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Review Article

Harnessing innovations in orthodontics: leveraging torque for optimal precision

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ABSTRACT:
Torque in orthodontics is a crucial biomechanical force essential for precise tooth positioning within the dental arch. This rotational force, utilized through various orthodontic devices, is vital for achieving optimal alignment and functional occlusion. Effective torque application requires careful consideration of root angulations and precise adjustments to brackets and arch wires, ensuring smooth tooth movement while preserving functional integrity. Disparities in tooth size, root structure, and customised treatment goals comprise some of the major issues addressed. Orthodontists can improve treatment outcomes, reduce the likelihood of relapse, and improve aesthetics by grasping these subtleties. This review provides a thorough comprehension of torque's revolutionary potential and crucial significance in contemporary orthodontic practice. It also investigates how various torque applications influence tooth positioning, stability, and overall effectiveness. Furthermore, it emphasises modern procedures and equipment that improve torque control, resulting in more reliable outcomes. Practitioners can improve patient care and treatment efficiency by incorporating a more in-depth understanding of torque dynamics. This review is an invaluable resource for orthodontists eager to harness torque's full potential, paving the way for innovative strategies that significantly improve patients' lives. It delves into the intricacies of torque, exploring its definition, application techniques, and clinical relevance in detail. This review highlights cutting-edge torque management techniques, including enhanced bracket designs and innovative wire modifications, while also taking into account patient-specific anatomical variances.By mastering these elements, orthodontists can achieve remarkable outcomes, enhancing both aesthetics and functionality in their practice. This rigorous examination broadens clinical understanding and enables practitioners to execute revolutionary tactics that provide extraordinary patient outcomes, leaving a lasting impact on their smiles and lives.

Keywords: Orthodontics, Torque, Tooth movement, Force application, Torque control, Stability, Treatment efficiency

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INTRODUCTION

The term "torque" in orthodontics originates from the Latin "torquere," meaning "to twist" or "to turn," and refers to the rotational force applied to teeth to facilitate specific movements, particularly for correcting their positions and alignments.[1]Anterior teeth, vital for social acceptance, underscore the significance of orthodontic treatment in achieving optimal aesthetics and functionality and the degree of twist applied to an arch wire within a bracket.[2]Despite various treatment philosophies and torque prescriptions, managing torque remains intricate and often elusive.[3] Ensuring that all teeth achieve ideal axial inclinations by the conclusion of active treatment is essential for functional occlusion, as

torque allows orthodontists to adjust these inclinations effectively (**Figure 1**).[4]

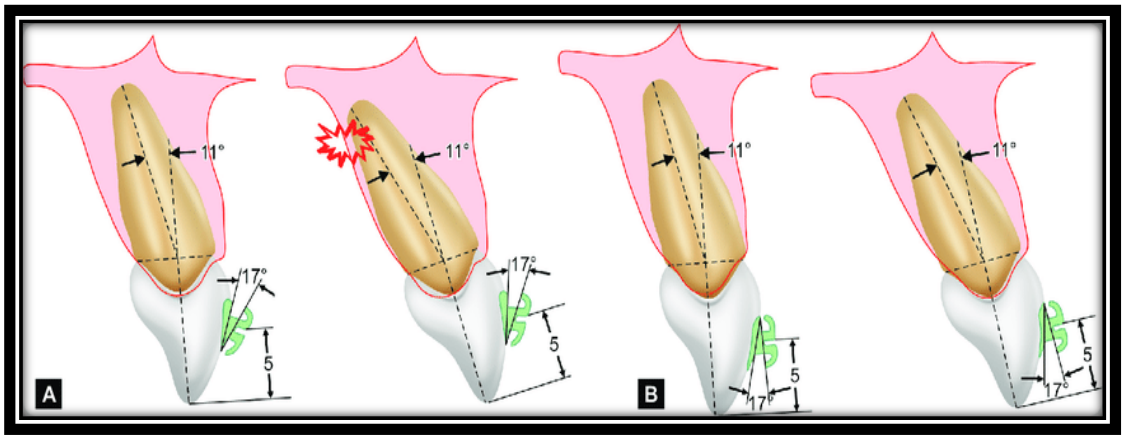

Figure 1: Torque in orthodontics
(a) Positive torqued bracket can cause impingement of root during alignment and intrusion (b) Negative torque bracket would keep the root in cancellous bone during alignment and intrusion.
Courtesy: Jayaprakash Pk, Verma Sk, Chauhan AKR, Kumar M. Effects of inverting bracket on maxillary central incisors with increased collum angle in Class II Division 2 malocclusion cases: a finite element analysis. J Contemp Orthod. 2018; 2(1):1-10.

Torque represents a shear-based moment resulting from the effort of a twisted spring wire to untwist itself, inducing rotation.[5] In dental contexts, it pertains to facio-lingual root movement This force arises from the torsion in the arch wire, generating a couple when interacting with the bracket slot, resulting in tooth rotation around its center of resistance.[6]In orthodontic mechanics, the third-order twist of the arch wire produces torque; for example, a wire twisted for lingual root torque in maxillary incisors will extrude those teeth, whereas one designed for labial root torque will intrude them (**Figure 2**).[7]

