Different Torque Prescriptions in Orthodontics

Dr. Somya Sharma
Dr. Poonam Agrawal

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Prescriptions in Orthodontics

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First Impression: March 2023

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ISBN : 978-93-93810-40-3

Rs. 650/- ($18)

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PREFACE

Over last so many years, many substantial contributions were made to the science and art of orthodontics in the form of scientific articles, textbooks and PhD dissertations. In spite of the level of knowledge acquired in their preclinical years, students are unable to recall and relate problems related to their training. This problem is more specific in relation to the changes that have occurred during time.

This book is a modest attempt to provide information of the change of the torque values over time in a logical format. This is a basic foundation for the treatment planning in orthodontics.

The contributors to this text have worked hard to present their ideas in a format that is both clear as well as scientific. Reading the work of all these authors have been an education as well as revelation of the depth of their understanding and their abilities.

ACKNOWLEDGEMENT

The author is conscious of the help rendered both directly and indirectly by his teachers, colleagues, friends and well wishers.

The following people need special acknowledgments for their help in bringing out this book.

Dr. Poonam Agrawal, Professor, Department of orthodontics and dentofacial orthopaedics, School of dental sciences, Sharda University, Greater Noida, Uttar Pradesh for her constant support and encouragement throught the author’s postgraduation.

Dr. Dinesh kumar Bagga, Professor and Head, Department of orthodontics and dentofacial orthopaedics, School of dental sciences, Sharda university, Greater Noida, Uttar Pradesh for his guidance and enduring support.

Dr. Rishibha Bhardwaj, Dr. Aartika Singh, Dr.Kanak Priya and Dr.Prashant Shahi author’s teacher’s deserve special thanks for their selfless and constant help in bringing out this book.

Dr. Somya Sharma

Dr. Poonam Agrawal

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Chapter - 1

Introduction

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For better aesthetics, stability and functional occlusal relationship, appropriate buccolingual inclination of anterior and posterior teeth is necessary to give.

Holdway affirmed: ―In attempting to treat for apical base reorientation, as has already been pointed out, keeping a good labial axial inclination of the upper incisors should be one of our objectives‖. This is helpful as mere lingual tipping movement of these teeth will not have a marked reduction in the angle SNA as compared to the bodily retraction of these teeth.

Torque force is called as per the action on the tooth crown. There is lingual torque and labial or buccal torque. In the lingual torque, the crown of the tooth will be tipped lingually and the roots labially or buccally, and labial or buccal torque, in which the crown of the tooth is tipped labially or buccally and the roots lingually.

Torque is defined as the labiolingual or bucco-lingual inclination of the tooth position. Torque, moment or moment of force is the propensity of a force to rotate an object about an axis, fulcrum, or pivot. Mathematically, torque is defined as the cross product of the force and lever-arm distance, which tends to produce rotation.

The torque is denoted as τ, the Greek letter tau. As it is called moment, it is commonly termed as M. The amount of torque is dependent on three quantities:

a. The appliedforce.

b. The length of the lever arm connecting the point of force application to the axis.

c. The angle among the force vector and the lever arm. In symbols: in which,

$\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F}$ $\tau = \|\mathbf{r}\| \, \|\mathbf{F}\| \sin \theta$

- ‗τ' is the torque vector and ‗τ' is the magnitude of the torque,
- ‗r' is the displacement vector (a vector from the point from which torque is measured to the point where force is applied),
- F is the force vector,
- θ is the angle among the force vector and the lever arm vector.

The extent of the lever arm is really important; choosing this distance accurately lies behind the working of levers, pulleys, gears, and other simple machines including a mechanical advantage. The SI unit for torque is the Newton metre (Nm).

In orthodontics, torque is engaged to alter the inclination of teeth, particularly the incisors. The amount of change in the buccolingual inclination of the crowns depends on the wire torque stiffness, design of bracket, the wire/slot play, and the mode of ligation used.

Torque is the force that enables the orthodontists to control the movement of the roots of teeth. A force that provides the operator control over the movements of the roots of teeth is called Torque. When the orthodontist does not have a consideration of torque, many negative tooth movements will occur, making orthodontic treatment more difficult and treatment results lessuseful.[1]

Basically, two types of torque are considered.

1. **Passive torque**, when wire is engaged it has no action or force acting on the tooth, a passive torque is present in an arch wire when the torque present in it does not result in torque movement even on full engagement of the wire. The objective of the passive torque is to maintain the already achieved torque.
2. **Active torque**, which has a certain action or force on the tooth when it is engaged. When an arch wire is capable of generating torque movement of teeth in a segment considered as an active torque in an archwire[1].

The clinical assessment of torque is made by drawing a line perpendicular to the dental margin and passing it through the Facial Axis Crown (FAC) of the tooth: the torque is called―positive‖ when the crown of the tooth is in a forward position to the line and the root is in backward position: the ―negative‖ torque will be considered opposite.

In the direction of torque, the crown of the tooth will move and the root of a tooth will be moved in the opposite direction of torque. With the application of an auxiliary force obtained from elastics or other sources, the torque action can be manipulated in either of the way i.e the crown or the root of the tooth can move in whichever direction that operator wants.

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Historical Preview

Dr. Edward .H. Angle (1928)[2]used a rigid stainless-steel wire. He developed a standard edgewise technique in which he incorporated torque into the arch wire by providing a third order bend (torsional bend) into the wire.

Watkin (1933) used a box type of attachment for movement of roots.

In 1938 McKeag and Friel , to induce torque he characterized a box attachment fabricated of stainless steel. This box was called the ―Mckeag box‖.

After 30 years, Dr.P.R. Begg (1956)[3]gave a differential force technique which was established as Begg philosophy. He used Australian arch wire (A. J. Wilcock wire) in this technique, in all the stages. And for torque instead of the torsion of the wire (third order bend), he used different torquing auxiliaries. The force levels will differ according to the number of coils that are used, degree of activation and the dimension of the wire used.

Andrews (1972)[4]completely replaced the theory of incorporating the torque individually by giving his fully programmed bracket system (Straight Wire Appliance-SWA) in which he introduced slot sitting features and also inclined the base of the bracket to decrease the bending of arch wire.

Bass (1975) has examined that this movement can be achieved by putting pressure in a

lingual direction at the gingival margin on the incisors using a double cantilever spring and by using a Sved bite-plane to intercept lingual movement at the incisal edges. Proffit (1986)[5]introduced a force of 75-125 gm that is best for torquing movements. For teeth with small root area,the lower end of the range was considered acceptable, while higher forces would be applicable for teeth with larger roots.

Kesling (1986)[6] merged Angle's edgewise bracket system along with the differential force concept of Begg (Preadjusted Edgewise). This system is not considered as pre-adjusted as SWA but the modification of the horizontal edgewise bracket slot into a propeller slot and the use of passive rectangular wires helped to control the tooth movement in both directions. Similar to Begg philosophy in this system, each bracket requires a torquing auxiliary to achieve the final prescription.

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Chapter - 2

Biomechanics of Torque

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Few terminologies that needed to be understand in detail:

A. Centre of resistance: Centre of resistance is an imaginary point at which the whole object may be considered to be condensed, for understanding and predicting its displacementfrom the application of forces. How a tooth moves will be determined by the relation of its Centre of resistance to the force acting on it.

Each and every object has a Centre of mass. The centre of mass is a point which will allow the free object to move linearly without any rotation if an applied force will pass through this point i.e The Centre of mass is a body's "balance point." (Fig. 1) represents the Centre of mass of a free mass. As the tooth is restrained by the periodontium within a periodontal support system i.e why it is not a free body. The Centre of resistance is related to the centre of mass for restrained bodies and is the equivalent "balance point" for confined bodies[7].

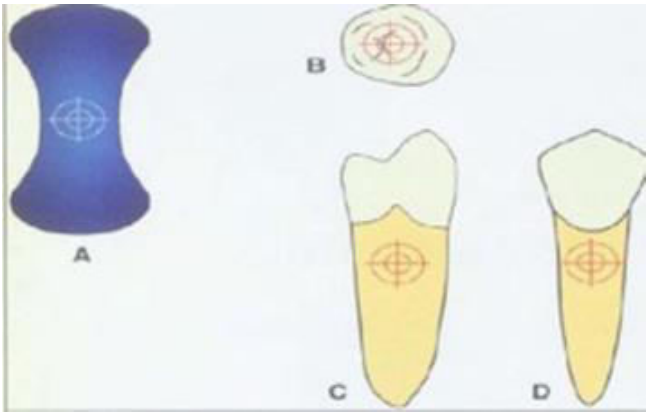

Fig 1:

Centre of resistance. A) Centre of mass of free body. B) occlusal C) mesial and D) frontal views of the Centre of resistance of a single tooth

Fig.B-D shows the estimated location of the Centre of resistance for an individual tooth. The Centre of resistance can be explained in each plane of space. Centre (s) of resistance is present in all single teeth, units of teeth, complete dental arches, and the jaws.

There is some difference of opinion about the precise position of the Centre of resistance for a one rooted tooth (though all authors agree that it is between the alveolar crest and the apex). Proffit and Nikolai estimate it at 50% of root length.

Smith and Burstone stated the centre of resistance for öne rooted teeth lies between 50% and 33% of root length and Nanda between 33% and 25% of root length. The Centre of resistance will be examined not only by the mass of the tooth but also by various characteristics related to the periodontal ligament.

All the authors mostly accepted that in a multi rooted tooth, the centre of resistance is near the furcation point on the root area. The Centre of resistance can be explained in each plane of space. Single teeth, units of teeth, complete dental arches, and the jaws themselves each have Centre (s) of resistance.

The length of the root and root morphology, the no. of roots, and the level of alveolar bone support are responsible for the Centre of resistance of an individual tooth. The accurate location of the Centre of resistance of a tooth is not efficiently recognised.

The Centre of resistance for one-rooted teeth (fig. 2) with standard alveolar bone levels is near about one-fourth to one-third the distance from the cement enamel junction (CEJ) to the root apex[7].

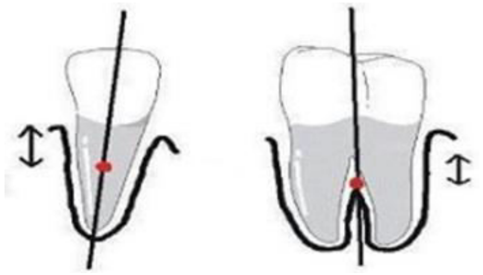

Fig. 2: Centre of resistance of incisor and molar

The estimated centre of resistance for facial bones, (fig. 3) entire teeth arches, or segments of teeth can be determined.

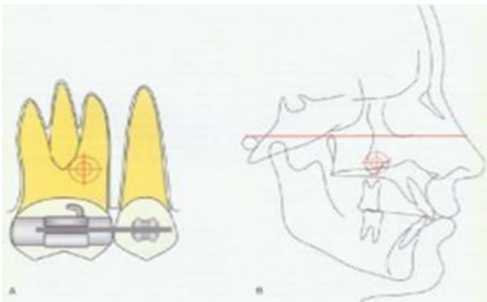

Fig: 3 Centre of resistance for A) two tooth segment and B) a maxilla

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B. Centre of rotation

Application of force couple will result in rotation of tooth around its centre of resistance. Pure rotational displacement, the centre of resistance is the centre of rotation. A combination of movement i.e translation and rotation of tooth will occur when a single force does not pass through the centre of resistance (Fig. 4)[8].

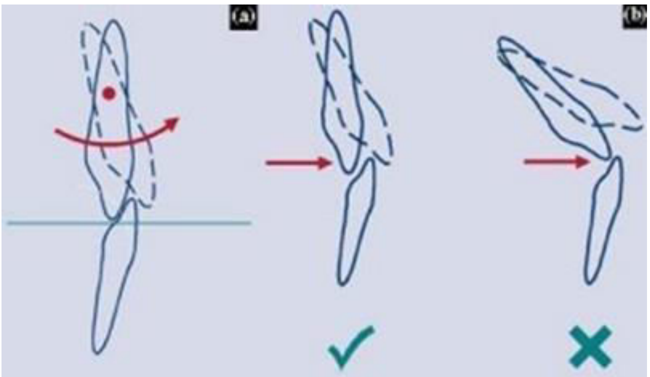

Fig: 4 Centre of rotation

C. Moment force ratio

Rotational movements also occur due to the moment of the force. Rotation that is produced by force is called the moment of the force. It is obtained by multiplying the magnitude of the force by the perpendicular distance of the line of action to the centre of resistance (Fig. 5). The line of action around the centre of resistance toward the point of origin will evaluate its direction. The measurement unit of moments are in gram-millimetres (Newton millimetres). To develop effective and efficient appliance designs in clinical orthodontics, awareness of the moment of a force is important which is often not recognized in clinical orthodontics[7].

