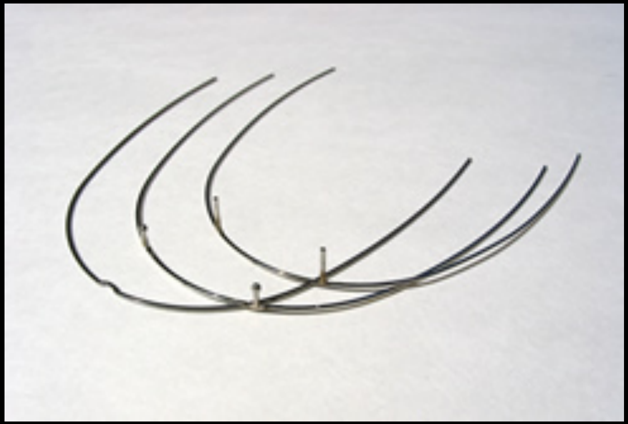
Orthodontic Wires



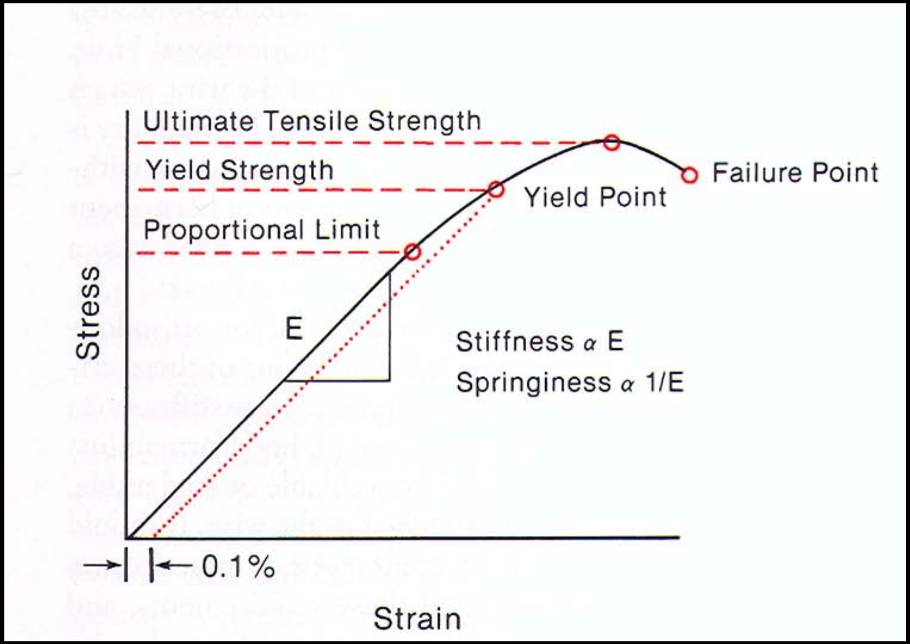
Nabeel F Talic, BDS, MS, PhD, FICD
Associate Professor and Consultant Orthodontist
Department of Pediatric Dentistry and Orthodontics
College of Dentistry
King Saud University