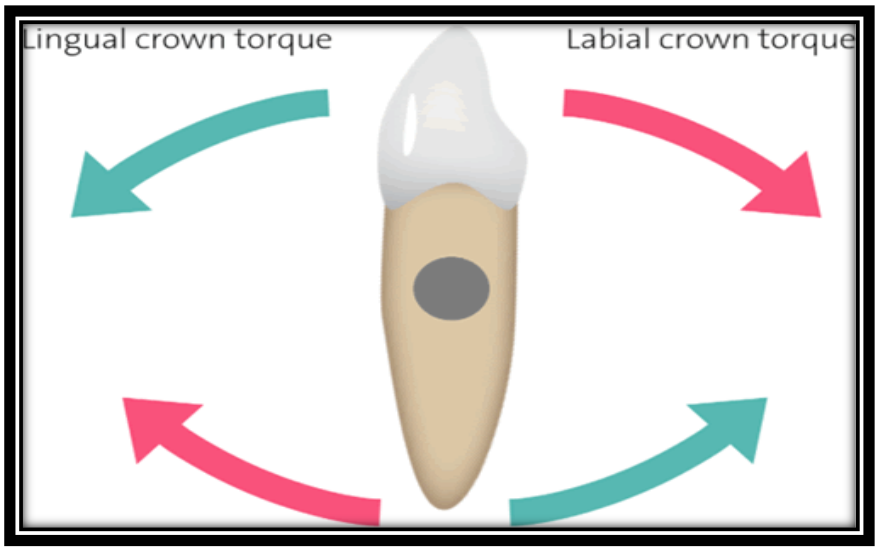

Figure 2: Lingual and labial torque
Courtesy:https://support.clearcorrect.com/hc/en-us/articles/4402323236247-Tooth-Movements

Biomechanically, torque is regarded as a fundamental force in orthodontics, often considered the third key to occlusion, being positive when the root is positioned lingually and negative when positioned facially relative to the crown.[8]Dr. Mohammed Alruby, as cited by Dr. Earman D. Rauch, highlights the importance of torque in orthodontics for managing the axial inclination of teeth, which is crucial for achieving optimal positioning and a refined result.[9]**Table 1** summarizes key developments in the historical evolution of torque in orthodontics, highlighting the contributions of notable figures and their impacts on the field.[10-14]

Table 1: Historical evolution of torque in orthodontics

Time Period	Key Developments	Notable Contributors	Impact on Orthodontics
Early 1900s	Introduction of basic mechanical principles	Edward Angle	Established foundational concepts of orthodontic mechanics.
1950s	Exploration of biomechanics in tooth movement	Holdaway, Roth	Focused on the relationship between force application and tooth movement.
1960s	Advances in bracket design	Begg, Kloehn	Improved torque control with specific bracket designs.
1980s	Introduction of self-ligating brackets	Burstone, Kuhlberg	Enhanced torque expression and reduced friction in mechanics.
1990s	Refinement of torque mechanics with wire materials	Nanda, Isaacson	Emphasized material properties affecting torque expression.
2000s	Digital technology integration	Various contributors	Improved precision in torque application through computer-aided design.
2010s - Present	Focus on patient-centered outcomes and efficiency	McLaughlin, Poon	Integration of torque control with treatment efficiency and aesthetics.

Torque enables the manipulation of tooth roots with minimal movement of the crowns by applying simultaneous opposing forces, with the center of rotation at the incisal edge. This process allows for labiolingual movement, aids in stabilizing teeth within the cortical bone, prevents relapse, and contributes to a natural appearance. Torque is especially vital during third-order bends in finishing and artistic positioning in a pre-adjusted edgewise system, as well as in pre-surgical and post-surgical phases for accurate axial tooth placement. It can be applied in several ways: by twisting an arch wire, utilizing the inherent torque of the bracket in pre-adjusted edgewise appliances, or employing torqueing auxiliaries, particularly common in Begg techniques.[15] Ultimately, torque is a crucial force that empowers orthodontists to effectively manage root movements for favorable dental outcomes. Furthermore, torque significantly impacts orthodontic treatment by influencing apical bases, assisting in the reestablishment of these relationships while preserving the correct labial axial inclination of maxillary incisors, thereby facilitating desired facial modifications and stable occlusal relationships. Enhancing smile fullness also involves adjusting the clinical crown torque of maxillary canines and premolars for optimal aesthetic appearance based on different facial types.[16] Moreover, torque is crucial in managing root resorption, as foundational studies by Ketcham have shown that gentle, intermittent torquing forces can minimize root resorption across various patient populations (**Figure3**).[17]

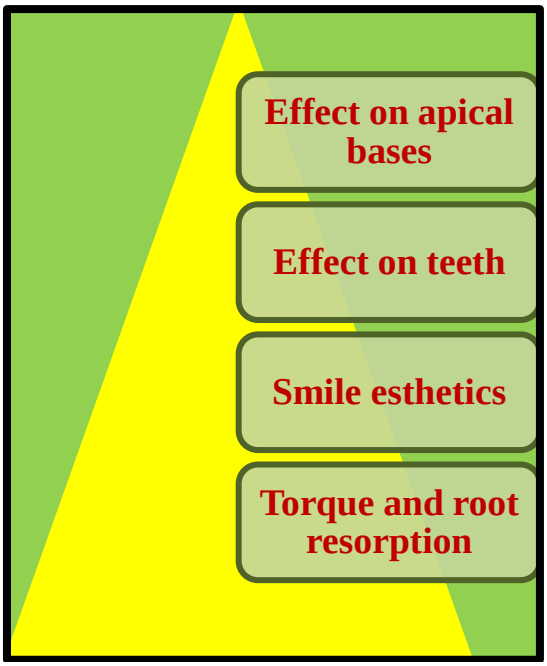

Figure 3: Importance of torque in orthodontics

A lack of understanding regarding torque can result in problematic tooth movements and suboptimal treatment outcomes (**Figure 4**), highlighting the need for precise torque application to achieve targeted SNA and SNB angle reductions.[18] Effective torque management is also vital for addressing bimaxillary protrusion, aligning crowded teeth, and correcting deep bites while ensuring normal axial inclination for Class II molar correction and preserving the health of teeth and surrounding structures. This review emphasizes the importance of torque in orthodontics, exploring its significance across various appliance systems and reinforcing its critical role in achieving optimal tooth positioning and improving treatment outcomes.[19]