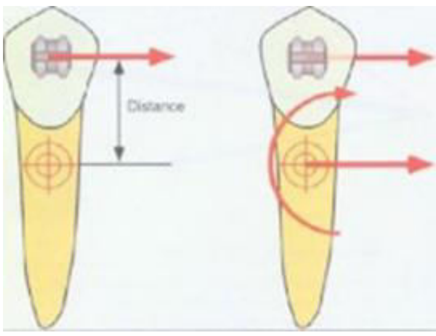

Fig. 5: Moment of a force

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Rotational movement as well as linear movement will be produced when force does not pass through the centre of resistance.

The magnitude of the force and the distance are the two variables that determine the magnitude of the moment of a force. Any of them can be efficiently changed by the clinician to obtain the required force systems.

Types of Tooth Movements

Tooth movement can be explained in different ways;

The number of movements can be differentiated into four types: tipping, translation, root movement, and rotation. Different applied moment and force (in terms of magnitude, direction, or point of application) will result in each type of movement. The correlation amongst the applied force system and the type of movement can be determined by the M: F ratio[9].

Translation

During translation, all points on a mass move in the same direction and with the equivalent magnitude (Fig. 6). The centre of rotation is effectively at an infinite distance away from the tooth because there is no rotation[8].

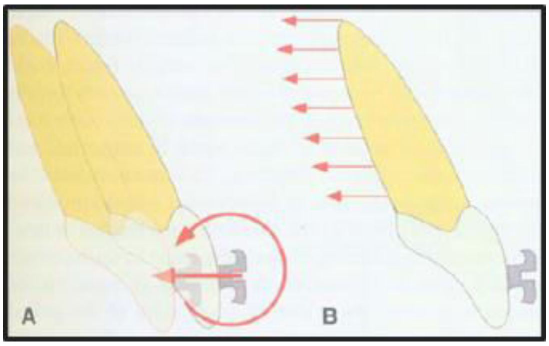

Fig.6: Translation. A) Translation or bodily tooth movement. B) Stress pattern in the periodontal ligament with translation. Uniform stresses occur throughout the periodontal ligament.

Rotation (pure)

Pure rotation occurs when a body (fig. 7) rotates about the centre of resistance (i.e. when the centre of rotation is at the centre of resistance)[8].

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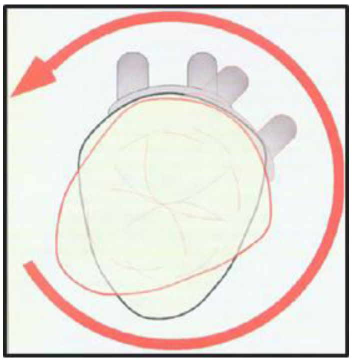

Fig.7: Rotation. Pure occurs around a tooth's centre of resistance.

Tipping

Tipping is movement of a tooth crown while the root apex remains essentially stationary , resulting in an inclination of the axis of the tooth in one direction. The centre of rotation of the motion is apical to the centre of resistance. Tipping can be categorized according to the location of the centre of rotation into

a. Controlled tipping

b. Uncontrolled tipping

Controlled Tipping

Controlled tipping is a required movement of the tooth. As achieved in uncontrolled tipping, the force applied to move the crown and implementation of a moment to conserve the position of the root apex. Figure 8 shows the centre of rotation present on the root apex with tipping movement. For controlled tipping a moment/force ratio of 7: 1 is usually required. (fig. 8)[8].

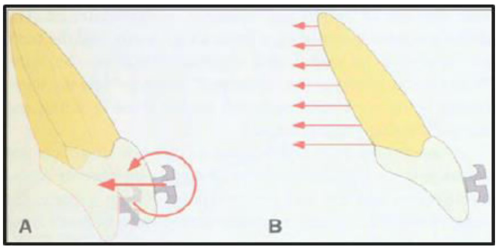

Fig.8: Controlled tipping. A) Controlled tipping with the centre of rotation at the root apex. B) Stress pattern in the periodontal ligament with controlled tipping. The stresses are greatest at the cervical margin.

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Uncontrolled Tipping

Movement of the crown and root apex in opposite directions will result due to a single, horizontal, lingually-directed force at the level of a bracket. This is the easiest type of tooth movement as the tooth's crown simply needs to be pushed or pulled, but it is usually unwanted. It is generally called uncontrolled tipping. Greatest stresses are created at the root apex and crown. These stresses are nonuniform. For uncontrolled tipping movement of the tooth the moment/force ratio is 0:1 to 5: 1. In few cases uncontrolled tipping can be, such as with Class II, Division 2 and Class III malocclusion patients where the extensively upright incisors need to be flared (Fig. 9)[8].

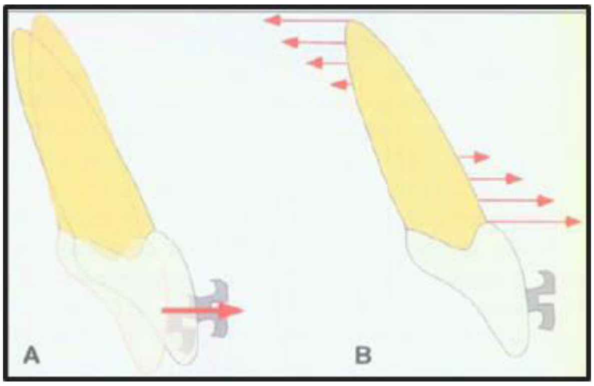

Fig. 9: Uncontrolled tipping. A) Uncontrolled tipping produced by a single force (no applied moment). B) Stress pattern in the periodontal ligament. The root apex moves in the opposite direction from the movement of the crown.

Root movement

Root movement is defined as change in tooth's axial inclination by the movement of the root apex and holding the crown in place (Fig. 10). The incisal edge or bracket is considered as the centre of rotation of the tooth. Root movement will occur with a M/F ratio of 12:1 or greater. (Fig. 10) depicts the stress distribution in the periodontium with this type of tooth movement. For tooth movement to occur in this area the stress levels in the apex area require notable bone resorption. A significant decrease in the rate of movement will result due to the concentration of stresses that may produce undermining resorption. This slower speed of root movement can be used greatly to increase anchorage. "Torque" in orthodontic treatment is described as the root movement.

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Rotation is caused as a result of application of force called Torque. Torque is also termed as the placement of twists in a rectangular wire or the angle of the bracket slot with the long axis of the tooth and the occlusal plane.

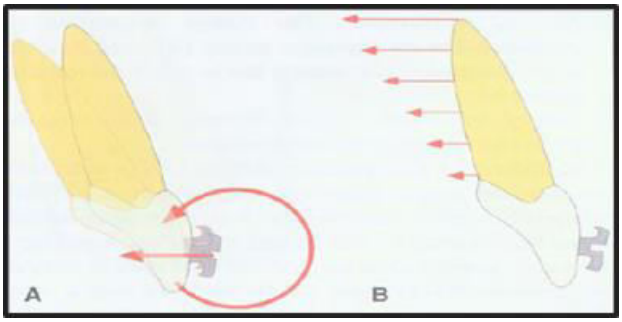

Fig. 10: Movement of root. A) Root movement with centre of rotation at the incisal edge. B) Stress pattern in the periodontal ligament with root movement. At the apex the stresses are maximum

It is evaluated by calculating the angle of the degree of twist placed in the wire. Angular measurements are a poor signifier of the mechanical characteristics of the spring design or the stresses that influence the tooth movement. Slot size, wire dimension, amount of play between the two, as well as the actual tooth position are the factors on which the torque magnitude is dependent. As an example, a 0.018" x 0.025" wire has 17° of torque for four maxillary incisors and gives no indicator of the magnitude of the moment or the measurable stress placed on teeth [8].

D. Couple System

The moment of a couple is one of the other methods of achieving rotational movements (Fig. 11). A couple is two parallel forces of equivalent magnitude placed in opposite directions and isolated by a distance. The magnitude of a couple is evaluated by multiplying the magnitude of force(s) by the distance between them; the units are also in gm-mm. The direction of either force around the centre of resistance to the origin of the opposite force will determine the direction of the rotation. Couples outcomes in pure rotational movement about the centre of resistance nonetheless of where the couple is applied on the object (Fig. 11). Couples are called the applied moment in orthodontics. Torque is a common synonym for moment (both moments of forces and of couples)[9].

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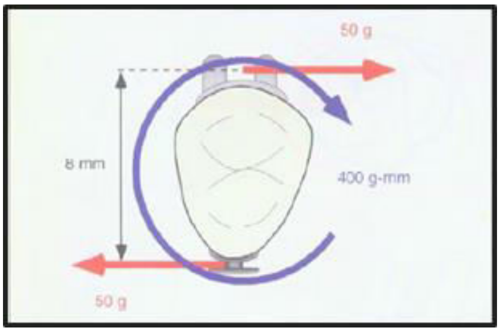
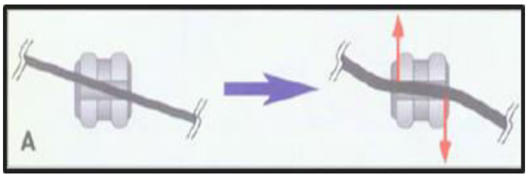


Fig. 11: Moment of a couple. A couple produces pure rotation about the centre of resistance.



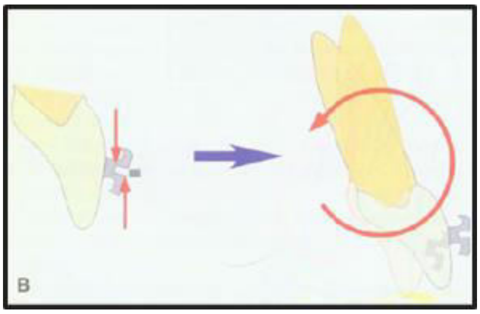


Fig. 12: In angulated bracket wire is engaged

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Chapter - 3

Factors Affecting Torque in Orthodontics

The factors affecting torque can be broadly classified under various headings:

Shape of the wire:-

Square and rectangular wires are used after rotations have been corrected. Square and rectangular wires are quite a bit stiffer in both planes of bending; therefore, the square and rectangular wire will help in levelling the bracket slots. Most of the rectangular wires are used initially after leveling and for their torsion attribute. It is used usually to "torque" roots that tip in all three planes of space. The transition of changing arch wires from the round more resilient wire to the square or rectangular stiffer wire. No torque or little torque will be exerted as any square or rectangular wire apart from one that almost completely fill in the slot and seated in the brackets because of the freedom of rotation the smaller square and rectangular wires have when seated in the 0.022 x 0.028 slot; i.e There is from 10° to 31.5° of rotational freedom between the square or rectangular wire and the 0.022 x 0.028 slot in a range of wires from 0.016 x 0.016 (31.5° freedom) to 0.018 x 0.025 (10.0° freedom)[10].

Size of the wire:-

With the thicker wire, i.e. 0.018, 0.022, 0.025 in the horizontal plane, without any twist present in the wire itself there will be a much greater ability to "torque. An example is any difference of torquing ability in the 0.017 x 0.017 and the 0.017 x 0.025. The change of torque freedom is from 21.3° to 12.6°; therefore, choosing the thickness of the edgewise plane of the wire will alter the torsion effect of uprighting roots a significant amount[11]. Square and rectangular wires are used initially for their torsion characteristic, yet 0.016 x 0.016, and 0.017 x 0.017 square wires are used for their levelling capabilities.

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EFFECTIVE TORQUE – .018 SLOT range .0182 - .0187 Nominal .01845										
Wire size	Play (degrees)	Effective torque (degrees) for various bracket torque angles								
		1°	3°	7°	10°	11°	17°	22°	25°	30°
.016 x .016	16.7°	0°	0°	0°	0	0	0.3°	5.3°	8.3°	13.3°
.016 x .022	9.3°	0°	0°	0°	0.7°	1.7°	7.7°	12.7°	15.7°	20.7°
.016 x .026	7.3°	0°	0°	0°	2.7°	3.7°	9.7°	14.7°	17.7°	22.7°
.017 x .017	8.2°	0°	0°	0°	1.8°	2.8°	8.8°	13.8°	16.8°	21.8°
.017 x .022	5.4°	0°	0°	1.6°	4.6°	5.6°	11.6°	16.6°	19.6°	24.6°
.017 x .025	4.5°	0°	0°	2.5°	5.5°	6.5°	12.5°	17.5°	20.5°	25.5°
*.018 x .018	3.2°	0°	0°	3.8°	6.8°	7.8°	13.8°	18.8°	21.8°	26.8°
*.018 x .022	2.4°	0°	.6°	4.6°	7.6°	8.6°	14.6°	19.6°	22.6°	27.6°
*.018 x .025	2.0°	0°	1.0°	5.0°	8.0°	9.0°	15.0°	20.0°	23.0°	28.0°

Table 1: Effective torque - .018 slot

'Play' is defined as the angle of freedom of the wire within the bracket slot, and the play will be increased with the difference in size between the arch wire and the slot. To transfer third-order information to the tooth, the arch wire should come into contact with the walls of the slot and then go through further torsion, causing a force couple through which a moment, or torque, is generated.

