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Review Article

Importance of frictional forces in orthodontic treatments: A review article

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Abstract

The resistance to slipping in Orthodontics is influenced by multiple factors. It is directly impacted by the kinds of materials employed and influences the efficiency of orthodontic tooth movement. The biological factors affecting friction appear to have been ignored by orthodontists. Basic elements like the buildup of debris on the wire surface and the biodegradation of brackets noted after intraoral application may be as significant as the material type when evaluating friction in Orthodontics. Recent advancements in manufacturing methods for new and innovative orthodontic materials have resulted in reduced frictional resistance compared to similar products tested previously. Accurately assessing the various factors influencing the frictional resistance in orthodontic sliding mechanics within a clinical context is challenging. This is additionally complicated by the presence of numerous orthodontic devices, along with a significant diversity in the biological characteristics of patients. It has been proposed that, in clinical settings, these forces might be overvalued due to frictional resistance and are lower than those observed in steady-state laboratory tests. The decrease in the force exerted due to friction in sliding mechanics has been acknowledged for quite a while. Even more crucially, to avoid unwanted tooth movement and guarantee ideal tooth movement, it is essential to comprehend and manage friction.

Keywords: Frictional force, Sliding mechanics, Orthodontic tooth movement.

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1. Introduction

In the modern world, appearance and aesthetics are essential in everyone's life. Orthodontic treatment focuses on enhancing a patient's appearance through smile adjustment using the application of regulated force. This is accomplished through the use of different archwires and orthodontic brackets. The interaction of archwires and brackets produces frictional forces. If not controlled and accounted for, these frictional forces could negatively impact the treatment plan. The characteristics of friction in orthodontics are influenced by various mechanical and biological factors. Friction in orthodontics plays a crucial role that affects the effectiveness of tooth movement and the overall outcome of orthodontic treatment.[1]

Friction is the opposition to movement that happens when one object slides along another tangentially. The growing fascination of patients with orthodontic equipment that is more discreet and can provide quicker positive outcomes has resulted in the creation of numerous substitutes for traditional orthodontic tools, such as the aesthetic design of brackets and the ligation system.[2]

Friction is a force between two surfaces that are sliding, or trying to slide across one another, for example when you try to push a toy car along the floor. Friction always works in the direction opposite from the direction the object is moving, or trying to move. It always slows a moving object down. The amount of friction depends on the materials from which the two surfaces are made.[3]

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2. Frictional Force in Orthodontics

Frictional force is present in the all stages of the orthodontic therapy notably during the closure of spaces, and it must be controlled because it hinders the movement of teeth. When the friction is high, there will be a slow progress in the therapy and an increase in treatment time. Therefore, the orthodontist should apply a higher force to overcome the force of friction, but this is contradictory to the recommendation of using a light force for the initiating and maintaining the tooth movement, the light force is important for the optimal biological response that lead to effective movement of teeth additionally, the use of high force to overcome the friction during anterior teeth retraction may increase the risk of posterior anchorage loss.

FE = FA – Frictional force (FF)

The frictional force make the effective force lower than the applied force, and when the spring apply a force equal to the frictional force, the tooth will not move.[4]

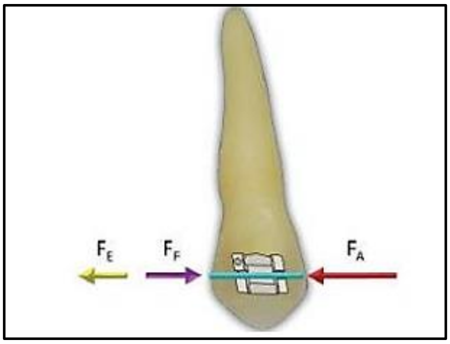

Figure 1: The tooth feels only the effective force (FE)

Asperities: Every surface is somewhat uneven, and the physical understanding of friction relies on the actual contact area, which is influenced by surface asperities and the pressure that compels the surfaces to come together.[5]

Asperities play an essential part in comprehending the mechanisms of friction, particularly in the study of surfaces in contact. When two solid surfaces are brought together, they may appear smooth at a macroscopic level. However, on a microscopic scale, these surfaces are irregular, composed of numerous tiny projections and rough spots known as asperities. The interaction between these asperities forms the foundation of how friction arises, making them central to the field of tribology.[6]