Mechanical Properties

- Strength
- Stiffness
- Range
- Formability

N. Talic

Stress-Strain/ Load-Deflection

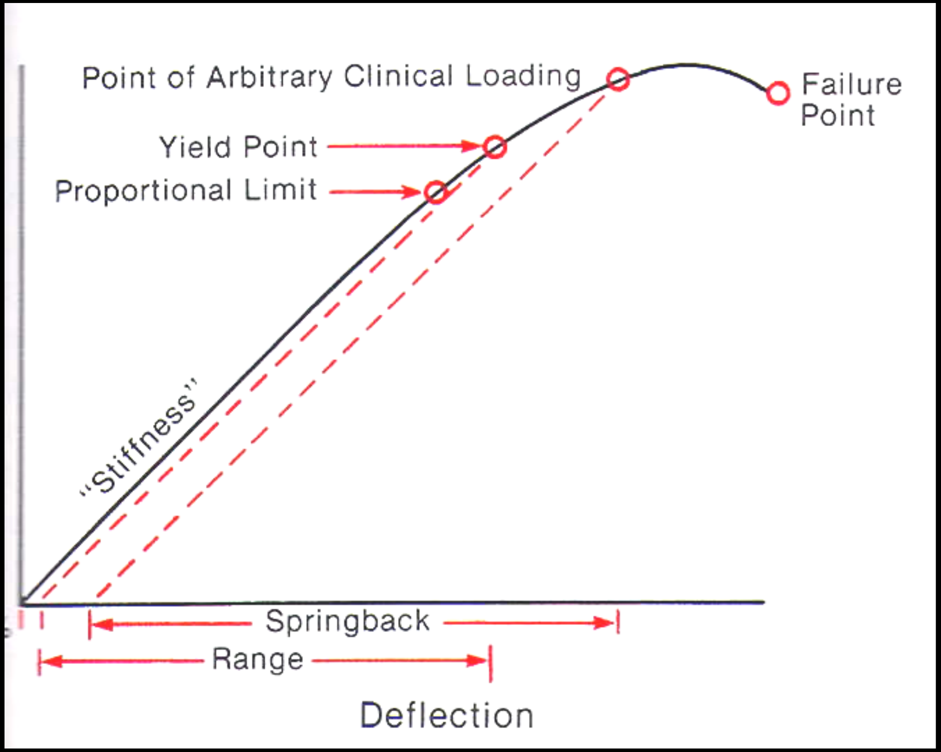


E is reported in gigapascals

1GPa= 10^9 N/m^2 = 10^3MPa = 145,000 psi

N. Talic

Stress-Strain/ Load-Deflection



N. Talic

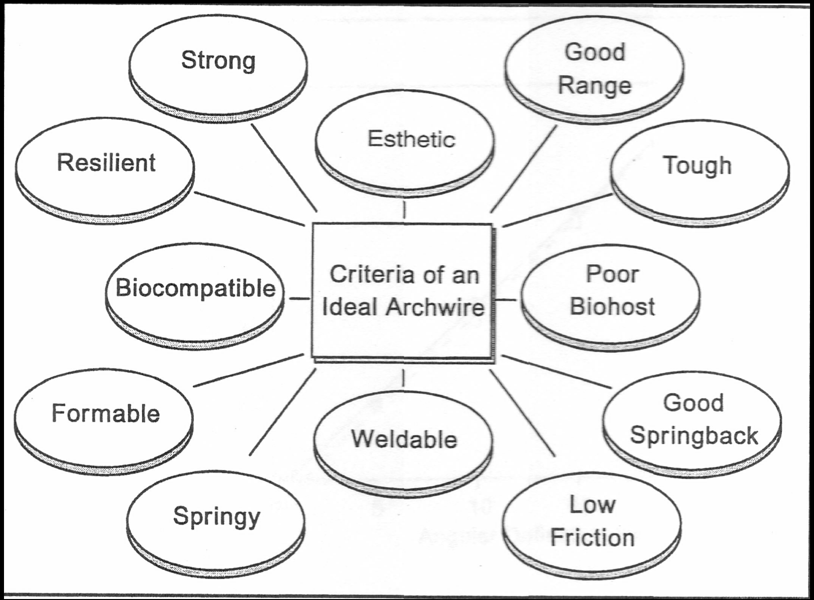
Mechanical Properties

- Strength: The maximum load the material can resist
- Stiffness: Proportional to the slope of the elastic portion of the force deflection curve

  Springiness=1/Stifness
- Range: The distance the wire will bend elastically before permanent deformation
- Springback: the extent to which the range recovers upon deactivation of an activated wire
- Formability: The amount of permanent deformation that the material can take before failing

N. Talic

Properties of Ideal Wire Material



N. Talic

Types of Arch Wires

Material	Coated or non-coated	Morphology
• Stainless steel, Elgiloy, titanium alloys, glass, polymers	• Ion implantation, spray coating, sleeving	• Round, square, rectangular, single, multi-strand

Orthodontic Wires

<u>Metal Wires</u>

Stainless steel

Cobalt-chromium (blue Elgiloy)

β-Titanium Molybdenum (TMA)

Titanium Niobium (TiNb)

Nickel-titanium (NiTi)

<u>Esthetic Wires</u>

Plastic coated wires

Clear Polymer wires

N. Talic

Wire Alloy	Composition (wt%)	Modulus of Elasticity (GPa)	Yield Strength (MPa)[a]
Austenitic stainless steel	17 – 20 % Cr, 8 – 12 % Ni, 0.15 % C (max), balance mainly Fe	160 – 180	1100 – 1500
Cobalt-chromium-nickel (Elgiloy Blue)	40 % Co, 20 % Cr, 15 % Ni, 15.8 % Fe, 7 % Mo, 2 % Mn, 0.15 % C, 0.04 % Be	160 – 190	830 – 1,000
β-titanium (TMA)	77.8 % Ti, 11.3 % Mo, 6.6 % Zr, 4.3 % Sn	62 – 69	690 – 970
Nickel-titanium	55 % Ni, 45 % Ti (approx. and may contain small amounts of Cu or other elements)	34	210 – 410