EFFECTIVE TORQUE – .022 SLOT Range .0220 - .0225 Nominal .02225										
Wire size	Play (degrees)	Effective torque (degrees) for various bracket torque angles								
		1°	3°	7°	10°	11°	17°	22°	25°	30°
.016 x .022	27.4°	0°	0°	0°	0	0	0°	0°	0°	2.6°
.016 x .026	20.0°	0°	0°	0°	0°	0°	0°	2.0°	5.5°	10.0°
.017 x .017	Rotates	0°	0°	0°	0°	0°	0°	0°	0°	0°
.017 x .022	22.3°	0°	0°	0°	0°	0°	0°	0°	2.7°	7.7°
.017 x .025	17.7°	0°	0°	1.6°	0°	0°	0°	4.3°	7.3°	12.3°
.018 x .018	31.8°	0°	0°	0°	0°	0°	0°	0°	0°	0°
*.018 x .022	18.4°	0°	0°	0°	0°	0°	0°	3.6°	6.6°	11.6°
*.018 x .025	14.8°	0°	0°	0°	0°	0°	2.2°	7.2°	10.2°	15.2°
*.019 x .025	10.5°	0°	0°	0°	0°	5°	6.6°	11.5°	14.5°	19.5°
.021 x .021	5.0°	0°	0°	2.0°	5.0°	6.0°	12.0°	17.0°	20.0°	25.0°
.021 x .025	3.9°	0°	0°	3.1°	6.1°	7.1°	13.1°	18.1°	21.1°	26.1°
.0215 x .025	2.3°	0°	7°	4.7°	7.7°	8.7°	14.7°	19.7°	22.7°	27.7°
.0215 x .028	2.0°	0°	1.0°	5.0°	8.0°	9.0°	15.0°	20.0°	23.0°	28.0°
.022 x .022	1.8°	0°	2.0°	6.0°	9.0°	10.0°	16.0°	21.0°	24.0°	29.0°

Table 2: Effective torque - .022 slot

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The 0.022 inch system in the clinical situation has some mechanical advantages, for an example as during sliding mechanics when a 0.019×0.025″ SS arch wire is used, however, 0.018 inch system appears to be superior in the amount of the couple it is able to express, when a 0.017 × 0.025″SS arch wire is engaged. The torsional play of a 0.017 × 0.025 inch arch wire in 0.018 inch systems could be mathematically evaluated at about 4 degrees and the double amount for a 0.019 × 0.025 inch in the 0.022 slot.

0.016 × 0.022 wires in 0.018 slots provide better torque control than 0.018 × 0.025 in 0.022 slots. Another advantage of 0.018 slots is most of the practitioners use 18 inch wire in 0.018 slots, whereas 21 or 22 inch wire may never be used with 0.022 slots. For the arch wire to be removed and reinserted so play between the arch wire and the arch wire slot is needed. An accurate 0.018×0.025-inch arch wire is a very precise fit in an accurate 0.018×0.025-inch slot.

In the 0.022" slot, the slope of 10° with a 0.019"x0.025" arch wire must be prevented by adding torque (10°- 15°) into the arch wire for employing complete built in prescription.

These slots have certain advantages in choice of alignment wires during levelling and aligning. 0.022" slots are made for sliding mechanics which are demonstrated to be more systematic in space closure.

Materials used in arch wire

Material such as nickel titanium (Ni-Ti) Alloys which have a low modulus of elasticity, resulting in decreased torque expression compared to stainless steel. Taking reference from recent publications stating that alloys such as Ni-Ti and beta-titanium (β-Ti) with reduced modulus, with only a fragment of the stiffness of stainless steel wire, may be unproductive in transferring a torque moment within a bracket slot. Commonly, 1.5 to 1.8 times the torque of TMA is produced by steel wires and about 2.5 times the torque of Ni-Ti at 24 degrees[12].

Bracket materials

Clinical concerns are however minimized with increased appliance stiffness in ceramic brackets and fibre reinforcement of plastic-polycarbonate appliances. polycrystalline

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Brackets have a lesser mean fracture strength than monocrystalline ceramic brackets. Even though the fracture resistance of ceramic brackets seems to be sufficient for clinical use, the mean fracture strength of ceramic brackets is less than that of metal brackets during lingual root torquing of the central incisors. Ceramic brackets will break under loads that are visibly deform but metal brackets do not break.

Bracket design

Bracket design plays an important role in load deformation. The major factors related to bracket integrity are:

1. **Point of force application:** In a study by Flores[12] and colleagues, placement of force on both sides of the ceramic bracket as opposed to only one side in a report by Holt[13] and colleagues rendered the bracket less vulnerable to fracture by dividing the force between the mesial and distal wings. Gunn[14] and Powers found that varying the location of the applied load could lead to differences in the load at failure and the location of failure. Bracket design was one of the reasons cited for this variability.

2. **Bracket size and wing type:** The force needed to permanently deform a regular twin metal bracket is greater than that required for a miniature twin, modified twin, or single-wing bracket. The reason is that a larger bracket will dissipate the forces over a larger area, thus reducing the stress at any given point.

3. **Slot size and design:** The slot shape is partially responsible for the load deformation behaviour of a bracket. Contact between the wire and bracket slot will be greater in brackets with a narrower slot and sharp edges, compared to brackets with a wider slot and rounded edges. Because the wire fits more loosely in the wider slot, there is a much smaller area to withstand the applied force, and more stress is transmitted to the bracket wings[15]. Slot torque also has a significant effect on the force required to permanently deform metal brackets. Brackets with wider slot angles have less material volume to resist the applied force, resulting in greater local stresses.

4. **Metal slot augmentation:** Metal augmentation of plastic bracket slots seems to reinforce the matrix to the extent that comparable torque can be applied as with metal brackets[16].

5. **Vertical slot:** Aknin[16] and colleagues found that the ceramaflex straight-edge bracket fractured exclusively at the incisal edge. They attributed this weakness to the vertical slot.

6. **Stalk-base junction:** A 90° stalk-base junction angle can contribute to stress concentration, leading to bracket failure at that site[17].

Edge bevel

Beta titanium segments show largest edge bevels due to the mechanical and wire properties of this alloy. The value of torque exerted by the wire bracket fusion for a rectangular wire in a rectangular molar tube will be affected by the amount of edge bevel on the wire. (fig 13).

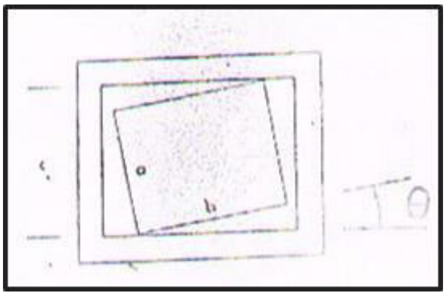

Fig: 13 Edge Bevel

Bracket height

The position of brackets on the crown evaluates the tooth's last tip, torque, height and rotation. Poorly positioned brackets result in imperfectly positioned teeth and require much more arch wire adaptations. This will result in an increase in treatment time or final occlusion that is less than perfect. Alteration in the torque values built into the appliance results due to errors in the vertical dimension.

Mode of Ligation

Arch wire is maintained in the slot by steel ligature or elastomeric modules. Elastomers are polyurethane, an elastic polymer that contains urethane linkage. However a

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supplementary source of torque control loss is the force loosening of elastomeric ligatures. Louis in 1997 showed elastomeric modules had a force degradation of 70% during the first 24 hours. The use of steel ligation would be effective in maintaining the arch wire in the slot to achieve good torque control.

A supplementary source of torque control loss is the force loosening of elastomeric ligatures that represents the reduction of force magnitude which is required to maintain a fixed strain. The elastomeric ligatures have an initial exponential decrease of about 40% in the first 24 hours due to the force degradation pattern. As a result, the engagement of the wire to the slot is malleable and deficient.

Inter bracket distance

As lingual appliances have significantly shorter anterior inter bracket distances (fig. 14) than labial appliances therefore an arch wire will act three times as stiff in 1st- and 2nd-order bends and about 1.5 times as stiff in 3rd-order bends. With this in mind, The lingual orthodontist can adjust arch wire flexibility during the initial alignment and final detailing stages of treatment.

Fig:14 Shorter interbracket distance

Surface conditions:

Ceramic brackets are less tolerant of surface flaws than metal brackets are. Scratching drastically reduces the fracture strength of ceramic brackets, but increases the fracture strength of metal brackets, possibly due to a work -hardening effect. Surface flaws can also contribute to variability in the range of torque, load at failure, and location of failure.

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Loop design:

The two factors that determine the torsional stiffness of a looped wire are the wire cross section and the loop geometry. Increasing the quantity of wire in the mesiodistal section of the loop and increasing the diameter of the apex will increase the loop's torsional workability. Clinically, to reduce torsional stiffness for anterior retraction, the T-loop (fig. 15) and the reverse closing loop are the best designs; to increase torsional stiffness, the Bull loop (fig. 16) is ideal.

Fig 15: T loop

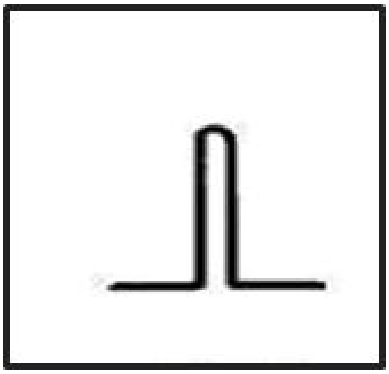

Fig 16: Bull Loop

Tooth morphology

For an optimal occlusion of teeth, an important feature is the variability in tooth morphology. Taking an example, the association of the bracket slot to the occlusal plane depends on the variability of the labial and/or lingual surfaces of crowns. The occlusion of the mandibular incisors is affected by the shape of the lingual surface of maxillary incisors. Crown-to-root angulation of maxillary central incisors may restrict the degree to which the roots of these teeth can be torqued lingually when related to the maxillary lingual cortical plate of bone.

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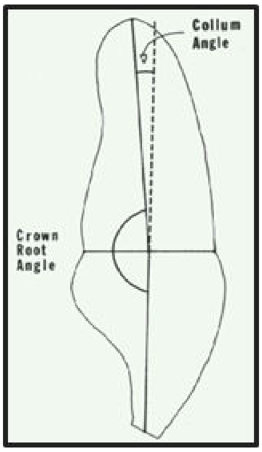
Collum angle

Bentley[18] defines the variation of the long axis of the crown to the long axis of the root as Collum angle (1.8° to 4.2°). The variation between the long axis of the crown and the long axis of the root results in the different root positions with constant crown positions even when the facial surface contours were constant. In 1973 Carlsson and Ronnerman[19] found the column angle of the central incisor to vary in a range of 17.5° with a SD of ±4.2°(fig 17).



Fif 17: Collum Angle

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Chapter - 4

Methods of Measuring Torque

 ISBN: 978-93-93810-40-3

1. Creekmore template:

Incisor torque template can be used to measure the torque angle of the labial surface of maxillary and mandibular incisors relative to the arch wire plane. The evolution and classification of a system to differ the adaptation of the bracket archwire slot with the labial surface of each tooth eventually results in a solution to these problems. Even with the accuracy or inaccuracy of bracket placement and the fact that brackets are situated away from the centre of resistance, orthodontic appliances have two supplementary significant mechanical deficits;

1. Play present between the arch wire and the archwire slot,
2. And force reduction

These deficiencies cannot be eliminated from current appliances; however, they can be reduced by using comparably stiff arch wires compared to the size of the arch wire slots. The amount of play plus the amount of force reduction inherent in your appliance can be added or reduced from the torque, tip, rotation, and height parameters for each bracket to obtain the desired tooth positions. Hence, desired treatment goals can be achieved with highest effectiveness[20].

