ARCH FORM- A REVIEW

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Article Received on 12/03/2019  Article Revised on 02/04/2019  Article Accepted on 23/04/2019

ABSTRACT
Dental arch form is one of the most important characteristic of dentition. In orthodontics, diagnosis and treatment planning is crucial to understand each individual dental arch and we try to preserve it throughout the treatment to achieve a higher stability. A well-established coordination between maxillary and mandibular dental arch is important to maintain to have a perfect functional occlusion.

INTRODUCTION
Dental arch form is the arch, formed by the buccal and facial surfaces of the teeth when viewed from their occlusal surfaces. Genetic, developmental, functional, environmental factors and orthodontic treatment have an influence on arch form. Arch form and size are unique for each and every individual. Arch form as a part of a whole dentition is a morphologic pattern of each individual which is controlled by the underlying basal bone and the balance between circumoral and intra oral muscles.

The arch form is important mainly from three points of view: Stability, Occlusion and Esthetics. Researcher and clinicians have accepted the relationship between dental arch form and the stability of the orthodontic result. Reidel (1860)[1], in one of his nine rules for stability have emphasized on the need to maintain the existing arch form for stability, particularly in the mandibular arch. Angle in 1907[2], described his line of occlusion, as one of the criteria for normal occlusion. He described the line of occlusion as “the line with which in form and position, according to type, the teeth must be in harmony if in normal occlusion”. Most patients seek the orthodontist for two reasons, namely the presence of facial disharmony and malalignment of the teeth. More frequently, esthetic is the factor. A good smile, among other things depends on how the teeth are arranged. Teeth arranged in a proper arch no doubt increases the smile value.[3]

The bonwill-hawley arch form was one of the traditional ideal arch forms for many years. In incisor region, it contours a circle with the radius equal to sum of mesiodistal widths of the incisors. From cuspids to molar, it follows a straight line. Edward Angle objected the posterior part and stated that a staright line existed from the cuspids to the mesio-buccal cusp of the first molar, however, there was a natural curvature in the molar region. Chucked noted the variation of human arch form and pointed out arch form can be square, tapered and ovoid. He suggested that the bicuspids regions should be wider than the cuspids to prevent excessive expansion of the cuspal. Studies by Nojima et al[3], Felton et al[6] have revealed that dental arch size was associated with the Angle’s classification of occlusion. Also the shape of dental arches have been correlated with class I, II & III malocclusion in Caucasian and japanese population. The dental arches have been described by various investigators in simple geometric terms such as ellipse, parabola, catenary curve, etc.

In order to determine arch forms and dimensions with the help of arch wires, the appropriate coordinates of labial and buccal dental surfaces that interface with the bracket base must be described. During the era of standard edgewise, most orthodontists customized archwires to each patient's arch form. In the early 1970s when the preadjusted appliance became available, there seemed to be an unwritten assumption that one arch form was appropriate, and it could be used for all cases with the preadjusted system, time has shown that this assumption

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was not correct. Some customizing of the arch form for individual patients is important.[7]

During orthodontic treatment, the inter-canine width can be increased, but many authors found that any change to the lower canine width was unstable. Therefore, the original width has to be maintained to increase long-term stability. In 1995, De La Cruz et al[^8] reported on long-term changes in arch form and they concluded that arch form tended to return toward the pre-treatment shape after retention and that the greater the treatment change, the greater the tendency for post-retention change. They suggested that the patient’s pre-treatment arch form appeared to be the best guide for future arch form stability, but emphasized that minimizing treatment change was no guarantee of postretention stability.

Walter (1962)[^9] and Herberger (1981)[^10], in contrast, found that the width was maintained when inter-canine width was increased by orthodontic treatment. However, the length of the dental arch can be modified by inclining the incisors without varying the inter-canine width.

In 1990s other more complex and advanced methods have also been used that reflect both size and shape changes and provide a more complete description of change in form than the traditional measures. These methods include Euclidean distance matrix analysis, finite element analysis and procrustes analysis. Changes in both size and shape are of interest to orthodontic treatment planning and prognosis.[^11]

**DISCUSSION**

Most orthodontic patients are growing children, knowledge of growth is important in determining the etiology, in outlining of treatment procedures, and in defining of probable outcome of treatment. Arch dimensions change with growth hence it is important to differentiate changes induced by appliance therapy and by growth. According to Scott arch form is determined prior to muscular development and is independent of functional activity of the oral musculature. Moorrees[^12] pointed out that considerable individual variation in arch form will occur with normal growth, with a tendency towards an increase in inter-molar width during change over from deciduous to permanent dentition.

