

THE EFFECT OF INCISOR AND CANINE ANGULATION ON MAXILLARY ARCH PERIMETER

1. Introduction:

Orthodontics has, in recent decades gone through some major modifications such as the development of space age metal alloys, the use of micro-implants for orthodontic anchorage and the individualization of brackets. Following the historic progress made by Angle in designing the Edgewise appliance, the work of Lawrence Andrews¹ culminated in the development of the Six Keys of Ideal Occlusion, which was fundamental to the eventual design of a fully programmed appliance. Characteristics present in natural optimal occlusions were identified, thus establishing ideal values for angulation, inclination and labio-lingual prominence to be incorporated in the brackets for each tooth. Using as starting the design and prescriptions of the original Straight-Wire appliance, some authors have altered the values of certain characteristics, including angulation. As it is well known, angulated bodies occupy more space and this also applies to teeth. According to Andrews², the angulation of the upper incisors can directly affect the whole upper arch perimeter. In view of this, we decided to investigate the effect of incisor and canine angulation on the upper arch perimeter by comparing 4 different prescriptions used in the Straight-Wire technique (Andrews, Capellozza, MBT and Roth).

2. Review of Literature:

Attempts to come up with an appliance with certain built-in characteristics aimed at reducing the number of bends in orthodontic wires began long before Andrews¹ developed his original appliance. In 1927, Angle³ suggested that the bracket should be angulated in the band to avoid second order bends. Holdaway⁴, in 1952 proposed that the brackets adjacent to the extraction areas be over-angulated in order to reduce the number of bends necessary to achieve overcorrection in angulation and translation. In 1957, Jarabak⁵ recommended that angulation be incorporated in the bracket groove and in 1958 John J. Stifter⁶ obtained an American patent for a bracket with various combinations of inclination, angulation and labio-lingual prominence. The tendency had thus been launched and in 1970 Lawrence F. Andrews⁷ introduced the totally programmed concept and appliance. Angulation having been defined as the angle formed between the buccal axis of the clinical crown and a line perpendicular to the Andrews plane, the study of untreated normal occlusion models came up with the values of 3.59°, 8.04° e 8.4° for the angulation of the central incisors, lateral incisors and superior canines, respectively. For these teeth, which will be the subject of this study, Andrews increased the values found to 5° for the central incisors, 9° for the lateral incisors and 11° for the canines in order to control what he called the wagon-wheel effect. This effect occurs when labial crown torque is added to the anterior segment causing a reduction in the mesiodistal angulation of the incisors. Definindo angulação como sendo o ângulo formado entre o eixo vestibular da coroa clínica e uma linha perpendicular ao plano de Andrews, encontrou em seu estudo de modelos de oclusões normais não tratados ortodonticamente, os valores de 3.59° , 8.04° e 8.4° para angulação do incisivo central , incisivo lateral e canino superiores respectivamente.

As the years passed, some authors, based largely on their professional experience with the Straight-Wire appliance, changed certain characteristics built into the brackets, especially inclination and angulation. Thus, Roth⁸ maintained the 5° and 9° values for the angulation of the central and lateral superior incisors, but changed the angulation of the superior canines to 13°. His justification for this increase was to attain a better functional occlusion.

McLaughlin e Bennett⁹ by introducing the MBT concept advocated for the superior incisors values that were slightly lower for the angulation than those of the original Straight-Wire appliance, justifying this by saying that they saw no need to increase these values to counteract the “wagon-wheel” effect. Using resources such as the distal tiebacks, little change occurred during the stages of alignment and leveling and, by using rectangular wires, all the angulation built in the brackets could be clearly expressed. As a result, they advocated the use of 4° and 8° for the upper central incisors and lateral incisors angulation. For the upper canines, they recommended an 8° angulation, obtained by Andrews in his study of optimal occlusion models, as they understood this to be sufficient to obtain adequate functional excursions.