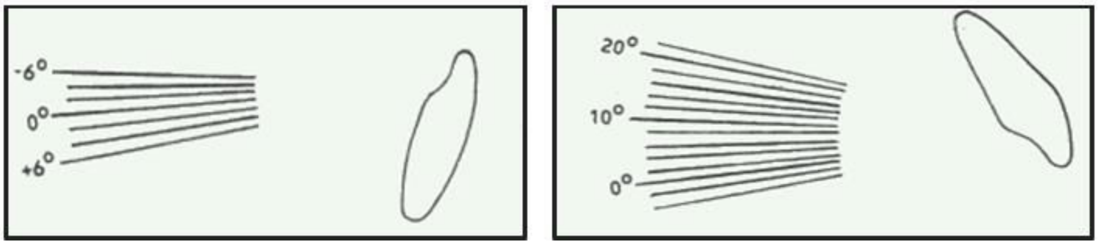

Fig :18 and **Fig:19 -** Creekmore template

2. **Tülin Ujur and Filiz Yukay**

The angle between the tangent that passes through the bracket point and the occlusal plane is necessary to measure such an angle. This angle is called the facial surface angle. It is believed that the quantity of each twist is related to the angulation of that portion of the tooth surface lying directly beneath the bracket. Thus, based on the speculation that brackets are placed at 90° on the crown surface, the torque value can be evaluated by subtracting 90° from facial surface angle (fig. 20).

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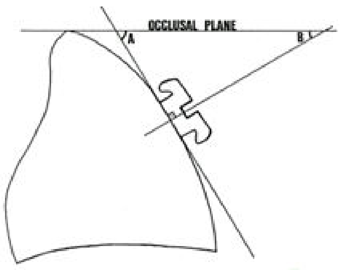

Fig:20 Angle between the tangent that passes through the bracket point and the occlusal plane.

3 . Tooth Inclination Protractor (TIP)

Gauges used to calculate the incisor inclination and vertical jaw relationship directly from the patient, or from study models, have been explored as a form of evaluation substitute for radiographs. Estimates related to orthodontics were taken straight from the face by Salzmann[21] (1945) using a device known as the maxillator. This was considered as the most useful for measuring the Frankfort–mandibular planes angle (FMPA) and LIA. The labial face of the crown is an easiest method to visualize for measuring incisor inclination.

The angle of the face of the incisor to the Frankfort plane is not the true axial inclination of the tooth crown; neither does it take into thought the effects of crown/root angle upon the long axis of the whole tooth. Fredericks (1974) compared the angle between a tangent to the labial face of an upper incisor, measured on both extracted teeth and patients, with actual UIAs on radiographs. The difference was 23.9 degrees on extracted teeth and 24.1 degrees on patients, an encouragingly high level of agreement. Tebbett(1990) used standardized photographs to calculate the most aesthetic labial face inclination of the upper central incisors.

The ideal was 90 degrees to the maxillary plane, 19 degrees less than the standard radiographic UIA (Hamdan and Rock[22], 2001). Richmond[23] et al. (1998) used a tooth inclination protractor to obtain measurements of incisor inclination from study models. Upper incisor inclination showed better correlation with values taken from cephalometric radiographs than did lower incisor inclination. Richmond and Jones (1985) and Richmond (1987) had previously used a reflex metrograph to build up a

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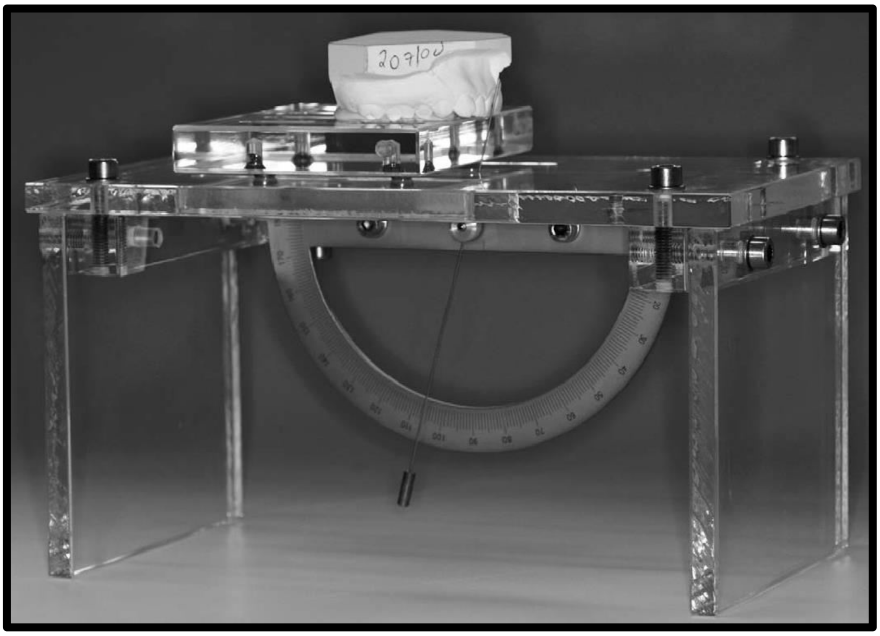
three-dimensional image of a study cast and from it measured incisor inclinations to the functional occlusal plane. Values obtained from study models and those measured on radiographs were evaluated and significant differences were found. N. Shah et al created a jig and tested it to calculate the inclination of the upper and lower incisors to their particular planes.

To record the inclination of the maxillary and mandibular incisors on dental casts, the Tooth Inclination Protractor (TIP) was advanced. This device is made up of a perspex platform with a typical 180-degree protractor supported below.

To receive a hollow stainless steel tube consisting of a retractable wire of 0.5mm inserted into it, the platform was perforated.

The wire could be extended or shortened to lie against the labial surface of the incisor allowing for anatomical variation in crown height. Below the platform the other end dental casts.

To make the area above and below equal, the wire pointer was placed against the labial surface of the upper and lower incisors at their greatest bulbosity. The inclination was read off the categorized scale. Assessment of both left and right upper and lower incisor inclinations to the occlusal plane was done (fig. 21).



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Chapter - 5

General Consideration of Torque in Wire and Brackets

 ISBN: 978-93-93810-40-3

Torque Incorporated In Wire

Even before rectangular wire was introduced to the orthodontic field, many orthodontists have attempted to place torquing force on the tooth in order to control root position. Many different methods, such as developing new appliances or techniques with auxiliaries on round wire, have been used to generate torquing force efficiently.

Torque itself is merely the twisting of the edgewise wire. Torque force is created when the wire makes an effort to untwist itself when engaged in the brackets of the mechanism. Because of the anatomic shape of the teeth it becomes impossible to place an edgewise wire in a completely banded arch without first placing proper torque in the wire to make it passive within the brackets.

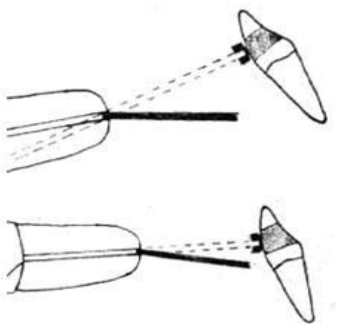

Fig: 22 A.labial torque of the wire but no torque force exerted on the tooth since the wire is parallel to the bracket box. B.labial torque of the wire but lingual torque force is created when the wire engages the bracket of the tooth.

In 1928, the standard edgewise appliance was presented by Dr. Edward H. Angle 6 who made the rectangular wire as a potent torquing force delivery device in orthodontics. He described the duty of the orthodontist as not only controlling the relations of the inclined planes of the tooth crown but also placing their roots in a given normal position with the necessary development of alveolar bone for their support. In his pin and tube appliance, the close fit between the pin on the arch wire and the vertical tube on the band provided axial control in all directions. Tooth movement in three planes of space had become easier and could be performed more efficiently by using twisted rectangular wire.

When torquing force on a rectangular wire within a bracket is generated by twisting, there must be a certain 2 degrees of freedom of rotation until it binds with the inner

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surface of the lumen. This freedom of rotation could be expressed as "play", deviation angle or deflection angle. This deflection angle seems to have become more important since the straight-wire appliance was introduced to orthodontics by Dr. Lawrence F. Andrew in 1972. In rectangular wire torque is incorporated by using a permanent twist in arch wire , whereas in a round wire torquing auxiliaries are used to deliver third order couples to anterior teeth.

Torque In The Base Vs Torque In The Face

Torque in base was an important issue with the first and second generation pre-adjusted brackets, because level slot line up was not possible with brackets designed with torque in face.

Torque in the base is said by Andrews to be a prerequisite for a fully programmed appliance- that is, one that produces acceptable results without arch wire bends, assuming the brackets are placed correctly.

Albert H Owen in 1980 conducted a study comparing Roth prescription and the Vari-simplex discipline appliance of alexander concluded that while torque in the base had a sound theoretical basis, its effectiveness is greatly influenced by the clinician’s success in accurately placing the brackets.

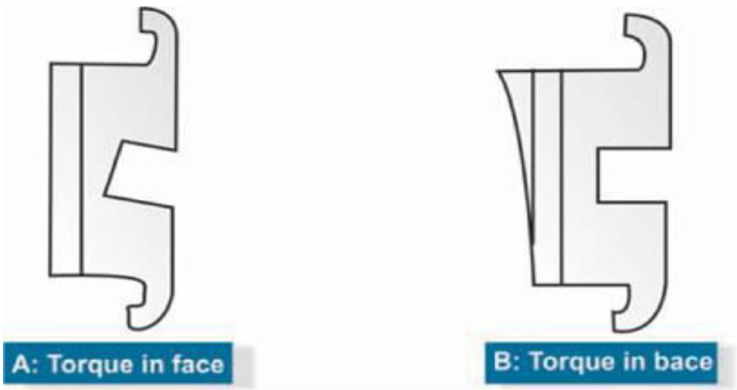

Fig:23 Torque in face and torque in base

The torque in base means that the bracket stem is parallel and coincides with the long axis of the bracket slot. The torque in the face slot is cut at an angle to the bracket stem. The long axis of the slot does not coincide with the bracket system.

ISBN: 978-93-93810-40-3

Chapter - 6

Torquing Auxiliary

 ISBN: 978-93-93810-40-3

The most popular with orthodontists practicing the Begg light wire technique is still the four-spur type auxiliary. This auxiliary is made from 0.012” Premium Plus wire. Auxiliary with two spurs are used in the central incisors that require torque.

Figure 24: Four spur torquing auxiliary,

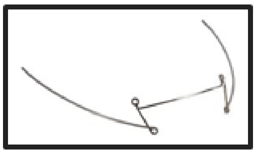

Figure 25: Two spur torquing auxiliary (Von Der Heydtauxillary) torquing auxiliary,

Pre-wound torquing auxiliary/ rat-trap type auxiliary, initially used by Dr Begg in early 1950's. Any size of the wire used in its establishment is simpler to apply and has the possibility to deliver a large force through a greater range of movement than other types of incisor torquing auxiliaries [47].

Kitchton’s torquing auxiliary was delieverd by Dr. John Kitchton, and is accomplished by putting an enormous amount of force. It can be made to include central and lateral incisors, or it can be shortened to torque central incisors only [48].

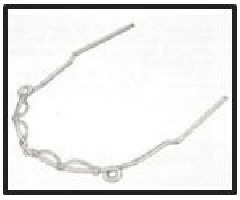

Figure 26: Pre-wound torquing auxiliary

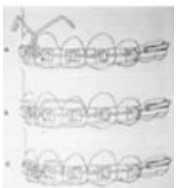

Figure 27: Kitchton’s torquing auxiliary

For any tooth that requires root torque in the labial or lingual direction, the single root-torquing auxiliary given by Kesling is a very beneficial design. It is indicated in case of an upper premolar, which requires buccal root torque to remove the cuspal interference from its hanging palatal cusp [47].

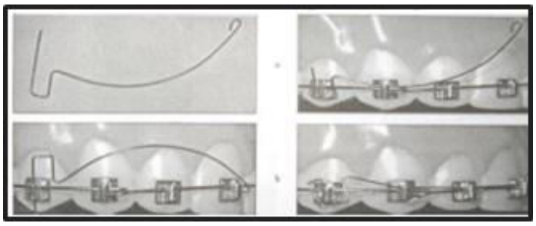

Figure 28 : Single root torquing auxiliary

Reciprocal torquing auxiliary (SPEC design) is used in those cases where two adjacent teeth need root torque in opposite directions. The 'Spec' auxiliary could be used for evaluating the root movements during the first and second stages if made in lighter 0.009" or 0.010" size wires [47].

Franciskus Tan explained the reverse torquing auxiliary for evaluating the roots of canines or premolars design in 1987. It was examined for the labial root movement of a palatally impacted maxillary canine, whose crown has been aligned but the root is placed palatally and requires labial root torque [49].