For most individual, maximum intercanine diameter of both arches showed little change after the stage of permanent dentition was attained. In the mandibular arch, increase in this width occurred largely before the eruption of the permanent canine teeth. Width at the deciduous second molars and their successors followed that of the canine teeth, though more individuals showed some decrease in these dimensions.

In adult, whether for male or female the change in arch width and depth decreases, causes for these is unknown, however the changes appear not to occur independently of each other and are not associated with any factor. It is spontaneous that a light consistent force of muscles may cause this arch decreases. The decrease in arch is well explained in equilibrium theory by Profiffi[^13], he noted that tongue pressure is greater than lip pressure during swallowing and at rest. The dental arch form is initially shaped by the supporting bone and following eruption of teeth, by the musculature & intraoral functional forces. Between the tongue and perioral musculature, there is no balance of force.

Changes in the size and shape of skeleton-dento-craniofacial complexes do not cease with the attainment of biologic maturity. Harris[^14] noted that during adulthood arch form change in both male and female they became shorter and broader. Lundstrom made the important observation that these changes in arch form actually occur twice in a person, first in the deciduous dentition and then analogously in the permanent dentition. On examination of the stable phase of the deciduous dentition, from about 3 to 6 years of age, arch length decreases and arch width increases. Due to which, the degree of spacing or crowding typically remains unchanged. These same arch shape changes occur in the permanent dentition, and they appear to develop most rapidly in the teens and twenties.

Dental arch growth is responsible by, both intrinsic, (i.e., genetic) and extrinsic, (i.e., environmental). Both this factors effect timing of tooth eruption, tooth migration, and size of adjacent teeth affect dental arch form as does jaw growth. Most distortion of tooth position (eg., rotations, displacements) are more likely to be controlled by environmental factors. While there are significant familial similarities in arch size, at least half of the phenotypic variation in the sample was due to environmental differences in the study by Cassidy et al.

Change in the arch form show the following findings:
- Male arches grow wider than female arches.
- Lower inter-canine width increases significantly in transition of dentition but doesn’t change in permanent dentition after 12 years.
- Upper and lower inter-molar widths increase spontaneously to a considerable extent between 7-8 years especially in males.
- Little change in arch width in premolar region after 12 years.
- Changes in arch width may not be accompanied by changes in arch length.

Various concepts of arch form have been put forward by different authors, they are as follows:
1. Bonwill’s concept of arch form
2. Bonwill – Hawley arch from
3. Angle’s line of occlusion
4. Catenary curve
5. Brader’s arch form
1. Bonwill’s concept of arch form
In 1885 Bonwill[4] stressed on geometry, physics and mechanics that these are in harmony in the human body. He developed postulates for artificial dentures. Bonwill noted mandible as the tripod shape formed by an equilateral triangle, with its base between the condyles and the apex between the central incisors. The average length of the sides was 4 inches, with a variation of not more than 1/4 inch.

2. Bonwill - Hawley arch form
Hawley in 1903,[4] modified Bonwill’s concept. He recommended that the combined widths of the six anterior teeth serve as the radius of a circle and the teeth be placed on that circle. From this circle he constructed an equilateral triangle with the base representing the intercondylar width.

The radius of each arch varied depending on size of teeth, so the arch dimensions differed as a function of tooth size but the arch form was constant.

This was used as a guide for establishing arch form.

3. Angle’s line of occlusion
In 1906 Angle described line of occlusion that it is “the line of greatest normal occlusal contact”. He again redescribed it in 1907,[21] as “the line with which in form and in position according to type, the teeth must be in harmony if in normal occlusion”.

4. Catenary curve arch form
In 1973 David Musich and James Akerman first proposed Catenometer to measure the arch shape and length. This instrument is a modified Boley gauge with chain incorporated in it.

Schulhoff in 1997 used the same concept to describe the lower arch. Catenary curve is the shape that is formed when a fine chain is suspended from 2 hooks. Shape of the curve depends on the length of the chain and the distance between the hooks for example width of the most distal molars in the arch form.

5. Brader’s arch form:
In 1971 Brader proposed that the geometry of the dental arch form was best represented by a trifocal ellipse, with the teeth occupying the portion at the constricted end of the curve. The trifocal ellipse was pattern after the shape of an egg extremely resistant to collapse and produced stable arch form.