Capelozza¹⁰ maintained the angulations recommended by Andrews for the upper incisors, but altered the canines from 11° to 8°. This coincidental value, as we have already seen with the angulation obtained by Andrews and adopted in the MBT, was adopted by this author based on clinical research informations. In clinical practice it was a common finding that either additional archwire bends or compensatory bracket placement be necessary to reduce the angulation of the canines to allow a more adequate relationship between the upper and lower canines and between the roots of its adjacent teeth. This clinical observation was based on a comparative study carried out by Capelozza and his collaborators¹¹, who evaluated the final root positioning by means of panoramic x-rays of cases treated using the Edgewise and Straight-Wire (original Andrews prescription) techniques. One of the conclusions of this work was that canines treated using the Straight-Wire appliance produced an excessive angulation.

As we can see, even though these authors altered the values of upper incisor and canine angulation, this procedure has some limitations. Considering the incisors there is an esthetical limitation when there is an increase in angulation. The reduction in angulation, creating space, seems to be more acceptable from an esthetical point of view, but is however, limited by the incisal guidance. Thomas, J L et al¹², analyzed the effect of variation in the dental angulation and smile esthetics and came to the conclusion that by increasing the angulation of the incisors, the attractiveness of the smile diminished proportionally and that angulations equal to or greater than 10° should be considered unacceptable.

Few studies are found in literature that evaluate the effect of changes in mesiodistal axial angulations on the arch perimeter. According to one study carried out by Andrews², the mesio-distal diameters of 120 upper incisors were evaluated to determine changes occurring when the angulation was altered from 0° to the ideal (5° for the central superiors and 9° for the superior lateral incisors). According to the author, the mesio-distal diameter of an upper central incisor is 0.15mm greater when it is angulated by 5° and for the lateral incisor, around 0.25mm greater when angulated by 9°. Thus, the arch perimeter is 0.8mm greater when the superior incisors are inclined.

Another study trying to evaluate the effect of angulation on the arch perimeter was carried out by Bennett, McLaughlin e Trevisi¹³ using a comparison of three different prescriptions (MBT, Andrews e Roth). Using the MBT prescription as a reference, they reached the conclusion that by utilizing the angulation proposed by Andrews, the arch perimeter increased by 1.8mm and using

the Roth prescription, it increased by 3.2mm. This alteration in the perimeter was evaluated at a root level, which probably produces different results to those obtained on clinical crowns.

It therefore seems reasonable and necessary to evaluate the effects of mesiodistal angulation on arch perimeter, both at a root and crown levels. The objective of this article, is to determine the effect of four Straight-wire prescriptions, namely Andrews, Roth, MBT and Capellozza on the mesiodistal axial angulations of the upper anterior teeth .

3. Materials and Methods

To represent the upper incisor and canine to be investigated in this article, we opted to use models of teeth manufactured by Kilgore International Inc. (Fig.1) These teeth were photographed using a Sony SCN F-717 digital camera and, by means of a computer program (AutoCad 2000), were imported and digitalized. The program AutoCad was chosen because it makes it possible to calculate linear and angular distances using simple tools.

Figure 1

In order to avoid using random values for the mesio-distal and occluso-gingival dimensions of the upper incisors and canines, 30 initial plaster models were randomly selected from the files of Brazilian Orthodontic Association - Petrópolis (Brazil), which presented average sizes and shapes. Using a digital pachymeter, two evaluators carried out measurements of the biggest mesio-distal and occluso-gingival dimensions of the upper incisors and canines. These measurements were repeated twice with an interval of ten days between measurements, and where there was an absence of significant variation. The resultant average mesio-distal and occluso-gingival were then calculated (Table 1). These average values replaced the original values of the Kilgore study model. After this substitution was made and with the help of the AutoCad 2000, we aligned the incisors and canines using the respective LA points (Labial axis) without any angulation, in other words, with the labial axis of the clinical crown perpendicular to the Andrews plane (Fig 2). Based on this reference and using the program tools, we angulated the incisors and canines using 4 different prescriptions used in the Straight-wire technique (Table 2). Each tooth was angulated in accordance to the desired value, with the LA point as its center of rotation. Whenever when angulating a tooth it overlapped its adjacent tooth, we moved them until their points of contact were reestablished.