Despite surfaces appearing smooth to the naked eye, under magnification, they reveal a landscape of uneven structures that make up the real area of contact. These contact points, or asperities, significantly impact the way two surfaces interact and slide past each other. In this context, examining the role of asperities in friction becomes essential to understand the mechanics behind everyday interactions between materials.[6]

When an archwire moves through the bracket, asperities on the wire and bracket interlock, creating static friction. Once movement begins, the asperities slide over each other, generating kinetic friction. If the asperities are significantly large or numerous, the frictional force will be higher, impeding the desired movement of the teeth. Conversely, smoother surfaces with smaller asperities generate lower friction, which is more desirable in orthodontic treatment.[6]

3. Friction and Sliding Mechanics

Tooth movement in orthodontics for closing spaces can be achieved using two distinct types of mechanics. The initial method is the "Segmented Arch Mechanics" (SAM), which involves bending loops made from stainless steel (SS) or titanium molybdenum (TMA) wires. When SAM is applied, the tooth or set of teeth shift because of the force to moment ratio produced when the loops are activated. SAM is referred to as "frictionless mechanics" since the brackets and tubes remain stationary on the archwire. Another space closure method utilized in Orthodontics is Sliding Mechanics (SM), which entails the real sliding of brackets and tubes along the wire. Orthodontic tooth movement is governed by two main mechanisms: sliding mechanics, also known as friction mechanics, involve multiple teeth being pushed together straightly with a wire of the same size for each bracket.

Although sliding mechanics is straightforward, the occurrence of friction between the wire and bracket surfaces is inevitable. Segmental mechanics, popularly referred to as frictionless mechanics, use selective forces to move single segments of teeth. This technique involves bending specific parts of the archwire, which reduces friction and affords greater control over individual tooth movements. Different factors such as the complexity of the case, the need for reduced treatment time, and the type of desired tooth movement pattern influence the choice between these techniques.[8]

As the orthodontic wire moves through the bracket slot and tubes, there is always some resistance encountered at the interface between the bracket and wire. This occurrence is noted during leveling, alignment, space closure, and also during torque expression at the treatment's conclusion. A portion of the orthodontic force exerted on the teeth is lost as static friction, while the remaining force is conveyed to the tooth and its periodontium, resulting in the true OTM.[9]

3.1. Friction between brackets and archwires

Directing a tooth along an archwire can be categorized into four sequential phases:[10]

1. Phase I: Prior to the application of force in the mesiodistal direction and upon finishing the leveling stage, the archwire is positioned in the slot without any interference.

2. Phase 2: Alongside the application of force in the mesiodistal direction, the tooth tips and rotates as the force application point is positioned above and buccal to the center of resistance (lower canines).
3. Phase 3: Continuous force application sets an elastic deformity in the archwire. The load at the contact points between wire and bracket increases as well as the friction. Thus, a portion of the mesiodistal force is lost. This elastic deformity concurrently produces antitip and antirotational movements of the tooth.
4. Phase 4: In an uneven scenario, a lasting distortion of the archwire may occur. Clearly, the second scenario should be evaded. Arch-guided tooth movement involves successive motions of tipping and upright positioning (Phase 1 to 3).[11]

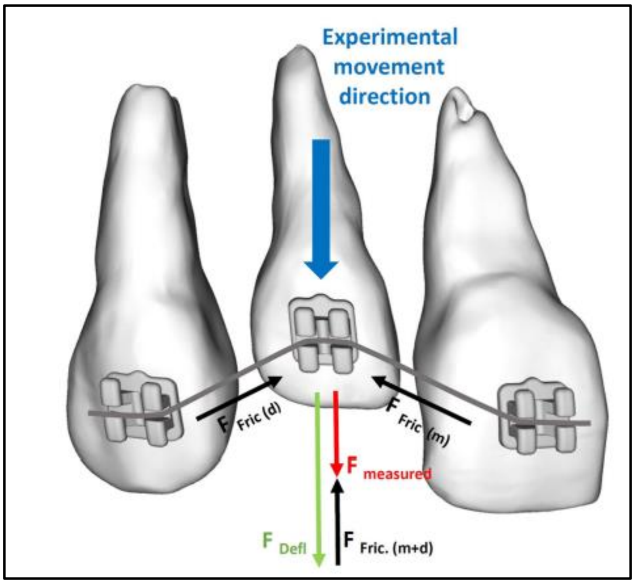

Figure 2: Force vectors acting on bracket and archwire

The friction system is characterized by the presence of a specific level of friction between the wire and the bracket. In sliding mechanics, to shift a tooth along an arc, a significant force must be exerted to counteract friction and initiate the tooth's movement. The main challenge lies in assessing the appropriate magnitude of this force. If the force is excessive, the posterior segment unintentionally shifts mesially, stressing the anchorage.[12]