The geometry of the dental arch form is related with the resting forces of the tongue. It was belief in orthodontics that the tongue pressure, the lip and the cheek pressure was equal in magnitude and opposite in direction. This hypothesis was disapproved by Lear and Moorees[15] in the year 1969. They found the tongue pressure was always more than the lip and cheek pressure. Not only pressure but duration of pressure should also be considered. PR=C, where:
P= pressure/unit area
R= radius of curvature of ellipse curve at the pressure site
C= mathematical constant

Considering the circumoral structures as an elastic envelope, the lips and cheeks exert counterbalancing inward tensions against the teeth according to an equation describing forces across the surface of any elastic container, given by : Pi= Pe+T (1/R + 1/R’) where:
Pi= internal +forces.
PC = external forces.
T = Tension of the elastic envelope.
R = Radius of curvature in the horizontal plane.
R’ = Radius of curvature in the transverse plane.

Drawbacks of Brader arch form
- Many clinicians found that this arch form created excessive narrowing in the cuspid region of many patients and led to excessive wear of the incisal portion of the cuspids.
- It fits majority of cases but may not fit in arches which are ovoid or square. In such cases the arch form must be altered accordingly.
- PR=C is a hypothesis and not a theory. Long term studies required for its verification.

Different ethnic groups show variations in the size and shape of the dental arch. In a qualitative survey of the dental arches from Negroid, Mongoloid, Caucasoid, Asiatic Indian and Australian aboriginal skull, has shown that differences exist between these races quite apart from the variation between individuals within the various racial groups.[16]

American blacks have a larger tooth crown dimensions than American whites, but blacks are less likely to exhibit dental crowding rather they have spacing between the anterior teeth. Blacks have larger arch dimensions that provide enough space to erupt of permanent teeth and they exhibit a squarer arch form than whites.

There is a definite relationship between facial form and arch form, leptoprosopic individuals have long narrow arches, euryprosopic individuals have broad and squarish dental arches, and the mesoprosopic individuals have arch forms which fit somewhere between these two and described as average. Different ethnicity show different shape of the face, where the shape of the upper incisors should be in harmony with the shape of the face.

Dolicocephalic head form is commonly seen among Caucasians, and Japanese are mostly Brachycephalic. Which means Caucasian has a tapered dental arch whereas Japanese has broad dental arch. Nojima et al
studied a comparison between Caucasian and Japanese in which they used tapered, ovoid and square arch form. Caucasian showed 44% tapered arch form and Japanese showed 46% square arch form, showing highest among the three arch forms.\[5\]

The success and stability of orthodontic treatment depends on two important factors that are not to be changed during the treatment they are dental arch width and form. It is well demonstrated that increases in dental arch length and width during orthodontic treatment tend to return to its pre-treatment form after retention. The original arch form is considered the most stable position since this is in the balance position of the teeth and surrounding muscles; the neutral zone. In certain cases, where arch development has occurred under adverse environmental conditions, arch expansion as a treatment goal may be tolerated.

Most of the studies have reported that when intercanine and inter-molar width changes during orthodontic treatment both in extraction and nonextraction cases, have a strong tendency to return to their pre-treatment position. Riedel postulated the arch form particularly in mandibular cannot be altered during appliance therapy.

It was noted that relapse of the upper intercanine width was influenced by the degree of pretreatment and posttreatment overjet. Relapse of the lower intercanine width was found more often in cases with severe pretreatment upper crowding, due to which extensive treatment efforts has to be made in upper arch. Relapse of the upper intermolar width was associated with the amount of pretreatment anterior and posterior deficiency, whereas lower relapse was related to the lack of posterior arch width.

Many authors\[6,8\] suggested that patients pre-treatment arch form appeared to be the best guide for future arch form stability, but also said that minimizing treatment change was no guarantee of stability. Because degree of changes observed makes it difficult for the clinician to predict whether it is due to altering or not altering the shape of the dental arch.

It was noted that mandibular intercanine width tends to expand during treatment by 1-2 mm and contracts post-retention by the same amount.

There is evidence to show that intercanine and intermolar widths decrease during the postretention period, especially if expanded during treatment. So maintenance of arch form rather than arch development is necessary.

CONCLUSION
It is generally believed that the arch shape is determined by genetic and many environmental factors such as pressure from soft tissues, shape and position of jaws, alteration in eruptive mechanism and morphology of teeth.

Retention is an important consideration when original arch form is changed during treatment. During orthodontic treatment, increased in the inter-canine width was found to be unstable. Therefore the original width has to be maintained for long term stability.

The clinician cannot use a preformed arch wire, for every patient, because of the individual variation. With the advent of preadjusted brackets, orthodontists have focused more on diagnosis, treatment planning and treatment mechanics rather than on complicated archwire bending. This not only lead to preadjusted brackets selection but even preformed archwire, which has become a more important step in clinical orthodontic practice due to which individualized arch form have been overlooked. So some customization is needed for individual arch form to obtain the optimum stable orthodontic result.

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