Table I

Table II

Figure 2

After obtaining these virtual models and using the AutoCad 2000 Linear Dimension tool, we measured the greatest distance between the crowns and between the root apices of the upper canines in order to obtain the perimeter of the upper dental arch, for crowns and roots.

4. Results

4.1 Perimeter of the superior dental arch (crowns)

The values obtained are shown in Table 3. The upper anterior perimeter obtained for the non-angulated superior upper anterior teeth (52.396mm) was considered as a reference. Different values were obtained for the prescriptions analyzed, maintaining a relationship with the increase in the total angulation for the front teeth. In this way the perimeter changed to 53.099mm using the MBT prescription (4°,8°,8°), with an increase of 0.703mm. Using the Capellozza (5°,9°,8°) and Andrews (5°,9°,11°) angulations, the perimeters totalled 53.190mm and 53.460mm, with increases of 0.794mm and 1.064mm respectively. The last prescription analyzed was Roth's (5°,9°,13°), which produced an increase of 1.114mm to a perimeter of 53.510mm. The effect of the different angulations on the position and relation of the teeth can be seen in Figure 3.

Table III

Figure 3

4.2 Perimeter of the superior dental arch (roots)

The values obtained are shown in Table 4. The upper anterior teeth perimeter obtained for superior canines and incisors (43.674mm) with no angulation was used as a reference. Different values were obtained for the different prescriptions we analyzed, retaining a relation with the increase in the total angulation for the front teeth. In this way the perimeter changed to 50.003mm using the MBT prescription (4°,8°,8°), with an increase of 6.329mm. Using the Capellozza (5°,9°,8°) and Andrews (5°,9°,11°) angulations, the perimeters totaled 50.229mm and 52.513mm, with increases of 6.555mm and 8.839mm respectively. The last prescription analyzed was that of Roth (5°,9°,13°), which produced an increase of 10.404mm to a perimeter of 54.078mm. The effect of the different angulations on the position and relation of the teeth can be seen in Figure 3.

Table IV

5. Discussion

The mesiodistal angulation influence in arch perimeter has already been discussed, especially after the introduction of the Straight-wire technique where this tooth position was built into the bracket. This seems to be particularly important for the upper anterior teeth, where the greatest amount of angulation is concentrated. This was recognized by Andrews², who admitted that the angulation of other teeth would have limited or no effect in the dimensions of dental arches. Such differences can be justified by the shapes of the mesiodistal surfaces of the crowns in the contact points.

The results obtained in this study provide evidences that there is a direct relationship between angulation introduced to superior canines and incisors and the arch perimeter. The greater the angulation applied to these teeth, the greater the resulting arch perimeter. This

conclusion is valid both in terms of evaluating crowns as well as roots, but the sizable difference observed at these different levels requires further discussion apart on the results obtained.

If we observe the values obtained for the coronary perimeter with an increase in angulation (Table 3), we can note slight increases. This coincides with the results obtained by Andrews², who described an increase of 0.8mm when he analyzed the influence of angulation of the superior incisors, following his prescription, on the arch perimeter. This can be considered very similar to our results, only slightly higher (1.065mm) due to the inclusion of the canines, when this prescription was evaluated. In the absence of more data in the literature, it does not seem unreasonable to assume that by angulating the crowns of the superior incisors and canines one would create moderate demand for additional space. In order to obtain a more exact idea of this possibility, the maximum tested angulation (Roth), which is 52° for the six superior front teeth, means an increase of 1.114mm when compared with the zero angulation used as reference, and 0.882mm when compared with the angulation advocated by Edgewise (22°). It seems obvious to admit that these values can vary depending on the shape of the teeth evaluated, as the more rectangular they are the more space is required for their proper angulation.

When investigated at the root level, the values found for the increase in perimeter as a consequence of an increase in angulation are very expressive. In order to enable a comparison to be made, the maximum tested angulation (Roth), which is 52° for the six superior front teeth, signifies an increase of 10.404mm when compared with the zero angulation used as reference in this work, and 6.650mm when compared with the angulation advocated by Edgewise (22°). Compared with that described in the case of crowns, this means a demand for space that is nearly ten times greater in the root area. The article that compared the increase in the unilateral length of the dental arch, from the apex of the central superior incisor to the apex of the mesial root of the first superior molar¹³, using as its reference the MBT angulation (20° for incisors and canines on one side of the arch), found an increase of 1.8mm when compared with the Andrews prescription (25° for incisors and canines on one side of the arch) and 3.2mm when compared with the Roth prescription (27° for incisors and canines on one side of the arch). These results, when compared with those obtained for crowns in this present article reaffirm a demand for a much greater space. In order to understand this in its true sense, other considerations need to be made.