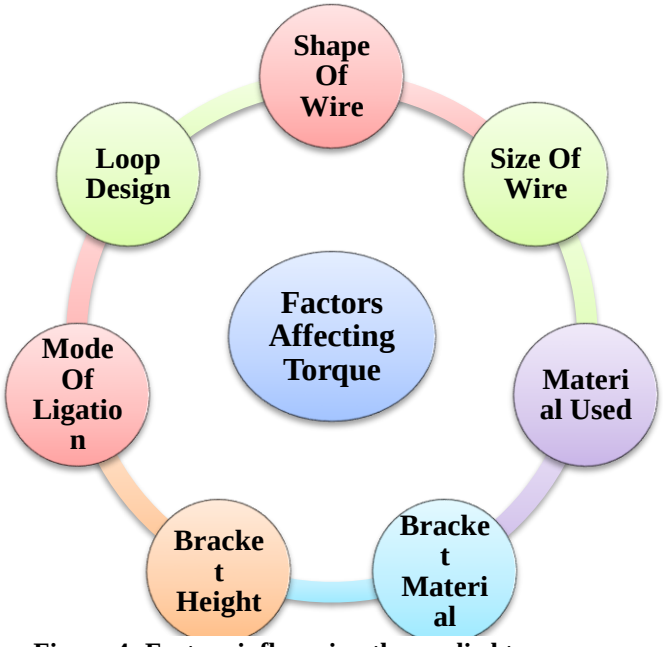

Figure 4: Factors influencing the applied torque

DISCUSSION

Torque significantly influences the results and stability of orthodontic treatment in multiple ways.[20]Careful management of treatment philosophies and appliance systems is vital for each case.[21] Maintaining torque control from the early stages is essential for directing teeth into their final positions, starting immediately after brackets and initial arch wires are placed.[22]Effective torque management facilitates a smoother transition to the finishing stage, ultimately requiring less effort at the end of treatment.[23]Future research and product development should enhance our understanding and tools in this area to achieve the primary goals of orthodontic treatment: functional occlusion, aesthetics, and stability (**Figure 5**).[24]

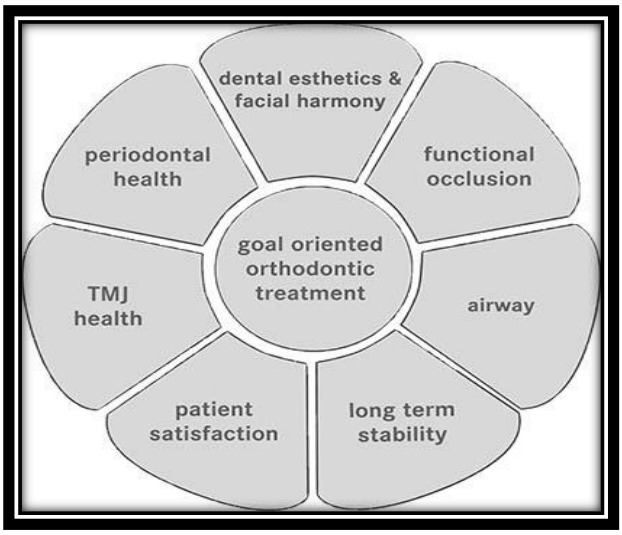

Figure 5: Goals of orthodontic treatment
Courtesy:https://www.suffolkbraces.com/patient-care/functional-and-cosmetic-excellence/

Innovations in torque application signify a major advancement, enabling orthodontists to achieve greater precision in treatment outcomes.[25] By utilizing advanced materials and techniques, controlled torque can be applied to individual teeth, optimizing their axial inclinations and improving overall alignment.[26] This refined approach not only enhances aesthetic results but also ensures better functional relationships within the dental arch.[27]Despite substantial empirical and research data supporting the need for adequate torque, considerable variability exists among different prescriptions regarding anterior dentition torque values.[28]For instance, the torque for maxillary central incisors in pre-adjusted appliances ranges from 12° in the Roth prescription to 22° in the Bioprogressive prescription, indicating nearly a 100% difference (**Figure 6, table 2**). [29]

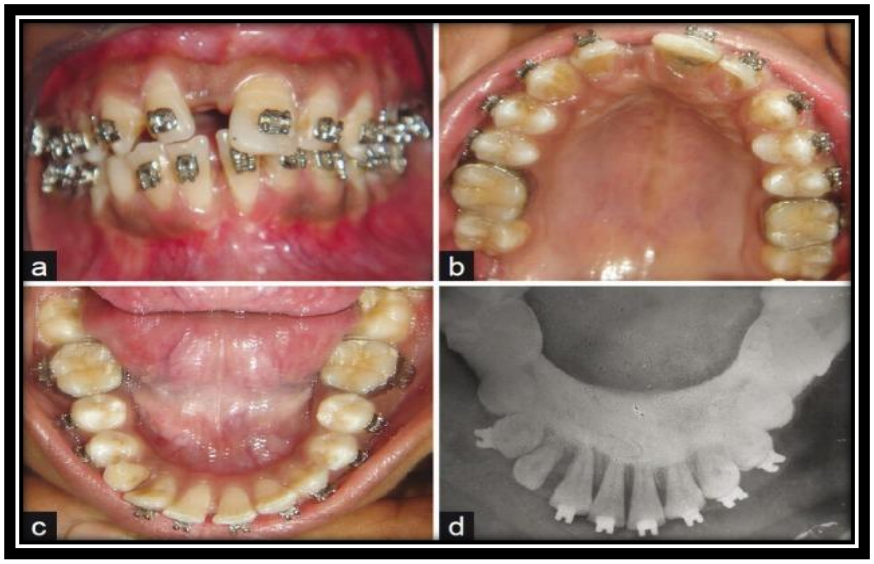

Figure 6: Preadjusted orthodontic appliance (Roth prescription - 0.022" × 0.028" slot) was bonded to maxillary and mandibular arches
Courtesy: Verma S, Sharma VP, Singh G. Management of a transmigrated mandibular canine. J Orthod Sci. 2012; 1(1):23-28.