3.2. Methods of anterior teeth retraction in sliding mechanics[13]

There are two ways in which anterior teeth are retracted:

1. By retracting the canine first followed by retraction of other four anteriors enmasse.
2. Enmasse retraction of six anterior teeth.

3.3. Force delivery systems in sliding mechanics

Composition and structure: Elastomeric modules and E-chains consist of polyurethanes, which are polymers that set thermally. The polymers exhibit rubber-like elasticity and feature long chains that are lightly cross-linked. The connections between chains should be limited in number to allow for significant stretching without breaking primary bonds.

E-chains:[14] It was launched in 1960 and utilized in orthodontics for retracting canines, closing diastemas, correcting rotations, and constricting arches. Elastic chains are frequently utilized in orthodontics for movements of teeth within the arch. The elastic chain serves as the force element of the retraction assembly, and the interaction between the wire and bracket generates a moment component. Polyurethane chain elastics are commonly used in orthodontics. Elastic chain is not recommended for closure of large spaces.

Figure 3: E-chain

Table 1: Advantages and disadvantages of E-chains

Advantages	Disadvantages
Affordable Quite clean	Water and saliva are absorbed, leading to permanent staining.
Can be effortlessly used without removing the arch wire	Stretching leads to lasting distortion.
No patient collaboration needed	

Elastic module with ligature: This method was popularized by *Benett & McLaughlin*. Two methods of placing active tie backs with elastic modules are

Type 1 - Active tiebacks: This is the method that is used most often. The .019x .025 rectangular steel arch wire is installed with modules or wire ligatures on every bracket. The elastomeric unit is connected to the hook of the first or second molar. A .010 ligature is utilized, with one end positioned under the arch wire. This enhances the stability of the active tieback and aids in preventing the ligature wire from contacting the gingival tissues. An elastomeric component is expanded to double its size.[16]

Table 2: Advantages & disadvantages of tiebacks type 1

Advantages	Disadvantages
The tiebacks are tensioned during installation, applying immediate stabilizing force to the wall or structure.	Continuous force may be too strong they can apply uncontrolled or excessive force if not carefully monitored.
This helps control deflections and movements right from the beginning	Elastomeric chains lose force rapidly due to oral environment (saliva, temperature, chewing)

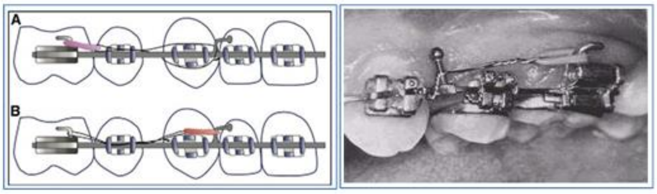

Figure 4: Active tiebacks (Type 1)

Type 2- Active tiebacks:[15] This follows the same principle as type 1, but the elastomeric module is attached to the soldered brass hook on the arch wire. The .019x.25 rectangular steel arch wire is placed with elastomeric modules or wire ligatures on all brackets, except the premolar brackets. The first or second molar hook is connected to a.010 wire ligature, which is connected to an elastomeric module on the arch wire hook after the wire has undergone multiple twists. Lastly, the tieback and arch wires are covered by a standard module that is positioned on the premolar brackets.