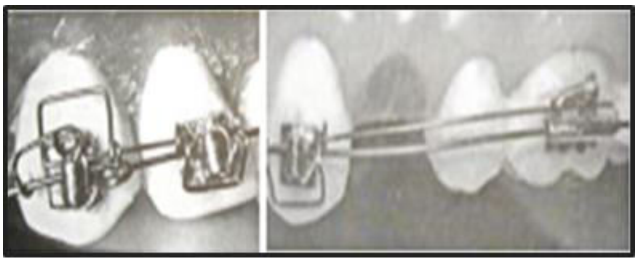

Fig:29 Spec auxiliary with cross-over bends

Activated Tan auxiliary pressing against the incisal portion of canine

Mollenhauer aligning auxiliary (MAA) can be used in crowded teeth and even strives root control from the very beginning, without notably affecting the anchorage and overbite correction. This is completed by using a consolidation of a stiff base arch wire made from 0.018 " Premium plus, and ultra-light root moving forces from the MAA made from the 0.009" supreme grade wire. It can be used after the stage I as the braking

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mechanism by adding more positive torque into the MAA. In growing brachy-facial cases, labial root torque on the lower incisors can be applied to prevent lingual movement of their root. Whereas, in regulating the mesiodistal root position, a ligature wire is tied to the auxiliary and to the pin to transfer the tipping effect to the tooth[50].

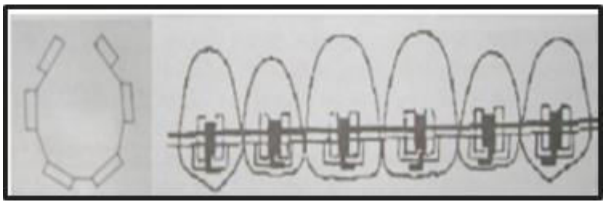

Fig:30 Mollenhauer's Aligning Auxiliary (MAA)

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Chapter - 7

Andrews Straight Wire Appliance

 ISBN: 978-93-93810-40-3

Edgewise appliances were non-programmed appliances. Some of the drawbacks that are present in bracket design in the edgewise appliance are bracket base is perpendicular to bracket stem, bracket bases are not contoured, slots are not angulated, bracket stem were of equal faciolingual thickness, and maxillary molar offset is not built in. Andrew's idea was to develop a bracket in which tip, torque, and in/out was essential accordingly for the required and desired movement of the tooth; the wire bending was not needed[3].

In-out: With the different bracket or tube thickness, the First order bends were removed.

Tip: Built in angulation of bracket slot results in elimination of Second order bends

Torque: By introducing the control mesio-distal crown angulation, the third order bends were removed. Presence of dots on the distogingival wing of the maxillary brackets[24].

Torque in base: For an easy and consistent bracket placement ,the centre of the slot and the centre of the base are always considered on the same plane. Depending on the tooth type, the bases of the brackets are inclined, to attain proper tooth "torque"- the centre of each slot at the same height as the middle of the clinical crown.

Table 3: Andrews prescription for maxillary arch

Andrews	1	2	3	4	5	6	7
TIP	5^0	9^0	11^0	2^0	2^0	5^0	5^0
TORQUE	7^0	3^0	-7^0	-7^0	-7^0	-9^0	-9^0
Crown prominence	2.1mm	1.65mm	2.5mm	2.4mm	2.5mm	2.9mm	2.9mm

Table 4: Andrews prescription for mandibular arch

Andrews	1	2	3	4	5	6	7
TIP	2^0	2^0	5^0	2^0	2^0	2^0	2^0
TORQUE	-1^0	-1^0	-11^0	-17^0	-22^0	-30^0	-35^0
Crown prominence	1.2mm	1.2mm	1.9mm	2.35mm	2.35mm	2.5mm	2.5mm

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Inclination of the base: [25] (+) sign indicates palatal root torque (labial crown torque) values. (-) sign indicates labial root torque (palatal crown torque) values.

Compound contour base: SWA bases are contoured vertically as well as horizontally, resulting in a good bracket-to-tooth fit and a dependable, reproducible location of the bracket slot in relation to the crown for good torque expression.

Bracket placement: Bracket is placed on the FA point on the clinical crown. FA point is present on the FACC (facial axis of clinical crown) and divides the clinical crown into gingival half and incisal half.

Level Slot Line up: The Straight - Wire Appliance is the only appliance that ensures that the slot of the bracket will always be parallel to the occlusal plane of the arch.

Wagon wheel effect: Andrews also highlighted the 'wagon wheel effect' in which the tip was lost as torque was eventually added. Therefore, he chose to add additional tip to the anterior brackets. Addition of 200 torque will negate the tip 5˚. Bracket positioning was based on the centre of the clinical crown.

Roller coaster effect: problems were experiences with treatment mechanics in the primary years, due to the heavy forces and perhaps due to the increased tip in the anterior brackets. Therefore, deepening of the anterior bite, with formation of a lateral open bite, was seen in no. of cases, and this eventually been called as the 'roller coaster' effect[24]. Highly placed canine, distally tipped canine, rapid space closure are the reason that causes this effect on resilient wires.

Arch form: For an arch form reference, Andrews continued to use the basal bone of the mandible. These clinical experiences resulted in Andrews introducing a series of modifications, and after using the original 'standard' Straight-Wire Appliance for an amount of time; he advised a wide range of brackets[24].

Incisors brackets[24]: He also advised the use of three different sets of incisor brackets, with different degrees of torque for different cases for class I, class II, and Class III.

In case of class I- base inclination for central incisor bracket is 7˚ , lateral incisor = 3

In case of class II- base inclination for central incisor 20˚, lateral incisor = - 2

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In case of class III- base inclination for central incisor 12˚, lateral incisor = 8

Mandibular brackets[24]:

In case of class I- base inclination for central incisor bracket is 1˚, lateral incisor = 3

In case of class II- base inclination for central incisor 4˚, lateral incisor = - 2

In case of class III- base inclination for central incisor - 6˚, lateral incisor = 8

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ROTH PRESCRIPTION

Andrews gave Roth the first set of high cost prototype brackets that were welded into pinched band material after which Ronald Roth started to use the straight wire appliance in 1970. After all these had inventory issues and Anchorage loss, in 1979 bracket setup was created by Roth with modified tip, torque, rotations and in-out movement of the Andrews standard setup brackets.

Increased torque was introduced in the maxillary incisors in the second generation of pre-adjusted brackets which enhances aesthetics, provides more space for lower anterior teeth, and provides appropriate anterior guidance.

Dr. Roth modified the values built into the original Andrews straight wire appliance eventually with time and through clinical testing, what is currently known as “The Roth setup”[26]. The Roth prescription was devised in 1975 and was marketed commercially in 1976[27].

Dr. Ronald Roth has been using Andrews SWA since its introduction in early 1970. However after using Andrews appliance for more than 4-5 years he noted certain drawbacks in it.

ROTH PRESCRIPTION: In the Roth Prescription of the Andrews Appliance, the anterior brackets were placed slightly more incisally from Andrew’s middle of the clinical crown", and the ingredients of those brackets were adjusted accordingly. This was to eliminate the need to place reverse and compensating bends into the finishing wires[28].

The Tru-Arch Form was developed to play a role in this overcorrection concept, because arch form affects the rotational positioning of the teeth as well as the brackets.

Auxiliary attachments were inserted into the brackets, for example the double and triple tubes given for headgears and lip bumpers and rectangular auxiliary tubes for Burstone or Bioprogressive mechanics.

For the utilization of short Class II or Class III elastics, additional hooks on each bracket are added, so that less adverse canting of the occlusal plane and less posterior interference would be created with inter-arch elastics.

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MAXILLARY PRESCRIPTION[28]: An additional torque in the maxillary incisors (5° more than normal) is introduced in the Roth Prescription .There is comparatively less negative torque in the upper canines to balance the corresponding effect of adding more positive torque into the incisors.

As the upper canines are being retracted in most treatments hence they have 2° more distal tip. Along with this, they have a 2° rotation to the mesial.

A set of maxillary anterior with "Super Torque" to be used in the following instances:

1. Two upper premolar extraction- only cases where a tooth size discrepancy is created. The additional torque and tip makes the upper anteriors engage more space. These are used in conjunction with the zero-rotation upper molars as the mesial molar rotation created causes the molars to occupy more space in the arch. In this way the tooth size discrepancy is compensated for and proper overbite and overjet can be established and the upper extraction sites remain closed.

2. In Class II division 2 cases and in any case that requires 6mm or more of upper anterior retraction.

The upper buccal segments are distally uprighted to 0°, the bicuspids are rotated 2° mesially to offset the rotation that accompanies distal traction, and the upper molars have 14° distal rotation (twice the amount found on the non-orthodontic normals) and 14° buccal root torque (5° more than normal). In cases where only two upper bicuspids are extracted there is a 0° upper molar rotation set.

In case of segmental surgical cases the Zero tip canine brackets are used to secure space among the canines and premolars for the osteotomy cut. After healing from surgery has occurred, the standard Roth treatment canine brackets are placed to achieve final finishing[27].

MANDIBULAR PRESCRIPTION[28]**:** As seen in the non-orthodontic normal, the incisor brackets are the same in the mandibular arch.

The lower canines have 7° mesial tip and 2° distal rotation. The entire lower buccal segment has a 3° distal tip from normal and a 4° distal rotation. These teeth organize

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more mesially than the uppers and concomitantly rotated mesially, thus requiring extra distal rotation.

The torque in the lower buccal segments will remain normal, because overcorrection in this plane only leads to problems and intervention.

The two lower molars have exactly the same degree of root torque since the appliance rests on the mesiobuccal cusp (the torque measurement for the non-orthodontic normals was taken from the buccal groove).

Table 5: Maxillary and Mandibular prescription

Upper Arch	Inclination	Angulation	Off-set	Lower Arch	Inclination	Angulation	Off-set
Central	12°	5°	0°	Central	0°	0°	0°
Lateral	8°	9°	0°	Lateral	0°	0°	0°
Cuspid	0	11°	0°	Cuspid	-11°	5°	0°
1st Bicuspid	-7°	0°	0°	1st Bicuspid	-17°	0°	0°
2nd Bicuspid	-7°	0°	0°	2nd Bicuspid	-22°	0°	0°

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VIAZIS BIOEFFICIENT THERAPY

Bioefficient Therapy was given by Dr. Anthony Viazis. This was designed to shorten the time consuming initial phase of treatment as it is a patient-friendly and user-friendly system. With beginning more quickly to an individualized finishing stage, for both patient and clinician it decreases burnout, noticeable results early in treatment, improving patient cooperation and the quality of care[29].

The average treatment time is usually one year in the Viazis bio-efficient appliance system. The triangular bracket was invented to allow the first differential stiffness bracket to introduce the new, differential - force super elastic.

In this technique the bio-efficient super elastic arch wires are used that uses light, biological forces and to decrease the treatment time a unique new bracket was designed and to reduce patient irritation and decrease the potential risk of root resorption.

As the conventional single brackets have practically no capability of controlling rotations or tipping hence they are not as popular as twin brackets . To overcome this problem Dr. Viazis introduced a multifunctional single bracket for Bioefficient Therapy that resolves this design issue while providing optimal tooth movement[29].

Built-in torque in the bracket will be less time consuming and more systematic than torque in the archwires.To overcome the tipping effect produced by active mechanotherapy, especially during space closure, extra torque is added as most clinicians finish with undersized wires. To over correct malocclusions and to work with the largest wires possible from the initial treatment timing the bracket prescription for the Bioefficient system was designed.

This system is a modification of the pre-adjusted systems given by Roth, Andrews, Alexander, and Hilgers. The torque-in-base brackets are diagonal in shape, and the bases have anatomically contoured triangular shapes[29].

The height of the upper central incisor bracket is designed so that the middle of the tooth coincides with the bracket slot. Other bracket heights are decided according to the distance of the base from the incisal edge (Fig:23)[29].

