

## Review Article

### Friction in Orthodontics: A review article

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#### ABSTRACT

##### Aim

Friction is defined as the force that resists a movement when an object moves tangentially against another. As two surfaces in contact slide against one another, various forces arise. Friction is a challenge for the orthodontists specially with sliding mechanics, and must be dealt efficiently to provide desired tooth movements. There are various factors that affect friction such as archwires, brackets and ligation. Greater the diameter of the wire, greater will be the friction because the critical contact angle is met with less tip in the bracket. Ti brackets favored comparably with their Stainless steel counterparts. Ceramic brackets produce nearly twice as much friction compared to the Stainless Steel brackets.

#### INTRODUCTION

Orthodontic tooth movement is dependent upon the ability of a clinician to use controlled mechanical forces to stimulate biologic responses within the periodontium. Although various techniques are available to effectuate tooth movements.

To improve the arch form and dental function, contemporary orthodontists routinely move teeth by attaching brackets to them and activating archwires within the slots of brackets. Once the decision to extract teeth has been made, the orthodontist must plan how to close any space that is not devoted to relief of crowding. Whether anterior retraction, posterior protraction or

combination of both is used, the same basic principles of retraction mechanics apply.

Friction is highly relevant to orthodontic investigation of clinical anchorage requirements because they impact the treatment effects and time efficiency. Currently, engineering science of friction or tribology initiated by Leonardo da Vinci and originally documented by the French physicists **Amontons and de Coulomb** in the 17<sup>th</sup> and 18<sup>th</sup> centuries respectively, is changing rapidly. The laws of friction were largely derived from dry and often straight line sliding of materials.

Early in 17<sup>th</sup> and 18<sup>th</sup> centuries, **Amontons and Coulomb** were formally investigating frictional forces.

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From their efforts, fundamental laws of friction evolved. They are;

1. Friction force (F) is proportional to the applied normal force (N) by the coefficient of friction ( $\mu$ )  $F = \mu n$ .
2. F is independent of the apparent area of contact between two sliding surfaces.
3. F is independent of the sliding velocity (V).

#### **VARIABLES AFFECTING FRICTIONAL RESISTANCE DURING TOOTH MOVEMENT:**

- 1) Archwire.
- 2) Bracket
- 3) Ligation

**Archwires<sup>2</sup>:** Kusy and Whitley described the effects of wire size on friction by describing the critical contact angle between the wire and bracket slot. As the diameter of the wire increases, the free space in the slot decreases and the amount of tip required to achieve the critical contact angle decreases. They claim friction is greater in wires of greater diameter because the critical contact angle is met with less tip in the bracket. In addition to the critical contact angle increasing friction, the larger wires are stiffer and there is a greater likelihood that the slot will cause notching of the wire. Several studies show that rectangular wires produce greater friction than round wires but only in certain circumstances

**Brackets:** Stainless steel has been the most popular material in orthodontics. Kapila *et al*<sup>4</sup> evaluated friction between edgewise SS brackets and orthodontic wires of four alloys (SS, Co-Cr, NiTi, and B-Ti). Mean frictional forces with conventional cast SS brackets ranges between 40 and 336 g. Vaughan *et al*<sup>3</sup> compared the frictional characteristics of sintered SS bracket with an ordinary one. They concluded that kinetic friction

produced by a sintered SS bracket is 45% of the frictional force produced by conventional SS bracket.

With the increase in demand for esthetics in dentistry, orthodontic suppliers have been developing brackets made of different materials that are more esthetic than SS. Ceramic, polycrystalline alumina, single crystal alumina, and polycarbonate brackets have been produced to meet this demand. In addition, titanium brackets are available that claim to be more biocompatible than SS at withstanding the oral environment. Kusy *et al*<sup>5</sup> compared the frictional characteristics of SS and titanium brackets. They concluded that the optical roughness of Ti bracket was more than that of SS brackets. With regard to the coefficient of friction, Ti brackets favored comparably with their SS counterparts. Ceramic brackets produce nearly twice as much friction compared to the SS brackets.<sup>67</sup>

To overcome the increased friction of ceramic brackets, some manufacturers have incorporated a SS slot into the ceramic bracket.