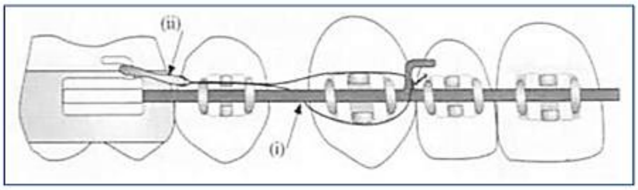

Figure 5: Active tiebacks (Type 2)

Table 3: Advantages & disadvantages of tiebacks type 2

Advantages	Disadvantages
Unlike Type 1 (which may have uncontrolled or degrading force), Type 2 systems allow for precise force application.	More complex to adjust: requires more precise clinical technique to activate and control force levels.
Helps prevent unwanted movement of anchor teeth (e.g., molars). Especially useful in maximum anchorage cases or when using TADs (temporary anchorage devices).	If not properly adjusted, forces may still be too high or too low, leading to inefficient or undesired tooth movement.

Closed coil springs:[16] In the field of orthodontics, coil springs were first used in 1931. The spring's properties may change slightly from those of wires made of the same material since the material is subjected to winding during the production process, which involves both torsional and tensional components. Co-Cr Ni alloy, NiTi, and stainless steel are among the different materials that have been utilized to make springs. Springs made of stainless steel coils Retraction can be accomplished effectively with stainless steel coil springs. They employ more consistent force levels than the previously discussed elastic-based devices. They're simple to use. When compared to springs made of other materials, such as NiTi, stainless steel springs exhibit a comparatively higher rate of load deflection.

Figure 6: Closed coil springs

Table 4: Advantages & disadvantages of coil springs

Advantages	Disadvantages
They provide a consistent and predictable force over time, which is essential for effective and safe tooth movement.	The spring ends or hooks may irritate cheeks or lips if not properly placed or if the patient has a sensitive mucosa.
Closed coil springs are compact and can be used in limited spaces within the oral cavity.	If not securely attached, the spring can dislodge during chewing or brushing.
Made from materials like stainless steel or nickel-titanium, they are resistant to deformation and maintain their elasticity over longer periods.	Although generally stable, some materials (especially cheaper versions) may lose elasticity over time.

Niti closed coil springs: They typically close distance with a single activation and apply a steady amount of force until they reach the terminal end of the deactivation stage. They are offered in 9 mm and 11 mm lengths. Extending springs beyond the manufacturer's recommended dimensions (22 mm for 9 mm springs and 36 mm for 11 mm springs) is not advised. Incisor torque may be lost if voids are closed too quickly, and it may take several months to recover.[17]

Figure 7: Niti closed coil springs

Table 5: Advantages & disadvantages of NiTi coil springs

Advantages	Disadvantages
It is simple to install and remove without removing the arch wire	Relatively unhygienic compared to elastic force systems
It doesn't require reactivation at every visit.	
Cooperation from the patient is not necessary.	

Direct headgear retraction: To slide them distally, J hook headgear—either the high pull or straight pull variety—is fastened to the arch wire midway to the canines. Compared to the high pull style, straight pull headgear enables faster canine retraction. On the other hand, this could result in adverse occlusal plane rotations and anterior extrusion. This could be particularly problematic when the maxillomandibular angle is high. More body retraction may result from high pull headgear. It is less effective for distal movement, though, and requires extended wear or spans of time to have noticeable effects. Depending on the specific needs of the situation, the force direction during retraction can be changed from high to straight pull.[18,19]

Figure 8: J hook headgear

Hycon device: The apparatus is made up of a centimeter section of rectangular wire measuring 0.021" x 0.025" that has a 7 mm screw device soldered to it. On the molar, the rectangular portion is positioned in the double or triple tube and bent distally. Ligature wire is attached to the screw head loosely. After that, the ligature wire is stretched forward and fastened to the archwire hook. The patient is given instructions to use a tiny screwdriver to turn the bolt for space closure. When space closure is difficult due to high friction, increased bone density, or constriction of the alveolar process at the extraction site, the Hycon Device can be utilized as an alternate technique.[20]

Table 6: Advantages & disadvantages of direct headgear retraction

Advantages	Disadvantages
Anchorage conservation is beneficial.	Compared to other canine retraction techniques, this is slower since force application is sporadic. Largely reliant on patient compliance.
It is possible to use head gear to support the molars further.	
Because of the distal force and binding of the arch wire, overjet reduction may occur during canine retraction.	In contrast to other systems, the correction of the buccal and molar segments typically occurs later in the course of treatment.
Suitable for simultaneous use on both the upper and lower arches.	The straight pull headgear may cause anterior extrusion and canine tilting.