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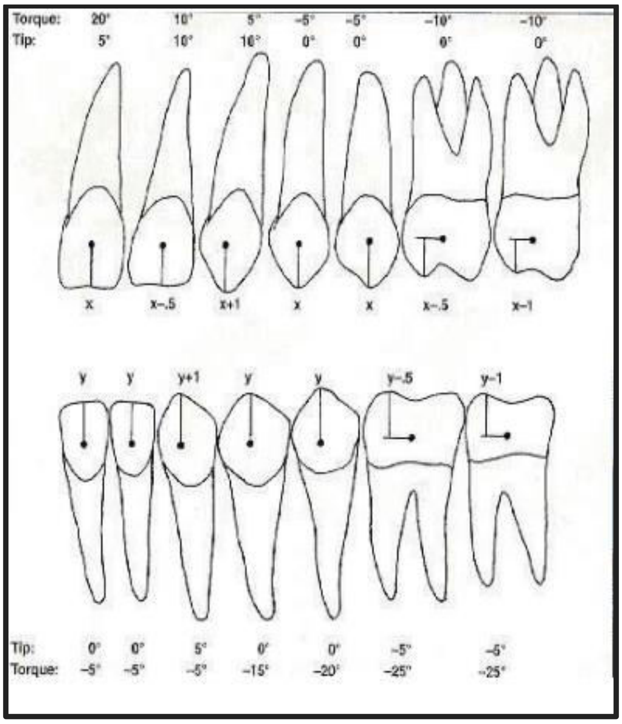

Fig: 31 Bracket heights and prescriptions (x = distance from upper central incisor bracket base to incisal edge; y= distance from lower central incisor bracket base to incisal edge)

With the introduction of new super elastic arch wire, the new Viazis bracket was introduced among other brackets.

These brackets were formed by Dr.Viazis quite cleverly to maximize the effect of the super elastic arch wires from the start of therapy. This is achieved by introducing a number of unique features within the pre-adjusted bracket. as stiffness is inversely proportional to the tube of the length of the wire and the amount of deflection or range is proportional to the square of the length of wire, then an arch wire between "narrow slot" brackets would have 3.37 times less stiffness and 2.25 times greater activation, and thus overall much greater flexibility.

The unique feature of the Viazis bracket may be categorized as follows:

1. To maximize arch wire flexibility the inter-slot distance is increased.
2. By using a single slot type contact with the slot elevated off of the horizontal member results in the reduced friction between the brackets and the arch wire.

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3. Elbow side additions are engaged to avert loss of tip control. With the movement of tooth the arch wire contacts the elbows and the narrow single slot instantly becomes a wide twin slot. This results in root movement early to any other crown movement can occur. The ultimate effect is a "walking" of the tooth into the desired location in a "zigzag" manner.

4. By using an elongated thin arrangement , maximum rotational control is achieved . This allows the twin wings to be widened to the mesial and distal surfaces of the tooth.

5. These brackets are pre-torqued. Torque is recieved in the early phase of treatment, by using a .020 x .020 starting arch wire.

When coupled with the new, high tech, low force arch wires this low friction bracket technology is very structured. Initial training in the Viazis technique is advised, before using this bracket system.

The Viazis bracket provides a clinician the speed of the smallest single slot bracket available with the control and stability of the largest twin slot bracket on the market hence intensifies "orthodontic economics". Placement of the bracket is easy due to its triangular design and has amazing retention due to its unique contoured base.

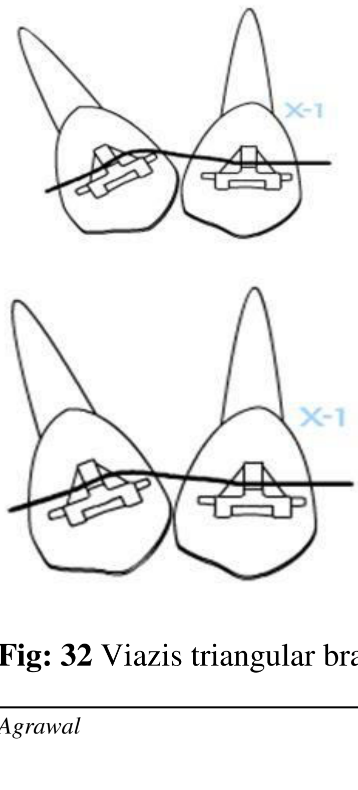

Fig: 32 Viazis triangular bracket

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ALEXANDER'S THE VARI-SIMPLEX DISCIPLINE

Richard G. Wick Alexander invented an appliance to provide outstanding treatment results in an easy orderly manner. The main concerns of Alexander discipline were Simplicity, to encourage cooperation, comfort and control. The main goals include high quality outcomes, patient comfort and decreased chair-side time.

A system of brackets placed on teeth, which is used by orthodontists around the world was introduced as an appliance called Vari-Simplex Discipline in 1977 by Alexander and he described Vari-Simplex Discipline, which comprises a specific bracket system used in case treatment[30].

The concept of straight wire appliances enhanced by the Alexander design. This system consists of a no. of principles that trains the practitioner through each case with a level of agreement and this discipline uses a force delivery system that has been well formulated and checked, ensuring predictable final results.

THE IDEA OF VARI-SIMPLEX DISCIPLINE[30]

Unique bracket selection and prescription:

1. For individualized teeth specific bracket designs are formed.
2. For easier engagement and lesser wire changes to allow increased flexibility with stiffer arch wires, single brackets create increased inter-bracket space in relation to twin brackets.
3. Rotational wings provide controlled guidance and direction to the teeth. In order to increase the rotation wings can be activated or deactivated. Rotation wings are advantageous as they provide force on the active wing.

The use of single brackets with wings provides an advantage over twin brackets. The prescription permits controlled and efficient mandibular arch levelling, mainly in non-extraction cases. This is achieved by first settling the brackets and ligating the individual tooth with a rectangular wire.

4. Alexander discipline makes the resulting straight wire appliance special with the unique prescription of torques and angulations. Maximum effort should be exerted

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to control the area of inter-canine width and mandibular incisor flaring. The most important unique design elements of this bracket system is exhibited in lower mandibular anterior brackets.

The incisors resistance to tipping labially , caused by the minus 5° torque, places a distal force on the first molars angulated at minus 6°, causing them to upright. This can gain 2–3 mm of arch length without flaring the incisors. This allows for more efficient control of teeth during the levelling process and actually sets up anterior anchorage in those situations where the mandibular posterior teeth are to be protracted in the correction of Class II malocclusions. The -5° torque also aids in ideally maintaining the position of these teeth over the mandibular basal bone. To control the torque in this important area the use of a flexible rectangular arch wire in the lower arch is recommended as soon as possible. The distinctive biomechanical principles of actively tying back a heat-treated, curved, rectangular stainless steel arch wire results in successful and stable arch leveling[30].

Each bracket consists of a 0.018 X 0.025inch wire slot. Slot sizes remain same from anterior to posterior brackets and, realizing that 5° of torque is lost for each 0.001-inch "play" in the slot, final ideal wires (0.017" X 0.025") are made to fill the slot as much as practical.

Various mechanics were invented and promoted by this technique.

These include:

1. Usually maxillary arch is treated first and one arch is treated at a time
2. In case of extractions, the maxillary arch is treated first with crowding in the mandibular arch allowing the mandibular arch to drift before the placement of brackets termed Driftodontics.
3. In case of low and average skeletal class II cases, to create an orthopaedic correction a cervical face-bow is fixed to a tied-back arch wire.
4. RPE (rapid palatal expansion) and lip bumpers are used as a method of gaining space in borderline cases that can be handled without extraction.

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5. Mandibular incisor flaring is administered by − 5° torque in the bracket
6. Mandibular 1st molars are uprighted with a − 6° tip.
7. Mandibular anterior roots are flared with unique angulated brackets.

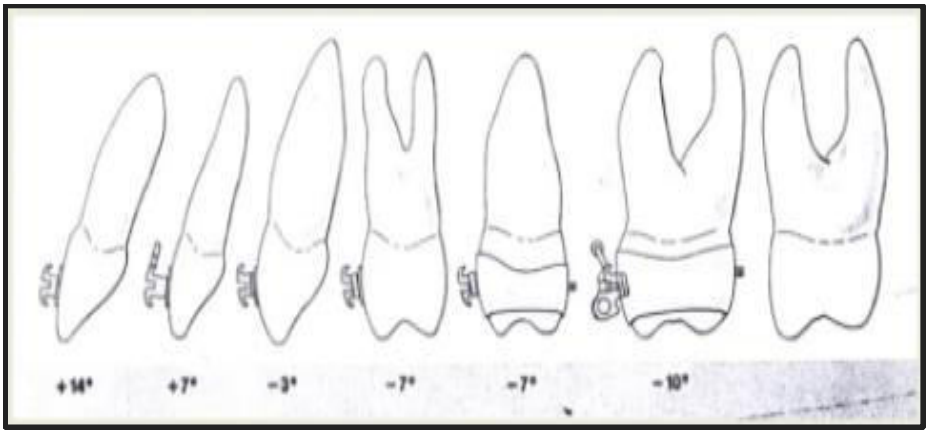

Fig: 33 Maxillary prescription

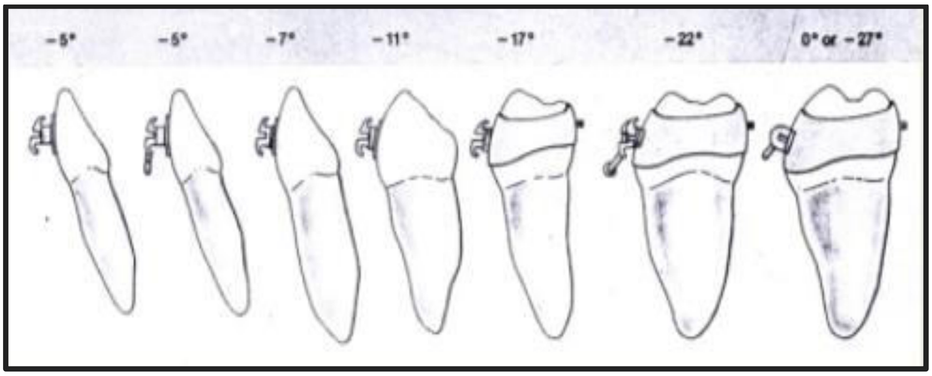

Fig: 34 Mandibular prescription

THE BIO-PROGRESSIVE SYSTEM

Given by Dr. Robert Ricketts and Ruel Bench who incorporated current edgewise mechanics with solid diagnostic principles.

Bioprogressive set-ups[31]: - the different setups are listed as

First is the standard progressive setup;

Second is the full-torque bioprogressive arrangement;

The third is the "triple-control" bioprogressive.

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To fabricate a set up for an individualized tooth including specific tip and torque for every single tooth will require much effort, time, and expense.

Including the delicacy of intraoral adjustments with the bioprogressive therapy, mainly those of a minor nature, the question is raised about absolute torque, tip, and rotation bands, and brackets.

Standard bioprogressive

As discussed earlier, the edgewise appliance includes the base for bioprogressive evolution. Tipping is examined, studied and evoluted for the original bioprogressive therapy over a period of years for clinical application[31].

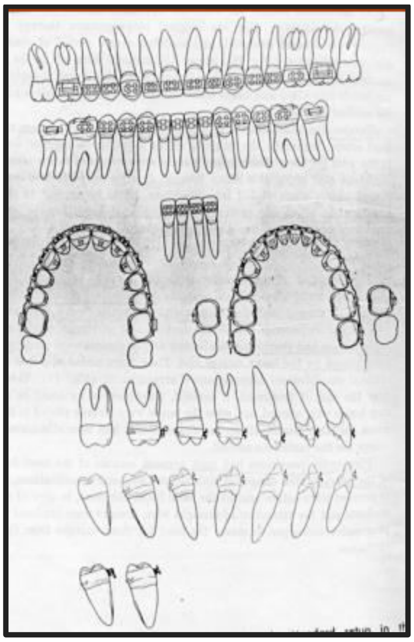

Fig 35: Standard bioprogressive setup

For individualized treatment conditions minor alterations were left in the hands of the operator and it was desirable to tap bands into place and swage them firmly onto the teeth. This is regarded as the method of choice. In the standard setup the torque was built into the upper incisors and all four canines. Basically, the torquing of the lower buccal segment and step bends in the arch for the premolars and molars were demoted to the arch wires[31].

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Full Torque

The torque is incorporated into the lower buccal segments only as the torque in the anteriors has already been made.. Rotation tubes are placed on the lower molars as new torque designs are made. These were added as a first option to the original standardized bioprogressive arrangement (Fig. 28)[32].

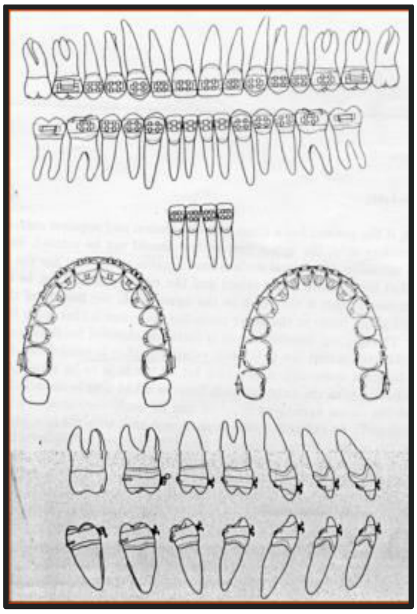

Fig 36: full-torque bioprogressive arrangement

This meant if needed , untorqued wires could be used, near the end of treatment. Lateral step bends were required, and the bends were already situated in the preformed wires. All torque neccessity had been eliminated in the wire except for the differences needed.

