2.19 – 2.96
	lower	120	1.52±1.51	1.25 – 1.80
5R	upper	120	2.69±1.55	2.40 – 2.98
	lower	120	1.81±1.13	1.60 – 2.01
6R	upper	120	5.42±2.12	5.01 – 5.82
	lower	120	2.27±1.04	2.09 – 2.46
Left hemi-arch				
1R	upper	120	3.84±1.70	3.53 – 4.15
	lower	120	0.61±1.30	0.37 – 0.84
2R	upper	120	9.00±2.33	8.58 – 9.42
	lower	120	0.54±1.48	0.28 – 0.81
3R	upper	120	8.58±3.37	7.97 – 9.20
	lower	120	2.87±3.61	2.34 – 3.39
4R	upper	120	3.23±2.43	2.80 – 3.67
	lower	120	1.52±2.20	1.25 – 1.80
5R	upper	120	3.03±1.47	2.77 – 3.30
	lower	120	1.81±1.50	1.60 – 2.01
6R	upper	120	5.96±1.62	5.66 – 6.25
	lower	120	2.27±1.19	2.09 – 2.46

Table 5. **Crown angulation**. Basic descriptive statistics of Andrews' data for hemi-arch after revisited by us. Values are expressed in degrees.

The results for crown inclination are reflected in table 6, and Figures 4A and 4B, which show that the variability of the data is very similar for all teeth. The mandible data presented a top-down performance in terms of average values of the central incisor to the first molar. The study of confidence intervals 95% shows differences between the teeth and the side. In general, the profiles of the subjects were similar for both the maxillary and mandibular teeth (Figs. 5A and 5C, and Figs. 5B and 5D).

Tooth		n	mean±SD	range of confidence interval
Right hemi-arch				
1R	upper	120	5.76±4.01	-2.76 – -0.67
	lower	120	-1.71±5.77	0.21 – 0.67
2R	upper	120	3.83±4.43	3.03 – 4.63
	lower	120	-3.25±5.60	-4.26 – -2.24
3R	upper	120	-7.02±4.52	-7.84 – -6.21
	lower	119	-12.19±4.28	-12.96 – -11.42
4R	upper	120	-8.57±4.11	-9.31 – -7.82
	lower	119	-18.12±4.95	-19.01 – -17.22
5R	upper	120	-9.17±4.23	-9.93 – -8.40
	lower	120	-22.49±5.46	-23.48 – -21.50
6R	upper	120	-12.0±4.08	-12.73 – -11.26
	lower	120	-29.4±5.75	-30.44 – -28.36
Left hemi-arch				
1R	upper	120	6.47±3.94	5.75 – 7.18
	lower	120	-1.70±5.85	-2.76 – -0.64
2R	upper	120	5.00±4.28	4.23 – 5.77
	lower	120	-3.21±5.15	-4.14 – -2.28
3R	upper	120	-7.47±3.90	-8.17 – -6.76
	lower	120	-13.17±5.01	-14.09 – -12.24
4R	upper	120	-8.37±3.96	-9.09 – -7.66
	lower	120	-19.78±4.87	-20.66 – -18.90
5R	upper	120	-8.39±4.01	-9.12 – -7.66
	lower	120	-24.77±5.81	-25.76 – -23.77
6R	upper	120	-11.07±3.71	-11.74 – -10.39
	lower	120	-31.93±8.02	-32.98 – -30.88

Table 6. **Crown inclination.** Basic descriptive statistics of Andrews' data for hemi-arch after revisited by us. Values are expressed in degrees.



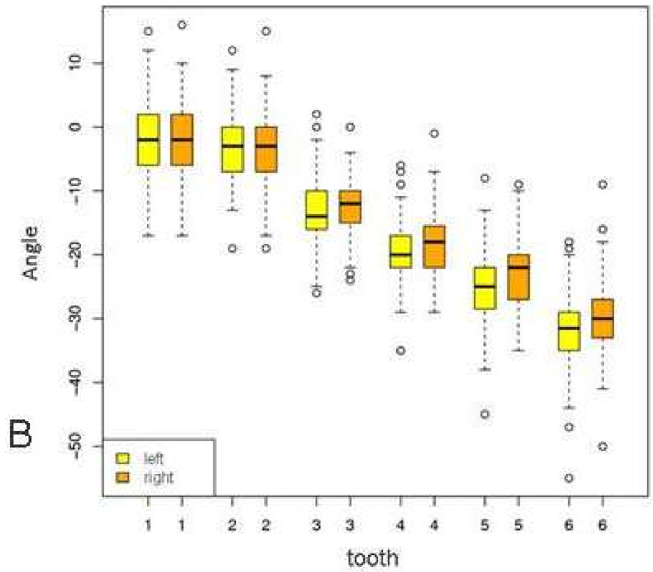


Fig. 4. Box-plot representation of the maxillary crown inclination (A) and mandibular crown inclination (B) of the data from the Andrews' series.