Table 7: Advantages & disadvantages of hycon device

Advantages	Disadvantages
The Hycon gadget has an activation length of 0.35mm that can be achieved with a single 360° rotation of the screw. This enables the delivery of a precise space-closing activation while maintaining a relatively high force level across a little distance.	Invasive compared to purely dental anchorage systems.
Excellent Anchorage Control: Uses skeletal anchorage (TADs) to prevent mesial movement of molars during anterior retraction. Great for cases requiring maximum anchorage.	Needs proper planning and placement for optimal biomechanics. More suitable for experienced clinicians.

4. Factors Affecting Friction

4.1. Archwire wire material

1. Stainless steel: This material is widely used due to its strength and rigidity. While it effectively transmits forces, stainless steel wires tend to produce higher friction compared to other materials, which can slow down tooth movement.
2. Nickel-titanium (NiTi): NiTi wires are known for their superelastic properties, allowing them to exert a consistent force over a range of movements. They generally exhibit lower friction than stainless steel, particularly in the initial stages of treatment, making them ideal for achieving efficient tooth movement.
3. Beta-titanium: This material combines the advantages of stainless steel and NiTi, providing a balance of strength and flexibility. It often results in moderate friction, which can be beneficial in specific clinical scenarios.

4. Titanium molybdenum: TMA wires outperformed SS and NiTi wires of the same diameter in terms of frictional resistance. Due to the fact that thicker wires fit into bracket slots and require more force to move orthodontic teeth, the impact of wire size on friction increases.[21]
5. AJ Wilcock: AJ Wilcock, since we can regulate the movement of our teeth in three dimensions. When torque control is not a top priority, 0.018" SS (3M) can be utilized for incisor retraction rather than 0.018" AJ Wilcock in cases of highly proclined incisors.[22]
6. PTFE/ Teflon coated: PTFE is an anti-adherent substance that demonstrates exceptional mechanical stability as well as excellent chemical inertia. It is produced via a sintering process and comes in two varieties: expanded PTFE (ePTFE), which is microporous, and traditional PTFE, which is not (Teflon). Solid connections hold the orientated microfibrils that make up ePTFE together.[23]

4.2. Brackets

Today we have multiple of options for selecting the brackets. No doubt the most popular bracket material remains the stainless steel however the sintered variety has overcame the conventional cast stainless steel. When esthetics comes to play a significant role ceramic brackets which are available in the monocrystalline and polycrystalline forms.

1. Conventional stainless steel brackets: According to studies on frictional forces, the typical cast stainless steel brackets had mean frictional forces ranging from 40 to 336 gm. A number of bracket wire combinations made of stainless steel produced frictional forces that were below 110g. Significant friction reduction can also be achieved by adding extra design elements to the bracket bumps on the floor and bracket slot walls.
2. Ceramic brackets: Ceramic brackets demonstrated significantly higher frictional forces than with stainless steel brackets with most of the wire size and alloy combinations in both 0.018" and 0.022" slots. This difference in friction is attributed to the characteristics of the ceramic bracket the scanning electron micrographs material or slot surface texture. Because of the high magnitude of the frictional forces with ceramic brackets greater force is needed to move teeth in sliding mechanics. Ceramic brackets provide an aesthetic alternative but often come with drawbacks. They tend to have a rougher surface texture compared to metal brackets, which increases frictional resistance. This higher friction can hinder efficient tooth movement and may necessitate more force for the same displacement, potentially prolonging treatment time.
3. Zirconia brackets: The brittle nature of ceramic brackets allows even the smallest surface crack or flow to spread quickly within the material. Zirconia brackets have been proposed as a substitute for ceramic brackets because zirconium oxide can undergo surface hardening treatments to improve fracture toughness. However, in both wet and dry conditions, zirconia brackets' frictional coefficients are found to be greater than or equal to those of polycrystalline alumina brackets.
4. Composite brackets: Made from resin-based materials, composite brackets can vary widely in their frictional characteristics depending on their surface treatment and design. While these brackets are often used for their aesthetic benefits, they can exhibit increased friction due to surface roughness and other factors. Their frictional properties can also differ based on the bonding technique employed during their application.

5. Recent Advances in Orthodontics to Reduce Friction

5.1. Brackets

The golden standard materials to perform sliding mechanics is the combination of stainless steel brackets and wires.