Table 2- : Various Prescriptions Values For Torque

Torque prescription		Central incisor	Lateral incisor	Canine	1st premolar	2nd premolar	1st molar	2nd molar
Roth's	Maxilla	12°	8°	-2°	-7°	-7°	-14°	-14°
	Mandible	-1°	-1°	-11°	-17°	-22°	-30°	-30°
Vari-simplex discipline	Maxilla	14°	7°	-3°	-7°	-7°	-10°	-10°
	Mandible	-5°	-5°	-7°	-11°	-17°	-22°	-27°
The Bio-progressive system	Maxilla	22°	14°	7°	-7°	-7°	-10°	-10°
	Mandible	-1°	-1°	-7°	-11°	-17°	-27°	-27°
MBT™ bracket system	Maxilla	17°	10°	-7°,0°,+7°	-7°	-7°	-14°	-14°
	Mandible	-6°	-6°	-6°,0°,+6°	-12°	-17°	-20°	-10°

Courtesy: Deepshikha, Chaukse A, Gupta K. Rotational force in orthodontics. J Orofac Res. 2020; 9(3):32-8.

Such variations arise from material properties, manufacturing processes, and biological factors.[30]A study by Morina demonstrated that conventional brackets outperformed self-ligating brackets in generating the necessary moment angle for torque, with ceramic brackets providing the best torque retention, followed by conventional metal brackets, active self-ligating brackets, and passive self-ligating brackets (**Figure 7**) (**Table 3)**.[31]

Figure 7: Passive and active self ligating brackets
Courtesy:https://theorthodonticnotefile.blog/2014/09/19/active-versus-passive-self-ligation-control-versus-low-friciton/

Table 3: Comparative overview of overall attributes of passive vs active self –ligating brackets

Feature	Passive Self-Ligating Brackets	Active Self-Ligating Brackets
Mechanism	Uses a sliding mechanism; the clip remains passive	Sliding mechanism applies active force to the archwire
Advantages	- Reduced friction enhances tooth movement efficiency -Less chair time; ligatures don't need replacing - Potential for faster treatment	- Increased control over torque and rotational movements - Beneficial for complex cases requiring precision
Considerations	- Limited control over certain movements, especially torque -Less adaptable for complex cases	- Slightly increased friction may impact speed of movement -More frequent adjustments may increase chair time
Clinical Implications	- Aims to reduce friction and improve treatment efficiency	- Effectiveness varies by individual cases
Patient Comfort	Generally improved comfort due to fewer ligatures	Generally improved comfort due to fewer ligatures
Aesthetic Options	Available in clear or ceramic options	Available in clear or ceramic options
Conclusion	Choice depends on patient needs and treatment complexity	Choice depends on patient needs and treatment complexity

Bracket positioning (**Figure 8**) is critical for effectively expressing torque; forces should be applied at the center of the clinical crown. Variations in positioning can lead to torsion angle discrepancies of 10° to 15°. [32]

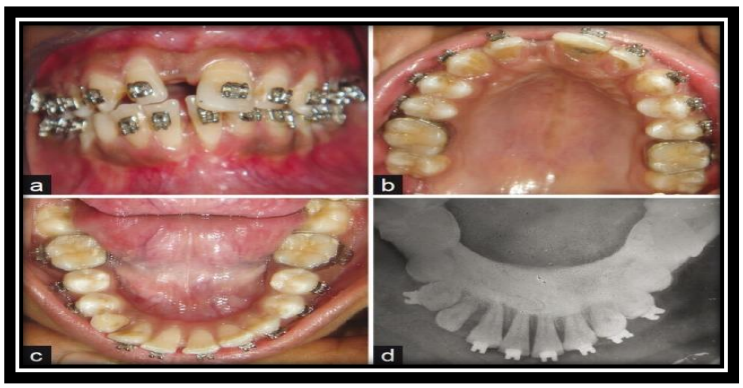

Figure 8: Bracket positioning
Courtesy: Pitts TR. Bracket positioning for smile arc protection. J Clin Orthod. 2017; LI (3):142-156.

The shape of the teeth also affects bracket placement; differences between the vertical axes of the crown and root can influence the bracket's effectiveness.[33] Orthodontists must carefully remove and reposition brackets to correct their placements, being aware that debonding procedures can have negative consequences.[34]Proper vertical control during removal enables adjustments to bracket positions, providing options to reduce or increase torque.[35]Altering bracket placement, including inversion techniques, can aid in achieving desired movements for specific teeth.[36] Strategic planning of bracket positioning from the beginning is crucial for maximizing treatment outcomes (**Figure 9,10**).[37]

Figure 9: Bracket positioning in class II division 1 malocclusion patient
Courtesy: Pisek P, Manosudprasit M, Wangsrimongkol T, Keinprasit C, Wongpetch R. Treatment of a severe Class II Division 1 malocclusion combined with surgical miniscrew anchorage. Case Report. 2019; 155(4):572-583.

Figure 10: Bracket positioning in class III malocclusion patient
Courtesy: Carrièr L. Nonsurgical correction of severe skeletal Class III malocclusion. 2016; L (4):216-230.

Various clinical scenarios illustrate this, such as Class II division 1 malocclusions with palatally displaced lateral incisors or cases involving missing lateral incisors for space closure.[38] In Class III malocclusions, factors like canine angulation and labial movement of palatally displaced canines, along with incisor inclination, are essential considerations. When a lateral incisor is positioned palatally, reversing the brackets can shift torque values from positive to negative, facilitating desired root movements and conserving valuable treatment time.[39]For palatallydisplaced lateral incisors, rotating brackets 180 degrees can adjust torque from +10 degrees to -10 degrees, aiding in labial root torque during the rectangular wire phase.[40]

Torque with the Edgewise Appliance: The edgewise mechanism has transformed orthodontic treatment by providing exceptional control over each tooth's axial inclination, enabling precise adjustments in all directions.[41]By strategically positioning the arch wire within the bracket slot, the edgewise system effectively applies torque, facilitating both buccal and lingual movements through an activated rectangular wire. However, it’s essential to consider the dynamics of adjacent teeth, which experience equal and opposite forces that can inadvertently reduce the

facio-lingual discrepancies between them.[42] To address this, rectangular arch wires with twists are often employed for reciprocal torque, although they can generate high moments with full-sized stainless-steel wires. Innovative solutions, such as undersized wires, torquing arches for concurrent application of third-order couples, and additional brackets on the molars, enhance torque management.[43]The integration of torquing spurs (**Figure 11**) into round-base arch wires and the use of Warren springs further tackle the challenges associated with torque in edgewise appliances.[44]