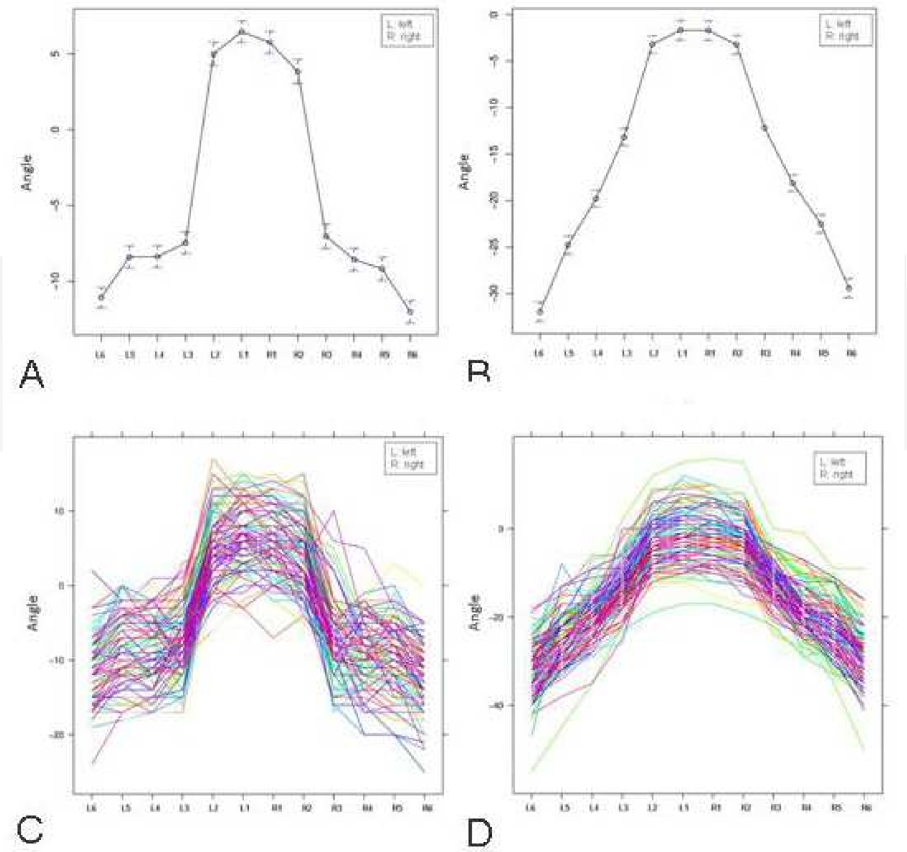


Fig. 5. Mean values of confidence interval 95% and profiles of the maxillary crown inclination (A,C) and mandibular crown inclination (B,D) of the data from the Andrews' series.

3.2 Critical comments to the Andrews' work

After the analysis of the data published by Andrews (1989) in his book *Straight-Wire, The Concept and Appliance* the first thing that draws attention is that the author annex provide data relating to 240 casts instead of 120, which are those said to have studied. This may be due to the fact that the author carried out two measurements by subject (left and right) in each arch, and then globalize the data into a single; but Andrews does not clarify this fact. Is this right? The statistical study we have performed on the Andrews' data shows that there are significant differences between left and right for crown angulation and crown inclination for most of the upper teeth, and form the lower teeth for crown angulation of the lateral incisor to the first molar, and for crown inclination in the canine, premolars and first molar. Therefore, it seems evident that the data from the Andrews study cannot be grouped, and it is necessary to work with each hemi-arch separately and perform the descriptive and comparative analysis for each one of them. From these results the following question arises: it should be necessary use different brackets on left and right side of each patient?

Another surprising finding of our review of the Andrews' data was that the results presented in terms of basic descriptive statistic not always coincide with those from the sources. These errors can be due to erroneous data sheets records or that have been made evil the descriptive analysis.

The Andrews' results are expressed as average values, and the standard deviation was occasionally elevated, thus reflecting a significant dispersion of the sample values. For example, the following measurements for crown angulation (mean±standard deviation, range: minimal-maximal) in the first premolar realize this: upper 2.65°±1.69°, -2.0° to +12°; lower: 2.90°±2.29°, -2° to +14°. The ranges show the enormous variation of values. If in cases of optimal occlusions the crown angulation of this tooth vary between -2° and 12°, take as reference a value of 2.65° in orthodontic appliances does not seems logical.