The need for space created by the increased crown angulation is simple to understand. Figure 3 shows the movement each tooth would present when angulated. Although this demand for space is small, it is nevertheless significant considering that the occupation of this space becomes an inevitable physical phenomenon. As it was pointed out earlier, the values obtained can vary to a greater extent, the more rectangular the teeth are. This concept is particularly important for treatment of incisor crowding with dental slenderization. In this case, where available space is minimal, it is especially important to avoid wasting it through unnecessary angulations for functional or esthetic purposes. In addition, slenderized teeth tend to assume a more rectangular shape and, as a result, require more space when angulated. Thus, angulating anterior teeth more than they were originally, inevitably means creating additional space demands.

Changes to the perimeter is more complex when the effect of angulation introduced to the anterior teeth is evaluated at root level. The impact at the root level is undeniably greater, as shown by the results available in another publication¹³, and confirmed by this article. To better analyze the significance of these results, it is interesting to consider that the authors of the MBT¹³ prescription suggest, amongst other things, that reduced angulation signifies less need for posterior anchorage. This concept implies that a significant increase in the perimeter caused by

angulation at the root level can be avoided or minimized. Thus, with adequate mechanics and anchorage, dental angulation can be done fully or partially by means of distal movement of the roots in the intra-radicular area, avoiding or minimizing mesial movement of the tooth as a whole. Aside from the inevitable physical occupation of space by the angulated dental crown, the effect of this angulation on the position of the root and the consequent increase in arch perimeter can be controlled. This does however require treatment planning with sufficient anchorage, which at the very least makes this treatment more complex.

From this point of view, it does not seem rational to use prescriptions that have an angulation that is greater than a minimum to position a tooth ideally in esthetical and functional terms. As pointed out before, excessive angulations are unproductive in terms of the esthetic of the smile¹². In the case of function, it seems obvious that a minimum angulation would be that in which the incisal edges are parallel to the occlusal plane and that the canines have sufficient guidance with the lower canines in lateral movements. This rule could be further enhanced using different prescriptions in accordance with contemporary and irreversible individualization of therapeutic goals.

Within this context, we can make certain assumptions. As we know, leveling has a naturally protrusive effect (by flattening the curve of Spee curve and aligning crowdings) and can, as already discussed in this article, be reinforced using brackets with a prescription with mesiodistal angulations greater than those already present in the dental crowns. This effect can be desirable or not, and conclusions can be inferred from it can be very useful. In the compensatory treatment of Class II malocclusions, protrusion is not adequate for the upper arch, therefore a prescription with minimum angulation is needed. This is the concept of the Capellozza¹⁴ prescription where the superior canine has an angulation of 5° and the incisors receive brackets that generate minimum mesiodistal angulation. In the compensatory treatment of Class III malocclusions¹⁵ meanwhile, protrusion is appropriate for the superior arch and absolutely not intended for the lower arch. Thus the brackets of the upper canines have a maximum angulation (11°) and the lower incisors and canines zero angulation¹⁰.

The concept to individualize the bracket prescriptions is supported by this investigation and clinical studies should be carried out to confirm the presence and magnitude of these effects in actual patients.

6. Conclusions

1. The perimeter of the upper anterior region (incisors and canines) depends on the mesiodistal angulations applied to the dental crowns, and there is a clear direct relationship between the increase in the arch perimeter and the increase in angulations, in other words, the greater the sum of angulations, the greater the perimeter.
2. The increases observed at dental crown level, was smaller than that observed at dental root level.
3. Although the extrapolation of these concepts and their implications for clinical practice require care and greater knowledge, it seems essential to consider them in contemporary orthodontic practice.

7. References

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