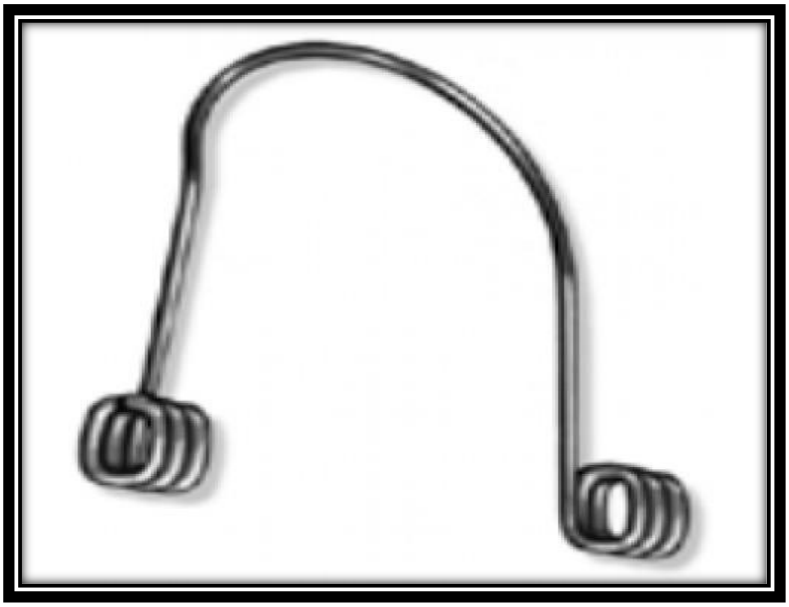

Figure 11: Torquing spurs into round-base arch wires
Courtesy:https://arthurhall.co.nz/webshop/index.php?route=product/product&product_id=1486

Effective torque management during the finishing stages is particularly dependent on maintaining an optimal moment-to-force ratio (Figure 12), especially in extraction cases. Historically, achieving the correct crown-root inclinations with edgewise brackets (Figure 13) required twisting the rectangular arch wire. [45]

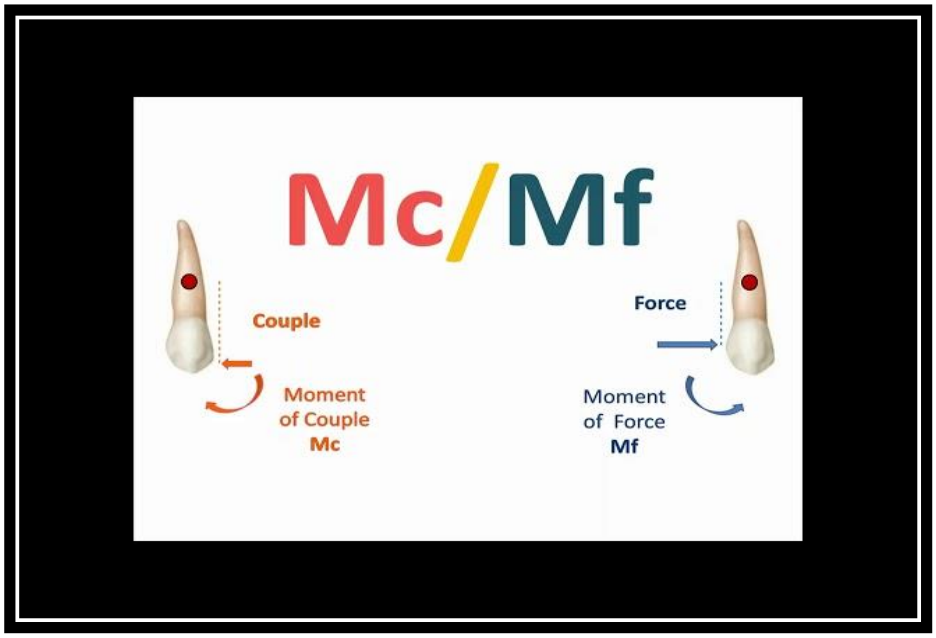

Figure 12: Moment-to-force ratio
Courtesy:https://www.youtube.com/watch?v=FxqIllh-2lk

Figure 13: Edgewise brackets
Courtesy:https://www.dontalia.com/edgewise-metal-bracket-replacement

However, The introduction of torqued slot brackets in the late 1950s and early 1960s streamlined this process for the anterior portion of the maxillary arch wire, eliminating the need for twisting.[46]Ultimately, the edgewise mechanism gives orthodontists comprehensive control over tooth positioning, ensuring that treatment plans effectively meet both aesthetic and functional objectives with precision and efficiency.[47]

Torquing with Begg's and Refined Begg's Appliance: Pre-adjusted edgewise appliances provide precise finishing and aesthetically pleasing results for teeth, in contrast to the classic Begg appliance (**Figure 14**), which utilizes round archwires and Begg brackets. These pre-adjusted brackets enable three-dimensional control over the dentition through rectangular wires that fit into rectangular slots.[48]

Figure 14: Begg's appliance
Courtesy:http://ortho.sdc.saveetha.com/beggs-appliance

The use of rectangular finishing wires also enables effective torque application to posterior teeth.[49] While individual posterior teeth can be torqued with Begg auxiliaries, achieving torque for multiple or all posterior teeth is more difficult with round-base wires.[50]During the final treatment phase, torque adjustments are made by slightly over-torquing and over-tipping the roots of all teeth by 10-15%, allowing the roots to settle into their proper positions.[51]

Anterior root torque, which involves the palatal movement of maxillary central incisor roots and the distal and palatal movement of maxillary lateral incisors, is commonly referred to as torque.[52] Various auxiliaries have been designed to facilitate these movements, with spur-type auxiliaries—available in two or four spur configurations—being among the most widely used (**Figure 15**).[53]

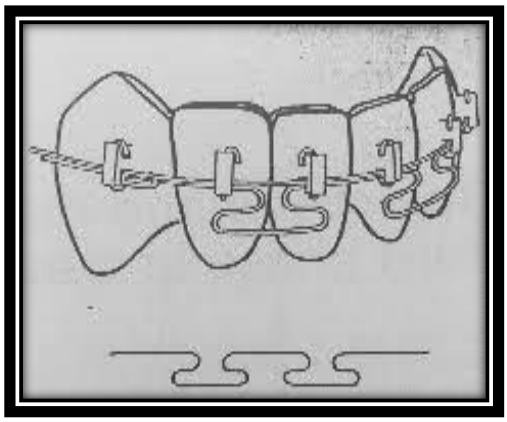

Figure 15: Spur-type torquing auxiliary
Courtesy: Chakraborty P, Mathur P, Mahajan S Tandon R. Torquing Auxiliaries - A Review. SF J Oral Med Dent Health. 2020; 1(1): 1002.