It would also be desirable that Andrews had studied the type of the data distribution in the sample, and the author seems to assume that the distribution is symmetric, but in the light of the results presented here, it is unlikely to be so. In fact, the normality test indicates that the distribution is not normal in all cases.

The listing of all the individual data of the sample is a sign of honesty by the author, and reflects the statistical methodology of the 1970s. But at the same time it allows us to appreciate their low methodological rigor, in the light of current knowledge when presenting the conclusions as a definitive response to a widely discussed problem. Thus, it is difficult to understand why the orthodontists from around the world have continued to put the brackets using as a reference the average values of the measurements made on 120 casts without rigorous selection criteria. In our casts, as well as in those from other groups (Roth, 1987; Martínez-Asúnsolo and Plasencia, 2004; Zanelato et al., 2004), the findings of Andrews for the crown angulation and inclinations were not confirmed.

Therefore, the Andrews study in terms of design, include the following shortcomings: definition of the characteristics of the sample, the exact criteria of selection of the subjects included in the sample, the absence of a descriptive statistic that analyze the way of the distribution of the data (if distribution is markedly asymmetrical, would be preferable to choose the mean than the average as a measure of central tendency), the type of sampling, and sample size calculation. In the Andrews study the sample size is adequate (240 measurements from 120 casts). Nevertheless, to work with greater precision, for example 0.5 mm, the sample should be higher.

On the other hand, the development of the work of Andrews also suffers from some defects. In this kind of studies it is necessary to assess their reproducibility or reliability, both intra-observer and inter-observed. It is not aware that the Andrews work has been performed by several observers, and therefore it must be we assumed that the measurements were carried out by Andrews himself or by another individual. Still, in any case Andrews should be repeated, at least once more, all measures in the same models and to analyze the reliability between measurements. Also, as quantitative variables, the degree of reliability should have been studied through the appropriate statistical tests: Bradley-Blackwood, correlation coefficient, tor the Student t test for paired samples. The errors we have detected in the

Andrews work are surely sufficient to raise necessary a reassessment of the theories of the straight wire. The real debate must be focused on whether the recommendations of Andrews for the crown angulation an inclination may continue to be used for the creation, development and industrialization of orthodontic appliances to serve for the entire population. The tooth size (Agenter et al., 2009; Lee et al., 2011), the place of each teeth in each side hemi-arch, the gender, and the ethnic group (Naranjilla and Rudzki-Janson, 2005) should be considered in the development of future orthodontic appliances.

4. Concluding remarks

While Andrews work is thorough and interesting for its time, it has enough limitations of design or execution to be considered actually as the foundations for the use of an appliance with universal angulation and inclination. Furthermore, we have not found one sufficient material and methodology description in the of Andrews' work to reproduce it accurately. In fact a number of errors in the results of basic descriptive statistics were detected in the Andrews' series. This could be due to errors is the data sheet, or to errors in calculating descriptive statistics.

On the other hand, it cannot be included in a common sample data from measurements obtained from the right and left sides of the maxillary and the mandible as Andrews, given that there are significant differences between the average values of both sides. Therefore it does not seem appropriate to use average angle and tilt values without specifying the side of the arch which belongs to the tooth. Considering the large standard deviations observed in values from the Andrews' series the values of both inclination and angulation cannot be standardized. The variations in the values of angulation and inclination reported by different authors would be sufficient to raise the need for a re-evaluation of the theories of the straight-wire appliance in orthodontics.

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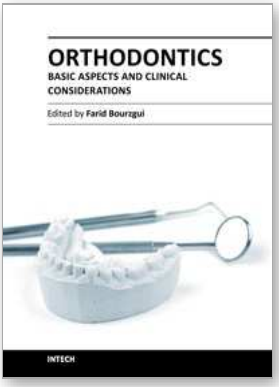

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The book reflects the ideas of nineteen academic and research experts from different countries. The different sections of this book deal with epidemiological and preventive concepts, a demystification of cranio-mandibular dysfunction, clinical considerations and risk assessment of orthodontic treatment. It provides an overview of the state-of-the-art, outlines the experts' knowledge and their efforts to provide readers with quality content explaining new directions and emerging trends in Orthodontics. The book should be of great value to both orthodontic practitioners and to students in orthodontics, who will find learning resources in connection with their fields of study. This will help them acquire valid knowledge and excellent clinical skills.

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