**Ligation:** Edwards *et al*<sup>8</sup> compared the frictional forces produced when elastomeric modules were applied conventionally or in a “figure of 8” configuration, stainless steel ties or Teflon coated ligatures were used for arch wire ligation. The “figure of 8” modules appeared to create the highest friction. Similar observations were made by Hain *et al* who found that the regular module tied in a ‘figure of 8’ pattern produced highest friction. This can be explained on the basis of three point contact between module and arch wire as well as increased stretching of module causing the normal force to increase, which in turn pushes the archwire more firmly against the bracket slot. There was no significant difference in mean frictional force between the conventional module and the SS ligature,

but the Teflon coated ligature had the lowest mean frictional force.

### **Role of friction in eliciting biological response**

Baker *et al.*<sup>9</sup> had studied the effect of saliva on friction and concluded that human saliva reduced the frictional force by 15–19%. However, Kusy *et al.*<sup>10</sup> suggested that saliva can act as a lubricant or an adhesive depending on the archwire-bracket combination. They also said that artificial saliva was the least effective fluid in reducing friction when compared to human saliva and water.

A variable that likely plays a role in orthodontic friction are the forces of occlusion. With teeth contacting thousands of times a day during chewing, speaking, and swallowing, it is likely that the teeth and the orthodontic appliance are repeatedly moving in relation to one another. Braun *et al.*<sup>11</sup> added random perturbations to the bracket or wire to assess their effects on frictional resistance. They found that each time the bracket or wire was tapped, the frictional resistance was essentially reduced to zero. They concluded that, while masticatory forces did reduce frictional resistance, they did so unpredictably and inconsistently.

### **Inhibitors to sliding mechanics**

1. **Occlusal interference** can hinder canine retraction - To prevent this proper aligning and leveling of the arches is required.
2. **Friction and binding** between bracket and archwire may place heavy demand on anchorage. Initially light archwires should be used to tip the canine into a favourable angulation. Later retraction should be started using a heavy rectangular arch wire seated passively into bracket slots. The use of

power arms theoretically causes more bodily movement and hence less binding.

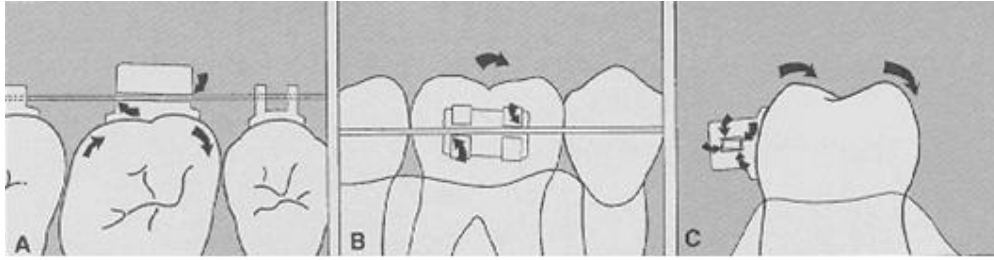
3. **Poor canine control can be a problem:** Doing canine retraction on heavier arch wire reduces the problem.
4. **Cortical plate resistance** (Narrowing of alveolar bone in extraction sites)
5. **Excessive forces causes lower molar tipping** and extrusion of distal cusps
6. **Soft tissue build up** in the extraction side can prevent space closure (or) reopen spaces after treatment.
7. **Rotation of canines** mesio-bucally and molar mesiopalatally

This occurs due to the use buccal traction. It can be prevented simultaneous palatal traction using lingual cleats or buttons.

Canine rotation can be corrected using rotation wedges and molar rotation by placing a mild toe in the wire.

In maximum anchorage cases, TPA, Nance's palatal button, lower lingual arch, headgear or intermaxillary elastics may be used during retraction by sliding mechanics. Molar correction should be done prior to canine retraction to reduce friction. This adds to the treatment period.<sup>4</sup>

According to Bennet JC, McLaughlin RP<sup>79</sup>, There are 3 primary sources of friction during space closure.



**Fig 1.**Sources of friction : A. First order or rotational, B. Second order, or tipping C. Third order or torsional resistance.