The responses to torque auxiliaries often include depressions and flaring in the maxillary buccal segments.[54] According to Swain, the depression of buccal segments results directly from the palatal root movement of the maxillary central incisors, while the flaring occurs due to the torque applied to the maxillary lateral incisors. In contrast, wing-type auxiliaries encourage expansion in the canine area.[55]

Spur-Type Torquing Auxiliary: Torque management is essential for achieving the optimal inter-incisal angle, ensuring proper contact between incisors, and aligning the dentition for ideal occlusion, particularly in maxillary incisors.[56] The biomechanics of torque involves root movement, which is facilitated by stabilizing the crowns and applying a moment to the roots, with the center of rotation located at the incisal edge during this process.[57] An effective moment-to-force (M/F) ratio of at least 12:1 is necessary for root movement, as noted by Dr. Ravindra Nanda. He indicated that a 5:1 ratio leads to uncontrolled tipping, 7:1 results in controlled tipping, 10:1 allows for translation, and 12:1 enables true root movement.[58] Proffit's perspective emphasizes that the relationship between the moment generated by force on the crown (Mf) and the counterbalancing moment from the bracket (Mc) determines the type of tooth movement.[59] Without a counterbalancing moment, pure tipping occurs; increasing the M/F ratio ($0 < Mc/Mf < 1$) leads to controlled tipping, while at $Mc/Mf = 1$, translation occurs, and $Mc/Mf > 1$ produces root torque.[60] Furthermore, torque expression is influenced by the interaction between the arch wire and bracket slot, tooth anatomy, bracket positioning, dimensions, ligation techniques, and arch wire stiffness. Importantly, studies indicate no significant differences in the final inclinations of maxillary and mandibular incisors or upper canines between MBT and Roth appliance systems in treatment outcomes.[61]

Torque Control in Tip Edge: This procedure occurs during the final phase of treatment. Torque is applied to the roots of the maxillary incisors using nickel-titanium torque bars, which are curved ribbon arch sections measuring 0.022 - 0.018 inches with a 30-degree torque.[62]These bars are nearly invisible during use, as they are positioned directly behind the arch wire. [63]Special deep groove brackets are necessary for the torque bars on the maxillary central incisors, incorporating conventional pre-adjusted edgewise arch wire slots into the base of the Tip Edge arch wire slots (**Figure 16**).[64] A cap covers the deep groove in the earlier stages.[65] At the start of stage three, this cap is removed, and a torque bar is securely ligated to the lingual side of the round base arch wire. For individual tooth torquing, a specific root torquing auxiliary is employed, often alongside ceramic tip edge brackets that do not feature the deep groove.[66]

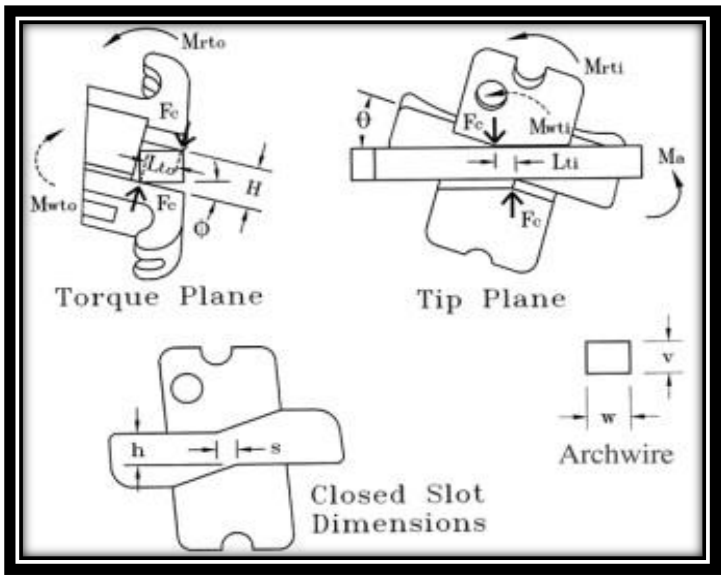

Figure 16: Torque Control in Tip Edge
Courtesy:https://www.sciencedirect.com/science/article/abs/pii/S0889540601397093

Torque Control in Lingual Orthodontics: Achieving precise torque control with lingual appliances is particularly challenging due to factors such as reduced arch radius, shorter interbracket distances, complex lingual geometry, highly variable tooth shapes, and restricted access and visibility.[67] With lingual brackets, early torque control is essential, as even minor deviations in the labiolingual inclinations of the incisors can result in noticeable height differences. The TARG (Torque and Angulation Reference Guide) (**Figure 17**) serves as a tool for transferring bracket prescriptions from the more reliable labial surfaces of the teeth to the lingual surfaces at the correct bracket height. [68]

Figure 17:TARG (Torque and Angulation Reference Guide)
Courtesy: Shetty V, Shetty SV, Sarje S, Tandon R, Singh K. Lingual orthodontics - A review. IP Indian J Orthod Dentofac Res. 2020; 6(2):44-50.