N. Talic

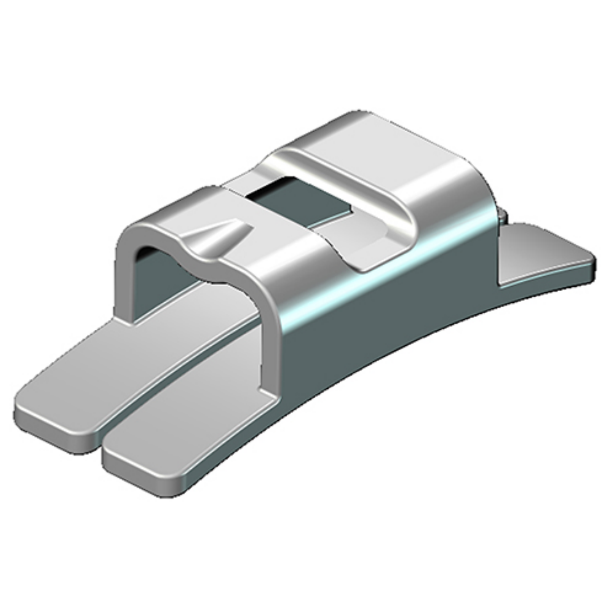
Stainless Steel Wires

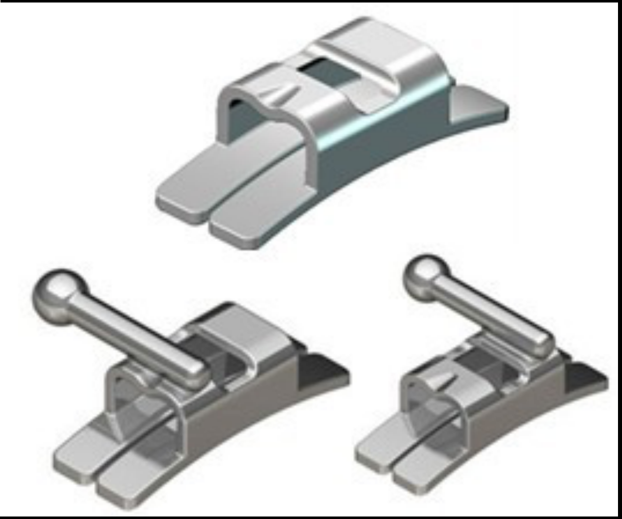
- By 1950s stainless steel alloys were used for most orthodontic wires
- **<u>The most popular wires because</u>**:

☛Low cost

☛Excellent formability

☛Can be soldered and welded





N. Talic

Stainless Steel Wires

- 18-8 type containing approximately 18% chromium and 8% nickel
- Chromium forms a thin adherent oxide layer that blocks the diffusion of oxygen to the alloy
- At least 12-13% is needed to give the necessary corrosion resistance
- Ni is an austenitizing element at room temperature

Cobalt-Chromium-Nickel Wires

- It was developed in the 1950's by the Elgin Watch Company and Rocky Mountain marketed as Elgiloy
- 40% Cobalt, 20% Chromium, 15% Nickel, and 5% Iron
- It can be easily manipulated into desired shapes and then heat treated to increase its strength
- Remaloy (Dentaurum), Bioloy (GAC), Forestaloy (Forestadent)

β-Titanium Wires

- Its marketed by Ormco corporation
- The commercial name is TMA
- It represent titanium-molybdenum alloy
- 80% titanium, 10% molybdenum, 6% zirconium and 4% tin
- The addition of molybdenum stabilize the bcc β-phase form of titanium at room temperature

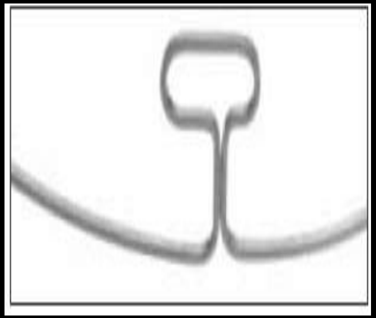
N. Talic

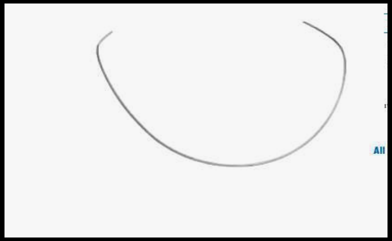
β-Titanium Wires

- Its stiffness is 36 % of stainless steel and blue elgiloy
- The only orthodontic wire with true weldability
- Highly biocompatible (NO Nickel)
- Highly corrosion resistant