First order provisions had been averted - because of the requirement for bulking-up of the brackets, the danger of aesthetic and hygienic complications, and the need to prevent lever action against the band itself. In accordance to the requests from students and the attraction of straight wire, designs were analyzed to fit the bio-Progressive technique

Triple control setup[31]

For the movement of certain teeth outward, the adjacent teeth will be required to step inward (Fig. 29).

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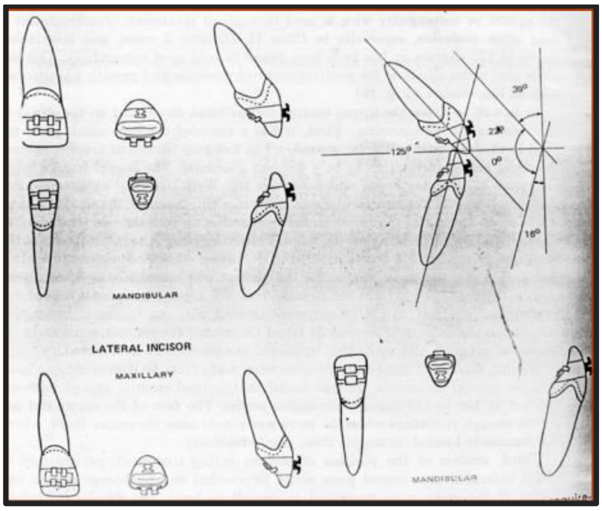

Fig: 37 Triple control setup

First of all , all the canine brackets would need to be raised to induce the buccal step for the 1st premolars.

Second, as the molar needs to be stepped buccally from the 2nd premolars and as to eliminate the step in the wire, the second premolar is raised so that it will be lined up lingually. In order to produce rotation of the upper molar, the flaring of the upper molar tube is done.

According to this the bracket is not raised and the rotation should not be made in the upper molar. If this is the setup in the upper arch, for best fit of the teeth the step bend is not made in the lower premolar area; nor is that tooth fully rotated distally[31].

The original standard setup hence is superior for these different cases. This suggests that the individual treatment plan is needed before any orthodontist becomes bothered with which kit of bands is to be applied. There is little problem with the anterior teeth because all of that is basically standardized and the small changes required can be made very simply with intraoral adjustments.

In case of extraction in the lower arch with the 1st premolar missing and the second premolar shifted into the position in the arch which is occupied by the first premolar, a 7 degree torque bracket would be needed on that; tooth, which means that the technique becomes more complex.

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Standard bioprogressive (original) [32]

Second-order and third-order factors are built into the bracket and tubes for the anterior teeth. First-order factors will be contemplated afterwards.

Provisions for tipping (second-order control) : -[31]

To angle the band on the tooth up to 3 to 4 degrees without band distortion the operator should be able to fit, particularly with the band driver. Small angulations are too hard to be seen with the naked eye for premounting, and therefore tipping of at least 5 degrees or more was advised for pre-welds, leaving the minute detail to the technician at cementation. All bands hence obtains brackets parallel to the band margin except these:

Upper lateral incisor	8 degrees down on distal
Upper canine	5 degrees down on distal
Lower canine	5 degrees down on distal
Lower first molar	5 degrees down on mesial

For the coverage of different tooth morphology and natural fit of a band of these teeth, tipping of the bracket (or tube) is advised.

Provision for torque (third-order control): [31]

For standard bioprogressive, full-torque bioprogressive, and triple control bioprogressive

Upper central incisor	22 degrees (root to the palatal)
Upper lateral incisor	14 degrees (root to the palatal)
Upper canines	7 degrees (root to the palatal)
Lower canines	7 degrees (root to the palatal)

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MCLAUGHLIN, BENNETT AND TREVISI SYSTEM

McLaughlin and Bennett with Trevisi to re-design the entire bracket system to supplement their proven treatment principles and to conquer the distinguishing deficiency of the basic SWA. The MBT prescription was introduced in 1997 and established itself as one of the most popular bracket prescriptions on the market.[33,34,35]

McLaughlin & Bennett (1989) concluded that after the transformation from the edgewise to straight wire technique, an increased demand for anchorage control is necessary as there was an increased tendency for teeth to incline buccally[35].

McLaughlin et al (1997) conferred a review on MBT System orthodontic planning.

This technique used a series of intra- and extra-oral devices: palatal bars, lingual arches, Class II and III elastics, Nance's buttons and utility arches. The alignment and leveling phase includes: Use of thermo-activated Ni-Ti arch wires, Use lace-back ligature to control canine retraction, Use of cinch back bends to control anterior movement of the incisors, Use of open coil to obtain space, Set and maintain arch form from the beginning of treatment[3].

In the MBT System, .019 X .025 stainless steel wires are used as final arch wires to correct the upper and lower dental midlines and close remaining spaces by sliding mechanics. This necessitates the analysis of the direction and amount of tooth movements in each quadrant to make an extraction/non extraction decision and select appropriate anchorage.

They re-examined Andrews' original findings and considered additional research input from Japanese sources when designing the third generation of pre-adjusted brackets, namely, the MBT system. Due to the small area of torque application, the pre adjusted appliance system is relatively inefficiency in delivering torque, it is therefore necessary to build in extra torque into the important incisor and molar brackets to achieve the clinical goals with minimum of wire bending.

Torque movement is an extremely challenging aspect of orthodontic treatment, one that requires significant movement through bone with less than 1 mm of contact between the arch wire and the bracket to do so.

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In addition, traditional pre-adjusted appliances designed from Andrews' research and other studies did not consider the extent of torque loss that results from the fact that even a full-sized arch wire does not completely fill the slot and therefore cannot completely express the torque built into the bracket. So as difficult as it is to achieve desired torque, the factor of torque loss increases that difficulty.

Anterior Torque

insufficient torque induced in the anterior teeth can result in torque loss in the upper incisors during overjet reduction or space closure and proclination of the lower incisors when levelling the Curve of Spee or treating for crowding in the lower arch. The MBT Appliance System offers greater palatal root torque in the upper incisor area and greater labial root torque in the lower incisors. For increased versatility, two options are available for the upper central incisors: +17° or +22°, depending on the clinical need.

Posterior Torque

Because of their position on the curve of the arch, and because of their root anatomy, proper torque expression of cuspids is especially challenging and is influenced by each patient's natural arch form and treatment needs. The MBT Appliance System provides three torque options for upper cuspids -7°, 0°, +7° and three options for lower cuspids -6°, 0°, and +6°. This allows the practitioner to match the torque amount that will best achieve a secure root torque and inter-cuspidation. Insufficient torque expression in the upper molars is commonly manifested by "hanging" palatal cusps, creating centric interferences and requiring further correction. The MBT System increases the buccal root torque to help counteract this tendency.

Relative to Andrews' original research, the MBT System reduces lingual crown torque in the lower posterior area for three reasons:

- In cases of cuspid and bicuspid gingival recession, the teeth may benefit from having the roots moved closer to the centre of the alveolar process.
- In cases that show narrowing of the maxillary arch with lower posterior segments that are inclined lingually, buccal uprighting for the posterior area is a favorable step for both arches.

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- Lower 2nd molars tend to torque lingually over the course of treatment, especially when there is a high degree of buccal root torque in the buccal tube. Therefore, reduced torque values can more consistently assist the effort to keep the posterior segment centred and uprighted.

The main differences with other bracket prescriptions are

1. Increased palatal root torque in the upper central incisor brackets (17 degrees)

2. Increased palatal root torque in the upper lateral incisor brackets (10 degrees).

3. Increased lingual crown torque in the lower incisor brackets (− 6 degrees)

4. Decreased tip in the upper canine brackets (8 degrees).

The developers of the appliance claim that the increased palatal root torque in the upper incisors improves the under torqued appearance produced by other prescriptions and the increased labial root torque in the lower incisor counteracts the forward tipping during levelling.

Upper Arch	Inclination	Angulation	Lower Arch	Inclination	Angulation
Central	+17°	+4°	Central	-6°	0
Lateral	+10°	+8°	Lateral	-6°	0
Cuspid	7°/-7°	+8°	Cuspid	6°/-6°	3°
Cuspid	0	+8°	Cuspid	0	3°
1st Bicuspid	-7°	0	1st Bicuspid	-12°	2°
2nd Bicuspid	-7°	0	2nd Bicuspid	-17°	2°

Table-6 Maxillary and Mandibular prescription (MBT)

Following changes were made in the standard SWA Brackets: -

Original dots and dashes system for brackets identification was changed to laser numbering of standard metal brackets[33].

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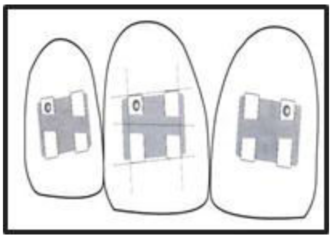

Fig: 38 Original SWA Brackets

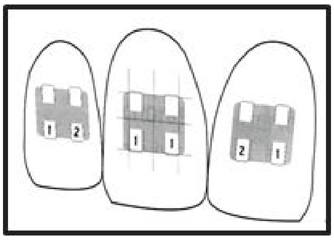

Fig: 31 MBT Brackets

Torque in base-the Computer aided design (CAD) factor[33] -

Torque-in-base was an important issue with the first and second generation pre-adjusted brackets. Technology was not available to set bracket slots in the correct position relative to the facial surfaces of the crown without torque-in base. Since the advent of CAD-CAM bracket design, the brackets may be finished with all torque-in-base (full size and clear) or a combination of torque-in base and torque-in-face with absolutely no difference in slot position.

Torque specification[33,34]:

In original standard SWA brackets the built-in torque was relatively inefficient in delivering torque. It was therefore necessary to build extra torque into the important incisor and molar region in order to meet clinical goals with minimum wire bending.

Torque is not efficiently expressed by the pre adjusted appliance system owing to two reasons:

1. The area of torque application is small and depends on the twist effect of a relatively small wire compared to the size of the tooth.
2. In order to slide teeth it is normal practice to use .019 x .025 steel wires in the .022 slot. These wires have a play of about 10 degrees.

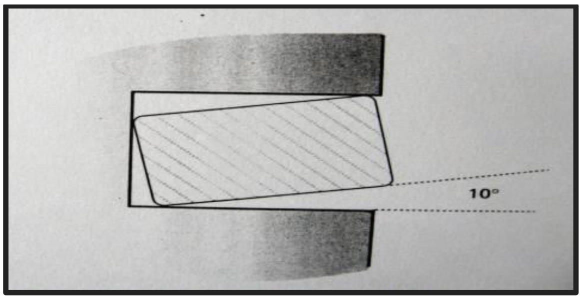

Fig: 39 Play of 10° between the 0.022 slot and 19 × 0.025’ wire

Incisor torque specification:

Upper incisor brackets are given an additional palatal root torque, while lower incisor brackets are given an additional labial root torque. This adjustment aids in the correction of the most common torque problems occurring in the incisor areas.

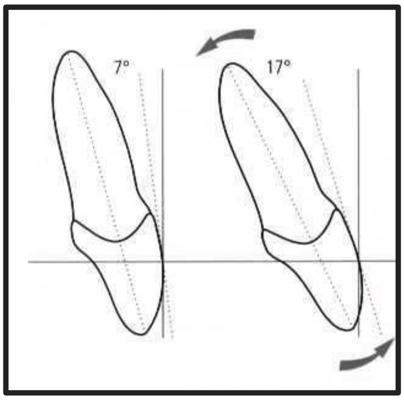

Fig: 40 Increased palatal root torque for Upper centrals incisors

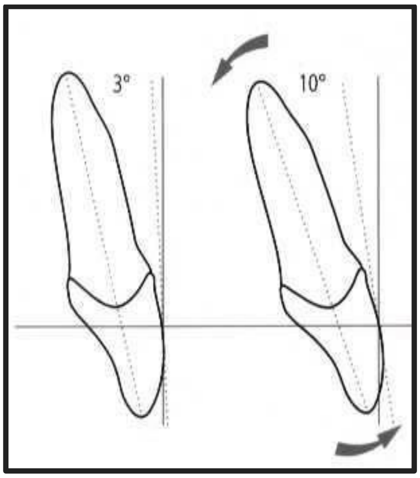

Fig: 41 Increased palatal root torque for upper lateral incisors

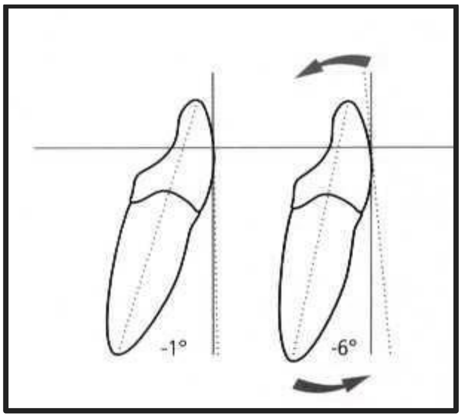

Fig: 42 Increased labial root torque for Lower Incisors

Upper Cuspid, bicuspid and molar torque specification.

