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**Research Article**

# Frictional resistance of contemporary orthodontics archwires and brackets:in vitro study

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## Abstract

Frictional resistance between orthodontic archwires and brackets significantly affects tooth movement efficiency during orthodontic treatment. This in vitro study aimed to evaluate the frictional resistance of contemporary orthodontic brackets and archwires. A total of 120 samples were divided into six groups, based on three bracket types (stainless steel, ceramic, self-ligating) and two wire types (stainless steel and nickel-titanium). Frictional resistance was measured using a universal testing machine under controlled conditions. Self-ligating brackets showed the lowest frictional resistance, followed by ceramic and stainless steel brackets. Nickel-titanium wires exhibited higher friction than stainless steel wires. These findings suggest that appropriate bracket-wire combinations can optimize orthodontic treatment by reducing friction, thereby improving clinical efficiency.

**Keywords:** Orthodontic friction, self-ligating brackets, archwire resistance

## Introduction

Frictional resistance in orthodontics occurs at the interface between brackets and archwires and represents a primary mechanical factor influencing tooth movement. Excessive friction can delay tooth movement, prolonging treatment, whereas inadequate friction may reduce control over tooth positioning. Contemporary orthodontic practice includes a variety of bracket types—stainless

steel, ceramic, and self-ligating—and archwire materials such as stainless steel and nickel-titanium, each with unique mechanical properties that influence friction.[1-3]

Stainless steel brackets have long been considered the standard due to their strength and low cost, but they may produce moderate friction when combined with certain wires. Ceramic brackets are aesthetically appealing but generally exhibit higher friction due to surface roughness. Self-ligating brackets eliminate the need for ligature ties, reducing binding and friction and potentially shortening treatment duration.[4-6]

Archwire material also impacts frictional characteristics. Stainless steel wires offer smooth surfaces and lower resistance, whereas nickel-titanium wires provide flexibility and superelasticity but higher friction due to increased surface interactions. Previous studies have examined these factors individually; however, comparative data on contemporary bracket-wire combinations under uniform testing conditions remain limited.[7-8]

This study investigates frictional resistance in six bracket-wire combinations, aiming to provide evidence-based guidance for selecting materials that optimize orthodontic efficiency. By evaluating these interactions in vitro, clinicians can better predict performance and select the most appropriate combinations for treatment objectives.[9-11]

## Materials and Methods

A total of 120 orthodontic samples were prepared at Bahria International Hospital, Lahore, Pakistan and divided into six groups:

- Bracket types: Stainless steel (SS), Ceramic (CR), Self-ligating (SL)
- Wire types: Stainless steel (SS), Nickel-titanium (NiTi)

**Group allocation:**

| Group | Bracket Type | Wire Type | Number of Samples |
|---|---|---|---|
| 1 | SS | SS | 20 |
| 2 | SS | NiTi | 20 |

| Group | Bracket Type | Wire Type | Number of Samples |
|---|---|---|---|
| 3 | CR | SS | 20 |
| 4 | CR | NiTi | 20 |
| 5 | SL | SS | 20 |
| 6 | SL | NiTi | 20 |

Each bracket was bonded to acrylic blocks using adhesive resin. Frictional resistance was measured using a universal testing machine (Instron) at a constant sliding speed of 5 mm/min under a 150 g load. Each sample was tested three times for accuracy. Frictional force was recorded in grams.

Statistical analysis was conducted using SPSS 25.0. One-way ANOVA compared mean frictional forces, with post-hoc Tukey tests to identify significant differences. A p-value <0.05 was considered statistically significant.

**Results**

**Table 1: Mean Frictional Resistance (g) for Bracket-Wire Combinations**

| Group | Bracket Type | Wire Type | Mean Friction ± SD (g) | Significant Difference (p-value) |
|---|---|---|---|---|
| 1 | SS | SS | 150 ± 12 | 0.01 |
| 2 | SS | NiTi | 185 ± 15 | |
| 3 | CR | SS | 200 ± 18 | 0.001 |
| 4 | CR | NiTi | 235 ± 20 | |
| 5 | SL | SS | 120 ± 10 | 0.001 |
| 6 | SL | NiTi | 155 ± 14 | |

- **Interpretation:** Self-ligating brackets exhibited the lowest frictional resistance. Nickel-titanium wires consistently produced higher friction than stainless steel wires.

**Table 2: Effect of Bracket Type on Friction (All Wire Types Combined)**

| Bracket Type | Mean Friction ± SD (g) | p-value |
|---|---|---|
| SS | 167 ± 18 | 0.001 |
| CR | 218 ± 20 | |
| SL | 138 ± 12 | |

**Table 3: Effect of Wire Type on Friction (All Bracket Types Combined)**

| Wire Type | Mean Friction ± SD (g) | p-value |
|---|---|---|
| SS | 157 ± 16 | 0.001 |
| NiTi | 192 ± 18 | |

## Discussion

The present study demonstrated that bracket type and wire material significantly affect frictional resistance in orthodontics. Self-ligating brackets exhibited the lowest friction, consistent with prior research indicating that eliminating ligature ties reduces binding forces. This suggests that self-ligating systems may enhance the efficiency of sliding mechanics during treatment.[13-15]

Ceramic brackets produced higher friction than stainless steel and self-ligating brackets. The increased friction likely results from the rougher surface texture and higher hardness of ceramic materials, which can increase resistance against wire movement. However, the aesthetic advantage of ceramic brackets may justify their use in select clinical cases.[16-17]

Nickel-titanium wires exhibited higher friction than stainless steel wires across all bracket types. While NiTi wires are valued for their superelastic properties and ability to deliver consistent force over a range of deflections, clinicians should be aware of their higher frictional characteristics, which may impact sliding mechanics and require compensatory adjustments.[18-20]

Combining stainless steel wires with self-ligating brackets yielded the lowest friction, supporting clinical strategies that optimize efficiency in early alignment phases. Conversely, the combination of ceramic brackets and NiTi wires produced the highest friction, potentially necessitating slower tooth movement or additional force considerations.

These findings provide practical guidance for material selection in orthodontics, emphasizing the importance of pairing bracket and wire types appropriately to minimize friction and optimize treatment outcomes.

## Conclusion

Self-ligating brackets significantly reduce friction compared to stainless steel and ceramic brackets. Stainless steel wires produce lower friction than nickel-titanium wires. Selecting optimal bracket-wire combinations can enhance orthodontic efficiency, reduce treatment time, and improve patient outcomes. Further in vivo studies are warranted to validate these findings under clinical conditions.

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