This method allows for a diagnostic setup without requiring model sectioning, enabling laboratory technicians to customize torque and angulations for each prescription. For instance, a Class IIdivision 2 case needing additional torque for the maxillary anteriors will be noted on the prescription. The technician adjusts the TARG to establish the prescribed torque, positioning the lingual bracket at a higher torque angle than average values and compensating for the fit of the lingual bracket base with advanced adhesive (**Figure 18**).[69]

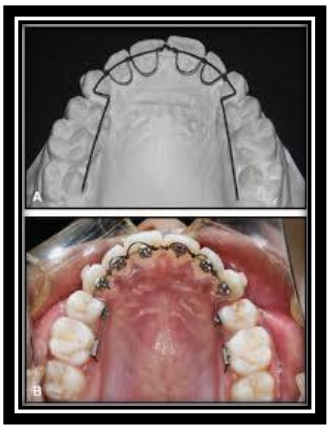

Figure 18: Torque control in lingual orthodontics
Courtesy: D'Souza IM, Kumar HC K, Shetty KS, Kishore MSV. The rat trap lingual torquing auxiliary. J Clin Orthod. 2013; 11(12):716-726.

Torque Control in Bioprogressive Treatment: Bioprogressive therapy emphasizes that effective tooth movement and treatment processes rely on precise control of root movements. Managing root torque is crucial in four key scenarios.[70]First, torque control is vital for maintaining roots in vascular trabecular bone, as efficient movements such as incisor intrusion or cuspid retraction require directing roots away from denser cortical bone and into the less dense, vascular trabecular bone.[71] For instance, lower incisors supported by lingual cortical bone require buccal root torque for successful intrusion.[72] Second, positioning roots against dense cortical bone is essential for ensuring anchorage during treatment.[73]Third, utilizing torque to remodel cortical bone is important for certain movements that involve positioning roots into dense, less vascular areas, including incisor retraction, maxillary incisor root torquing, correcting impacted upper canines, and advancing lower molars to close gaps from missing or extracted teeth. Finally, applying torque for final occlusion details is crucial for achieving proper function and enhancing the stability of the final occlusion (**Figure 19**).[74]

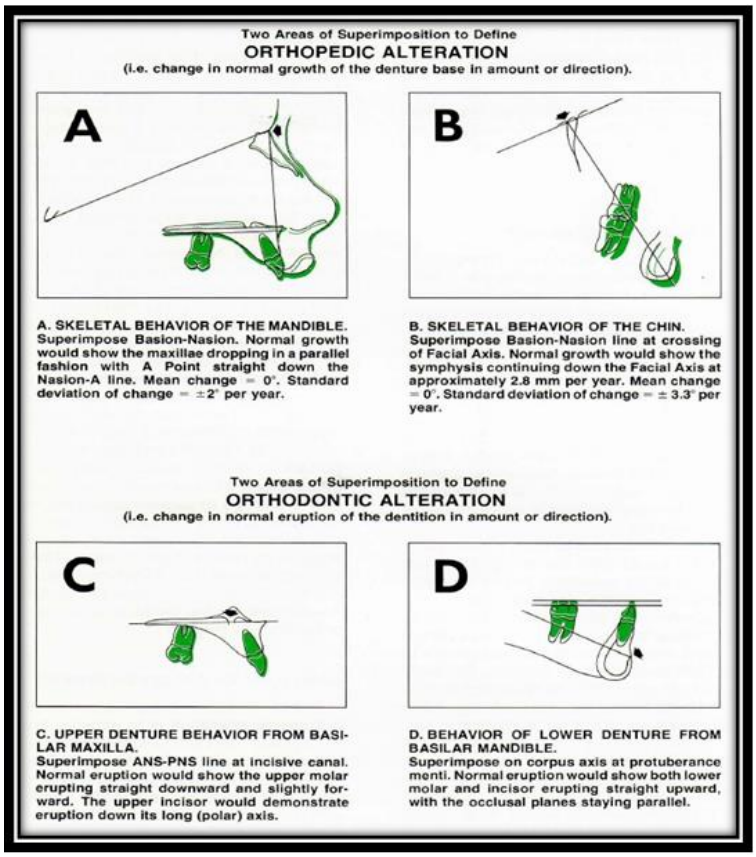

Figure 19: Torque control in bioprogressive treatment
Courtesy: Bench RW. Bioprogressive therapy. JCO. 1978; 12(1):48-69.

Torquing with Removable Appliances

Many simple malocclusions can be addressed with removable appliances; however, these devices primarily move the crowns of teeth and often struggle to achieve sufficient root torque, particularly in cases with spacing among anterior teeth.[75]While they can close gaps, they frequently result in labial root prominence by the end of treatment. [76]To tackle this issue, a new technique for achieving root tipping of anterior teeth with removable appliances has been devised.[77] This approach involves constructing a traditional removable appliance with Adams clasps on the first permanent molars and triangular clasps between the first and second premolars to enhance anchorage.[78] The labial bow, crafted from 0.7mm dentaurum wire, features a small wire lug soldered at the midline to act as a central anchor.[79]A torquing spring made from 0.4mm spring wire applies pressure on the cervical third of the crown while the labial bow restricts labial tipping, allowing only for lingual root movement. Although root movement of upper anterior teeth is typically associated with fixed appliances, removable appliances can also achieve this effect through flexible torquing springs. [80]Historical methods include Bass's 1975 double cantilever spring, which exerts pressure at the gingival margin of incisors while preventing movement at the incisal edge, and Watkin's box-type attachment for inducing torque.[81]The emergence of fixed lingual orthodontic appliances in the mid-1970s addressed the increasing demand for esthetic solutions in adult orthodontics. The lingual light wire technique marked a significant advancement, enhancing aesthetics and patient acceptance. Stephen Paige employed effective strategies such as a torquing auxiliary and torqued ribbon arch for torque control, showcasing the adaptability of both removable (**Figure 20**) and fixed appliances in achieving desired orthodontic results.[82]

Figure 20: Torque with removable appliance
Courtesy: Batra P, Miglani R, Saalim M. A Novel Approach to Intrude Incisor by Removable Orthodontic Appliance. J Clin Stud Med Case Rep. 2015; 2 (3): 014.