8. **First order (or) rotational resistance** at the mesiobuccal and distolingual aspects of the posterior brackets slots is produced by rotational forces on the buccal aspects of the posterior teeth. The most effective way to counteract this resistance is to apply intermittent lingual elastic forces – one month from cuspid to first molar, the next month from cuspid to second molar.
9. **Second – order or tipping resistance** at the mesio-occlusal and distogingival aspects of the posterior bracket slots is caused by excessive and over activated tieback forces, which lead to tipping of the posterior teeth, inadequate rebound time to upright these teeth, and a resultant binding of the system.
10. **Third – order or torsional resistance** occurs at any of the four areas of the bracket slot where the edges of the archwires make contact. Like tipping resistance, this is produced mainly by excessive and overactivated tieback forces, which cause the upper posterior lingual cusps to drop down and the lower posterior teeth to roll in linguallly. during sliding mechanics.

#### **Obstacles to space closure**

McLaughlinRP, Bennet JC, Trivesi HJ<sup>75</sup> found that in almost all cases, space closure is easy and proceeds uneventfully. Only rarely are problems encountered. If it appears that space is not closing as it should (about 1mm per mouth typically), the spaces should be carefully

measured at successive visits. If they are not reducing, or if wire is not appearing gradually from the distal of the molar tube, then possible obstacles should be evaluated before restoring to different mechanics. Obstacles to space closure

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**Inadequate leveling.** The working rectangular wires need to be in place for at least 1 month with passive ties, to ensure proper leveling and freedom from posterior torque pressure. Also, it is important not to attempt overbite correction using reverse curve in the lower archwire at the same time as attempting space closure. Overbite control should be achieved before space closure.



**Fig 2:** Inadequate leveling before space closure

- **Damaged brackets.** Lower first molar brackets can be damaged and partly closed down by excessive biting forces. As a short-term measure, the wire may be thinned in that area, but it is better to replace the molar attachment. The use of first molar non-convertible tubes is recommended, as these are not susceptible to damage in the same way as first molar convertible tubes, and they have other advantages.
- **Incorrect force levels.** Pizzoni L<sup>12</sup> found forces above the recommended levels can cause tipping and friction, and thus prevent space closure. Inadequate force may sometimes be a cause of slow- or non-space closure in adult treatment. Force levels need to be in balance with archwire size and stiffness. If they are not in balance, archwire deflection and unwanted friction can occur. It has been shown that archwire deflection causes friction<sup>8,9</sup>. Also, recent research in Japan<sup>10</sup> has measured the amount of deflection of rectangular archwires in response to typical space closure force. It has been shown that on average 47% more deflection occurs with a .016/.022 wire compared with a .019/.025 wire. Reilly D also stated force level needs to be in balance with arch wire size and stiffness. If they are not in balance, arch wire deflection and unwanted friction can occur.

- **Interference from opposing teeth** (Fig. 7.3). According to McLaughlinRP, Bennet JC, Trivesi HJ<sup>13</sup>, interference from opposing teeth or bracket can prevent lower space closure, and it is necessary to carefully check the occlusion. In the past this was often related to vertical bracket-positioning errors in the upper arch. The use of gauges has reduced these errors, and interference is seldom an obstacle now.



**Fig 3:** Interference from the opposing bracket

**Soft tissue resistance.** Gingival overgrowth in the extraction sites can prevent space closure, and can cause space to re-open after appliance removal. It can also be a problem when closing an upper midline diastema. Care is needed to maintain good oral hygiene and avoid too rapid space closure, as these can contribute to local gingival overgrowth. In a few cases, local surgery to soft tissue may be indicated.

## CONCLUSION

Orthodontic treatment in the past used to carry a pretty strong reputation for pain and time. Its amazing how even now, new patients, both kids and adults alike reference this aspect about orthodontics. With time we have tried to win over the situation to some extent.

Light forces on teeth, over the course of time have been proven to move teeth more effectively. Heavy force levels on teeth actually can cause an unhealthy delay in tooth movement. Starting from leveling and aligning. Light forces invokes a force between bone and tooth that

can create a balanced environment for tooth movement. As it proceeds, similar wires can be utilized to further express teeth and allow for more controlled movements as the teeth straighten.

If the teeth, after treatments are not carefully ordered, are not in balance, ultimate result will be unstable. Therefore retraction mechanics should be perfectly balanced in pairs in groups and as a whole for 'Balance' is the greatest word in orthodontics.

The process is easy gaining for both the patient and the orthodontist, with the advent of built in of the essential features in appliance system it becomes cumbersome and more efficient to bring about results. Results, are all we are pursuing for.

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