1. Titanium-coated orthodontic brackets: Because titanium coatings are biocompatible, they are employed. The TiO2-thin-film-coated bracket effectively inhibits S. mutans adhesion. Against S. mutans, L. acidophilus, A. viscous, and C. albicans, it exhibits strong antibacterial activity. Additionally, this stops gingivitis and enamel demineralization that happen during orthodontic therapy. TiO2 nanoparticles are utilized as lubricants and provide a protective layer on rough surfaces, lowering the coefficient of friction.
2. Silver-coated orthodontic brackets: Silver coatings are frequently utilized because of their exceptional antibacterial and antibiotic properties. The hardness and wear resistance of the silver coating are increased by the use of palladium (Pd). Silver coatings have the lowest contact resistance of any metal and minimize friction at high temperatures.[24]
3. Platinum coated brackets: Five times as much abrasion resistance as gold is provided by the platinum-coated brackets. This demonstrates enhanced sliding and less friction. Additionally, it serves as a barrier to stop the diffusion of chromium, cobalt, and nickel.[25]
4. Ceramic brackets with metal slot: Frictional force in ceramic brackets increases with wire size when ligating forces are fairly uniform; it is generally greater with rectangular wire than with round wire, and it is smaller with SS and CoCr wires than with Ni-Ti or 13-Ti wires in most wire sizes. Frictional resistance is significantly higher in ceramic brackets than in stainless steel brackets for most wire size-alloy combinations.[26]

5. Self-ligating brackets (SLB): SLB has been marketed as the latest and greatest advancement in orthodontics. Still, the concept of a self-ligating bracket is not so novel, as some earlier "innovations" have shown. SLB eliminates the need for steel or elastic ligatures by presenting a clip integrated into its buccal surface that locks the wire within the slot and turns the bracket into a tube-like device. The arch wire is not pressed up against the bracket slot's inside walls by the clip that passive SLB presents. On the other hand, wires with larger diameters are forced against the bracket slot by a spring clip seen in active or interactive SLB.[27]

5.2. Ligation methods

1. Polyurethane elastic ligature: A polyurethane elastic ligature presenting a very creative design (Slide®, Leone Ortodonzia e Implantologia, Florence, Italy) is another "new" low-friction material recently introduced in the market. This ligature combined to a conventional bracket forms a tube-like structure. There is significant lower resistance to sliding with the Slide® ligature than with conventional elastic ligatures.[28]
2. Metafasix: A new type of elastic ligature that incorporated a technology named Metafasix® (Super Slick Elastic Modules®, TP Orthodontics, La Porte, IN, USA) was recently introduced. According to the manufacturer, the engineering process is similar to the one implemented to fabricate stents used to treat coronary heart disease, consisting of a water resistance polymeric coating, thus making the elastic ligature extremely slippery in the presence of saliva. Recently, modules coated with covalently bonded Metafasix (Super-Slick, TP Orthodontics, LaPorte, Ind) have been introduced claiming to reduce the friction of ligation by 60% compared with uncoated modules with similar elastic properties.[29]
3. Orthodontic archwires: In orthodontic therapy, a tooth slides along an archwire. In contrast to the movement itself, this action creates a frictional force between the archwire and bracket. Orthodontic force must therefore be greater than this resistance. Friction may cause over 60% of the orthodontic force used to achieve OTM to be lost, which lowers the force used by the fixed appliance. Reduced friction would enable the use of less orthodontic force and provide significant advantages, such as reduced root resorption risk, improved anchoring control, and shorter treatment times.
4. Nanocoatings: Nanotechnology encompasses the use of minute machinery that can manipulate matter on an extremely small scale. Nanotechnology has been widely used for biomedical purposes that range from diagnosis and treatment to the modifcation of medical devices and the facilitation of personalized health care. Nanocoating of wires is performed to increase the efectiveness of brackets and decrease friction on archwires used in traditional orthodontic treatment, and to increase safety and biocompatibility by resisting corrosion and minimizing the precipitation of hazardous materials.