Torque with Clear Plastic Appliances: Clear plastic tooth-moving appliances (**Figure 21**) are excellent options for patients with mild to moderate alignment issues who prefer not to wear fixed appliances. Essix tooth movement employs a unique biomechanical system using a thin, durable, and nearly invisible removable plastic appliance.[83]

Figure 21: Clear aligners
Courtesy: https://zaradental.com/essix-retainer/

The efficiency of torque achieved with Essix appliances surpasses that of edgewise brackets, as torque is limited by the length of the clinical crown in millimeters rather than the width of a rectangular bracket slot measured in thousandths of an inch.[84]Torque is generated by creating a force-inducing projection in the plastic using Hilliard Thermo-pliers (**Figure 22**) or by applying composite molding on both the labial and lingual surfaces of the target tooth simultaneously. Additionally, clinicians utilize a block-out material on the cast to facilitate tooth movement.[85]

Figure 22: Torque forming pliers
Courtesy: https://www.ebay.com/itm/204251211841

Torque Expression of Self-Ligating Brackets: Self-ligating brackets (**Figure 23**) generally fall into two design categories based on how the slot closes: active and passive.[86] Research by Badawi and colleagues investigated the differences in third-order moments produced by engaging 0.019 x 0.025-inch stainless steel archwires in both types. Their findings indicated that active self-ligating brackets provide superior torque control, as the active clip firmly presses the wire into the bracket slot, reducing movement between the archwire and bracket.[87] While passive self-ligating brackets demonstrated lower moments at smaller torsion angles, they produced higher moments at greater torsion angles, which are not clinically advantageous.[88] In contrast, active self-ligating brackets exhibited a wider range of clinically relevant torque activation and enhanced torque expression at pertinent torsion angles (0°-35°).[89]Thomali et al. evaluated torque expression in both active and passive self-ligating brackets, finding only minor differences between them. They also noted that torque expression increased with larger engagement angles and bigger slot sizes.[90]

Figure 23: Torque capabilities of self ligating brackets
Courtesy: Siva S, Kishore S, Dhanapal S, Ravi J, Suresh C. The Value of Self-Ligating Brackets in Orthodontics: About the Damon Protocol [Internet]. Dentistry. Intech Open; 2022.

Future Prospects: The future of orthodontics is poised to revolutionize precision through innovative applications of torque.[91] Advancements in bracket design, wire technology, and digital tools are transforming how we achieve controlled and predictable tooth movements. Cutting-edge materials for arch wires and brackets will greatly enhance torque expression and resistance to deformation, leading to more reliable outcomes. [92]The emergence of three dimensional (3D)printing (**Figure 24**) enables orthodontists to create customized appliances tailored to each patient's unique anatomy, optimizing torque application for truly personalized care.[93]

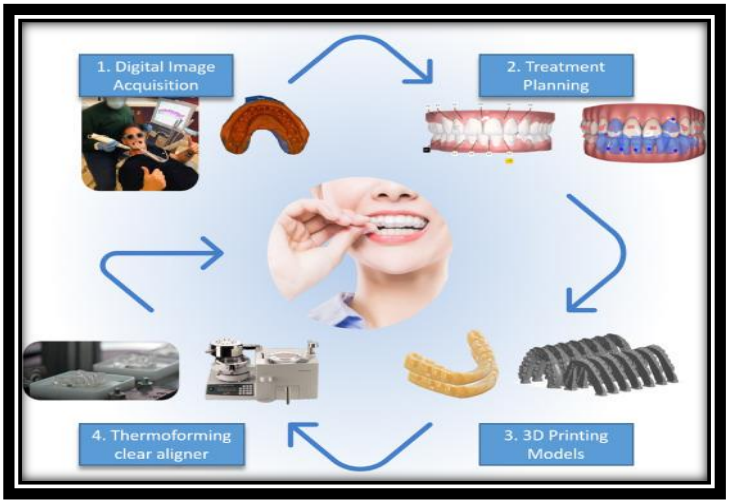

Figure 24: 3D printing in orthodontics
Courtesy: Bichu YM, Alwafi A, Liu X, Andrews J, Ludwig B, Bichu AY, Zou B. Advances in orthodontic clear aligner materials. Bioact Mater. 2023; 22:384-403.

Enhanced imaging and simulation software will provide crucial insights into torque dynamics, allowing for precise adjustments that maximize treatment effectiveness.[94] Additionally, the introduction of smart orthodontic brackets equipped with sensors offers real-time monitoring of torque application, facilitating dynamic adjustments based on each patient's needs throughout their treatment journey.[95] Ongoing research into the biological responses of dental tissues to torque forces is vital for developing techniques that minimize risks, such as root resorption, while maximizing treatment efficacy.[96]Collaboration among orthodontists, periodontists, and other dental specialists will foster comprehensive strategies for torque management, ensuring both aesthetic and functional outcomes are achieved without compromising dental health.[97]Incorporating patient feedback into treatment planning will enhance satisfaction and compliance, ultimately leading to superior results. By leveraging these innovations and refining torque application, orthodontics is set to deliver more precise, effective, and aesthetically pleasing results, empowering patients to achieve the smiles they desire with confidence and ease.[98]The horizon of orthodontics is bright, with the potential to redefine care standards and elevate patient experiences for generations to come.[99]

CONCLUSION

Torque, often seen as a complex challenge in orthodontics, can be mastered with a thorough understanding and systematic approach. The operator's ability to control torque is essential for achieving not just basic alignment but aesthetically pleasing results. Innovations in materials, 3D printing, digital treatment planning, and smart bracket systems are enhancing torque precision and treatment outcomes. Ongoing research and interdisciplinary collaboration are key to developing refined techniques that minimize risks while maximizing effectiveness. By focusing on patient-centered care and incorporating feedback, the orthodontic field can deliver more effective treatments and improve patient satisfaction. Embracing these advancements will transform orthodontics, enabling practitioners to meet both functional and aesthetic goals, ultimately redefining care standards and empowering individuals to achieve their desired smiles with confidence.

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