Upper cuspid and bicuspid brackets are given with the normal -70 of torque. Upper molar brackets are given with a supplementary 5° of buccal root torque (-9° to -14°) to reduce palatal cusp interferences with these teeth. Upper canine torque i.e available in 7°, 0°, +7°, torque. The 0° and +7° options are for those cases with narrow maxillary bone form and\or prominent canine roots, and are often used with arch wires in the tapered form.

There was a disposition for upper first molar palatal cusps to extrude. Bracket with 14° of buccal torque gives extra control. In some cases it is advised to add buccal root torque to the upper arch wire, even when using a 14° torque bracket.

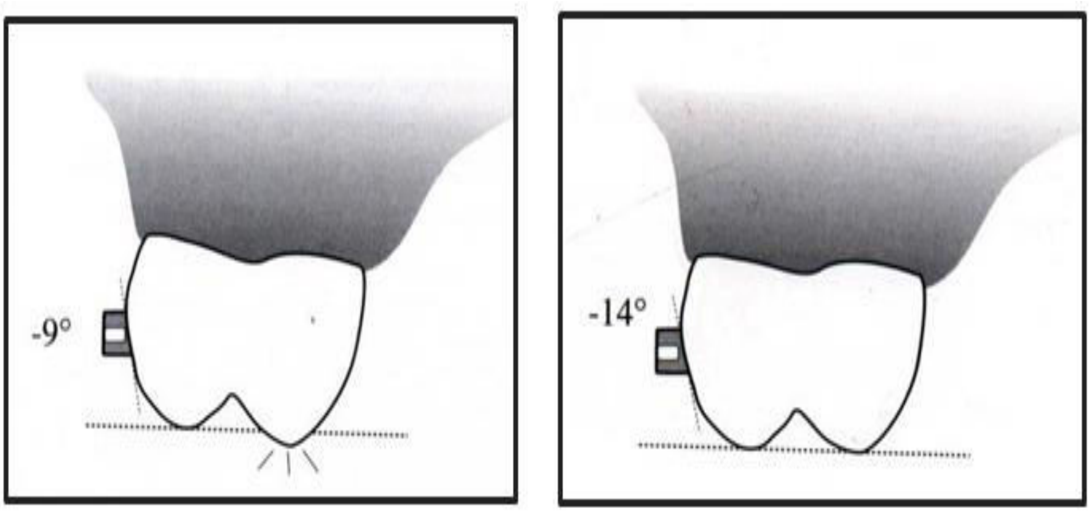

Fig: 43 Upper molar brackets with an additional 5° of buccal root torque (-9° to -14°)

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Lower cuspid, bicuspid and molar torque[33.34.35]

Increased buccal crown torque is induced in the brackets of the lower posterior segments. Buccal uprighting is allowed, which is important in most cases. The original SWA 1st molar torque -30°, 2nd molar torque -35° induces rolling-in of lower molars.

The lower premolar torque was alternated by 5°,1st molar torque was alternated by 10° and 2nd molar torque was changed by 25°. Lower canine torque updates as 6°, 0°, +6°. The 0° and +6° options are for those cases with narrow mandibular bone form or bulging canine roots, or deep bites at beginning of treatment.

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BOWMAN AND ALDO CARANO: THE BUTTERFLY SYSTEM

This system was introduced by Dr. Jay Bowman and Dr. Aldo Carano to explain the quite usual orthodontic mistakes reported by the ABO. The main feature is exceptional comfort provided by the bracket's low profile and smooth, rounded tie wings. The establishment of a vertical slot allows added convenience and versatility. The use of auxiliaries in the vertical slot permits control in all three planes and allows convenient tying-in of severely rotated or misaligned teeth[36].

In the Butterfly System the bracket is more comfortable, aesthetic, and hygienic reduced profile, due to its miniature twin wing design and rounded tie wings, and the elimination of standard hooks. The Butterfly System has different features made to advance existing pre adjusted appliance concepts, in relation to the findings of the ABO.

These are listed below[37].

Versatile Vertical Slot[37]

The affiliation of a simple vertical slot opens an entire new domain of treatment options. First, to reduce the likelihood of tissue impingement trapped food, and plaque, the elimination of ball hooks on the brackets results in making arch wires easier to tie. When elastics are required, a simple hook pin or T-Pin can be placed into the vertical slot of any bracket—virtually reducing the need for Kobayashi ties, soldered hooks, and crimpable surgical hooks.

One of the easiest uses of the vertical slot is for teeth that are blocked out, lingually displaced, or ectopically erupted. In these cases, it is about impossible to tie an arch wire into the bracket during early alignment, but a stainless steel ligature or elastic thread can be placed through the vertical slot to form a vertical or "sling" tie around the arch wire. Less friction will be produced from a loose stainless steel tie, especially a single vertical tie, than a self-ligating bracket.

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Fig: 44 Versatile Vertical Slot

The Compliance Spring is an auxiliary that can be used for two different purposes. With a round arch wire, an inter maxillary elastic from this spring will induce labial root torque for a specific tooth, such as a lingually displaced maxillary lateral incisor. With a rectangular arch wire, the Compliance Spring can also be used to stimulate cooperation with elastics. If the elastic is not worn, the spring will protrude enough to instigate a mild irritation of the cheek.

Traditional Begg uprighting springs are needed for root paralleling. When placed in the mandibular canine and/or first premolar brackets, they produce a mesial crown tip that can oppose retraction forces on the mandibular anterior teeth[38].

Progressive Posterior Torque

The most common deficiency of finished cases introduced by either orthodontic residents or successful ABO candidates is inappropriate buccolingual inclination [39,40].

Torque is not accurately expressed with pre adjusted appliances, as the area of torque application, that depends on the twisting effect of a thin wire, is very small compared with the bulk of the tooth [41,42].

Most clinicians do not use full-size arch wires of satisfactory stiffness to induce torque; for example, an .019" × .025" wire in an .022" × .028" system has about 10° of play. Many bracket prescriptions contain an enormous amount of mandibular posterior lingual crown torque, intentionally to acquire the so-called "cortical anchorage" [43].

Compounding this problem is the increasingly popular use of "arch development", with over-expanded, highly resilient commercial arch blanks [44] and bracket prescriptions

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having limited maxillary posterior lingual crown torque [45,46]. This combination tends to tip the upper posterior teeth to the buccal and "roll in" the lower posterior teeth to the lingual, resulting in overly prominent maxillary palatal cusps, inappropriate inter-digitation of the maxillary buccal cusps, increased occlusal interference, and an accentuated curve of Wilson[42].

Progressive posterior torque was invested into the Butterfly System prescription to correct these unwanted effects. The maxillary posterior brackets have –14° of torque to help remove the buccal tipping of the first and second molars.

The mandibular first and second molar brackets have only –10° of lingual crown torque. Reduction in the lower posterior torque while increasing the upper improves the final buccolingual occlusion by flattening the curve of Wilson, minimizing inconsistency in posterior overjet, and minimizing the bulging of palatal cusps.

	Torque
Maxillary	
Central incisor	+14
Lateral incisor	+8
Canine	0
First premolar	–7
Second premolar	–8
Mandibular	
Central incisor	–5
*Central incisor	–10
Lateral incisor	–5
*Lateral incisor	–10
Canine	–3
First premolar	–7
Second premolar	–9

Table - 8 Maxillary and Mandibular prescription of Butterfly system

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Self Ligating Brackets-DAMON System

The Self Ligating Brackets (SLB) has come into orthodontic practice since 1930's with the invention of Boydband bracket. These bracket systems along with the thermally activated NiTi wires have reduced the treatment duration, chair-side time, and improved the treatment efficacy and patient co-operation. This led to the invention of Damon's system by Dr. Dwight Damon in the year 1996. It is called as "System" rather than "Brackets" because it utilizes the benefits of both the brackets and copper NiTi wires, thus delivering a "low force- low friction" mechanics for the management of dental malocclusion.

Damon philosophy uses the concept of passive self-ligation technique which claims to have the lowest frictional resistance of any ligation system. Reduction in friction helps the force to transmit directly from the arch wires to the teeth and its supporting structures without any force dissipation by the ligature system.

Comparing the other prescriptions, Damon system has lots of benefits:

- Limitations in the use of intraoral expansion appliances such as quad-helix or jack-screw as the optimal forces from the arch wires completely allows the connective tissue and alveolar bone to follow tooth movement with uninterrupted vascular supply to the tooth and its surrounding system thereby providing the necessary expansion.
- In a study stated that Damon System produced a significant transversal increase in the posterior region of the arches with differences in teeth buccolingual inclinations at post-treatment.
- Faster alignment of teeth as passive self-ligation produces lower resistance thus allowing a wire to slide.
- Reduced amount of pain experienced by patients, and higher treatment efficiency as this friction-free system produces less forces on the teeth.
- Reduction in the need for extraction as the force applied is minimal that the pressure from lips can control unwanted tipping of incisors during alignment stage.

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- Decreased demand for the use of anchorage devices comparing the conventional appliances as there is reduced friction between the ligation for better tooth control.
- Reduction in the overall duration of orthodontic treatment up to 7 months

Damon's system has different torque prescription. This includes:

High torque brackets

These brackets can be used in cases where the incisors or cuspids are severely retroclined or palatally placed. Examples are:

- Class I extraction cases with proclined of anterior.
- Class II division 1 malocclusion.
- Class II division 2 malocclusion with retroclined incisors.
- Palatally placed incisors or cuspids.

Standard torque brackets

These brackets can be used in cases where the inclination of anterior is satisfactory and when there will not be any obvious change in the inclination during the course of the treatment.

Low torque brackets

Examples of the cases include:

- Anterior open bite cases with severe proclination of anteriors.
- Moderate and severe crowding.
- Treatment mechanics which may result in proclination of anteriors.
- Incisors with palatally positioned roots.
- In class II fixed functional cases or class II elastics cases where control of lower incisor proclination is necessary.
- Lingually placed lower incisors.

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	Upper arch						
	U1	U2	U3	U4	U5	U6	U7
High torque	+17°	+10°	+7°				
Standard torque	+12°	+8°	0°	-7°	-7°	-18°	-27°
Low torque	+7°	+3°					
	Lower arch						
	L1	L2	L3	L4	L5	L6	L7
High torque			+7°				
Standard torque	-1°	-1°	0°	-12°	-17°	-28°	-10°
Low torque	-6°	-6°					

Torque values in DAMON system

Advantages

- Clinically proven
- Enhances facial esthetics
- More comfortable than traditional braces
- Reduced friction and faster tooth movement
- Shorter treatment duration
- Lesser visits

Disadvantages

- Expensive than traditional braces
- "Metal Mouth" look

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Conclusion

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In order to attain our present day goals of treatment, a definite technique for the application of torque force becomes imperative. the orthodontist will experience little difficulty if he will keep in mind the following fundamental principles: the crown of a tooth moves in the direction of torque and the root of a tooth moves in the opposite direction of torque and by the application of an auxiliary force derived from elastics or other sources this torque action can be altered in such a way as to cause either the root or the crown of a tooth to move in whichever direction the operator may desire.

The torque that can be delievered by an orthodontic appliance varies greatly with the prescription used as offered by the various orthodontic manufacturers. The amount of deviation angle or play that exists for various wire bracket combinations can be advantageous or disadvantageous for the orthodontist.

 ISBN: 978-93-93810-40-3

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ABOUT THE BOOK

The state-of-the-art is the key to understand not only how we reach where we are but also to learn how to manage properly the torque, focusing on the technical and biomechanical purposes that led to the change of the torque values over time. In orthodontics the torque control is fundamental under a clinical point of view.

This book will be valuable in order to update the clinicians on the aspects that affect the torque under the biomechanical sight, helping them to understand how to managing it, following the "timeline changes" in the different techniques so that the Variable Prescription Orthodontic (VPO) would be a suitable tool in every clinical case.

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