NPs or nanocomposite materials can be applied to archwires. The friction between the wire and the brackets is significantly decreased by these coaings, which are made to be incredibly smooth and long-lasting. These coatings frequently use materials including carbon nanotubes, graphene sheets, silicon dioxide, and titanium dioxide. ZnO-NPs lower the friction coefficient of NiTi wires in addition to lowering WSL and caries. Certain nanocoatings can also lubricate themselves. Over time, they sustain a low-friction interface between the wire and the brackets by releasing lubricant molecules gradually.

Archwire surfaces can be coated with thin films of lubricant polymers that contain mineral nanoparticles (NPs) of boron nitride, molybdenum disulfide, inorganic fullerene-like tungsten disulfde, or certain ceramics. To lessen friction between the sliding surfaces, Te NPs function as tiny ball bearings.[30]

1. Diamond-like carbon (DLC): Diamond-like carbon (DLC): It has been proposed that applying a diamond-like carbon (DLC) surface coating to orthodontic wires made of stainless steel and NiTi will reduce static frictional force. When compared to traditional orthodontic wires, these ions were added to the wire's surface during manufacture, enhancing its hardness and dramatically lowering its SF.[31]
2. IF-WS_2: Inorganic fullerene-like tungsten disulfide (IF-WS,) nanoparticles were first described in 1992. These IF-WS, nanoparticles are multi- layered, onion-like spheres. The IF-WS, 20-200 nm nanoparticles are constructed of multiple layers, which can be represented as a sandwich within the plane. The layers, which covalently bonded S-W-S moieties, are weakly connected by van der Waals forces. This unique structure provides the IF-WS the unique coating of IF-WS_2 nanoparticles embedded in Co matrix demonstrated a significant friction reduction of the NiTi alloy. The IF-WS2 nanoparticles, which are impregnated in the Co coating, are responsible for the coatings' decreased friction. The spherical shape of the IF-WS2 nanoparticles indicates that a rolling friction scenario may potentially occur in this situation, and they also inhibit asperity contact between the bracket and wire surfaces.[32]

6. Discussion

Friction remains a critical factor in orthodontic biomechanics, directly influencing the efficiency, predictability, and duration of treatment. This review highlights how the interplay between mechanical, material, and biological factors determines the magnitude of frictional resistance in clinical practice. While much emphasis has traditionally been placed on mechanical variables—such as wire composition, bracket design, and ligation methods—the biological environment is increasingly recognized as equally significant in modulating friction. Surface alterations due to biodegradation, plaque accumulation, and salivary effects can dramatically change the clinical behaviour of bracket–wire interfaces, underscoring the complexity of replicating oral conditions in vitro.[9] Friction in orthodontics is a multifactorial phenomenon influenced by appliance design, material properties, and the oral environment. While advances such as self-ligating brackets, surface coatings, and nanotechnology have shown potential to reduce resistance, their clinical effectiveness remains variable. Orthodontists should recognize that friction is only one component of sliding resistance and must be managed in balance with biologic principles of tooth movement. Careful selection of appliances, application of light continuous forces, and consideration of patient-specific factors remain essential for optimizing outcomes. Continued clinical research is needed to clarify the true impact of friction-reducing strategies on treatment efficiency and long-term stability.[13]

7. Conclusion

It is debatable if friction is indeed a problem for orthodontics. A physician should, however, see past friction and understand that it is only a minor component of sliding resistance. The methods currently used to investigate how friction affects orthodontic biomechanics are insufficient and do a poor job of simulating oral circumstances. In orthodontics, the resistance to sliding is complex. It has an impact on the efficiency of orthodontic tooth movement and is directly influenced by the kinds of materials utilized. Friction can be detrimental in a variety of clinical settings. In others, though, it might be crucial. The orthodontists appear to have failed to consider the physiologic factors that affect friction. Research on the mechanical or physical factors that affect the creation of friction during OTM is more common than that on the biological factors. Throughout the various phases, they ought to be carefully considered.[9] Friction should be managed at every step of orthodontic treatment, but particularly during the space closure phase, since it prevents teeth from moving freely. A strong resistance to friction may result in slow development and unnecessary prolongation of treatment duration. In order to overcome the frictional force, a practitioner must progressively use stronger mechanical forces over the course of treatment. This goes against orthodontic guidelines that suggest applying light pressure to initiate and maintain tooth movement.[33]

8. Patient Consent and Ethical Approval

NA.

9. Source of Funding

None.

10. Conflict of Interest

None.

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