Beta-Titanium Wires

- Scanning electron microscope examination revealed rough surface of TMA wires
- This surface roughness contribute to the sliding friction
- A recent development by Ormco of N+ ion implantation technique to reduce friction. They claim a reduction in friction of 54%





N. Talic

Beta-Titanium Wires

N. Talic

Beta-Titanium Wires

Titanium Niobium

- They are composed of Ti 82%, Mo 15 %, Nb 3%
- The bending stiffness is 48 % lower than stainless steel
- They are easy to bend
- The stiffness of ti-nb in torsion is 36% of steel
- They are excellent as a finishing wires

Nickel-Titanium Wires

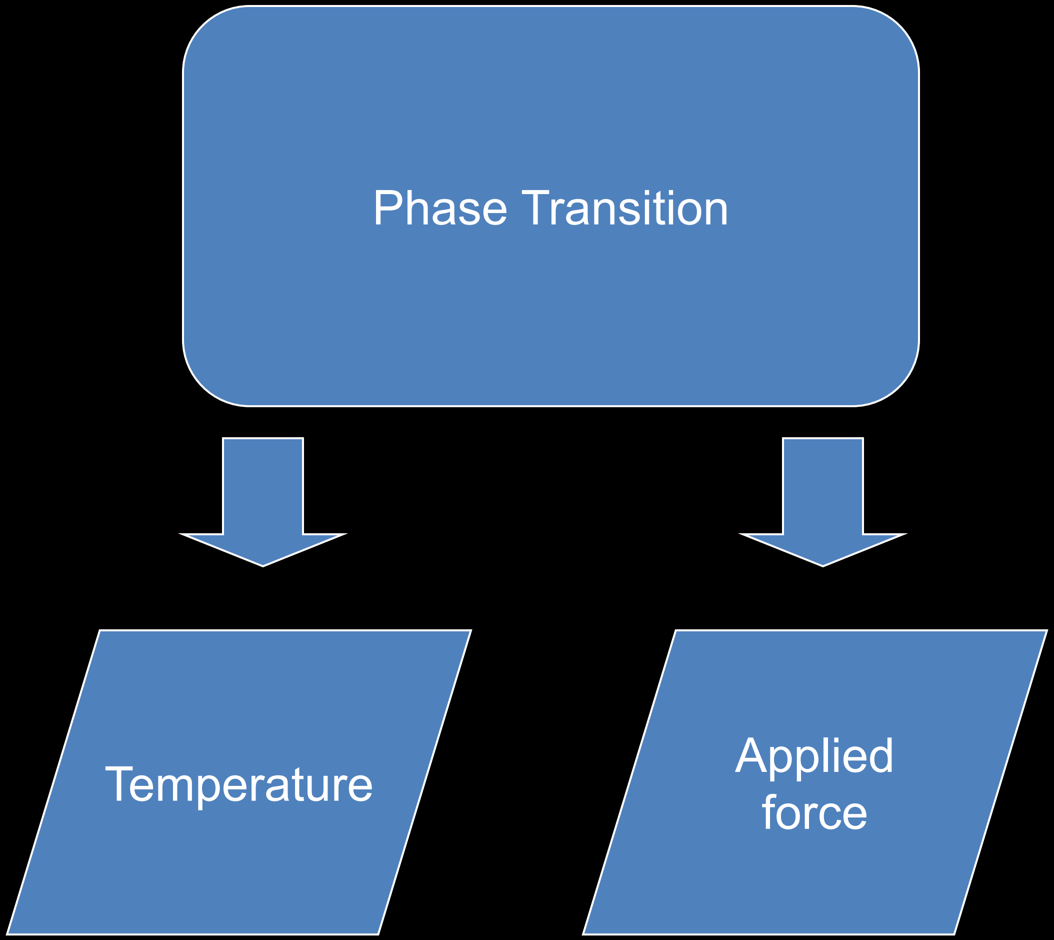
- The pioneer for the development of NiTi wires for orthodontics was Andreason in the 1970’s
- Orthodontic niti wires was first marketed by unitek company under the name of nitinol (nickel-titanium-naval-ordnanace-laboratory)

Nickel-Titanium Wires

It has two important properties:

- Shape memory: the ability of the material to remember it original shape after deformation (thermoelasticity)
- Superelasticity: large reversible strains and modulus of elasticity 17 % of stainless steel

Austenite ⟷ Martensite



N. Talic

Nickel-Titanium Wires (1970’s)

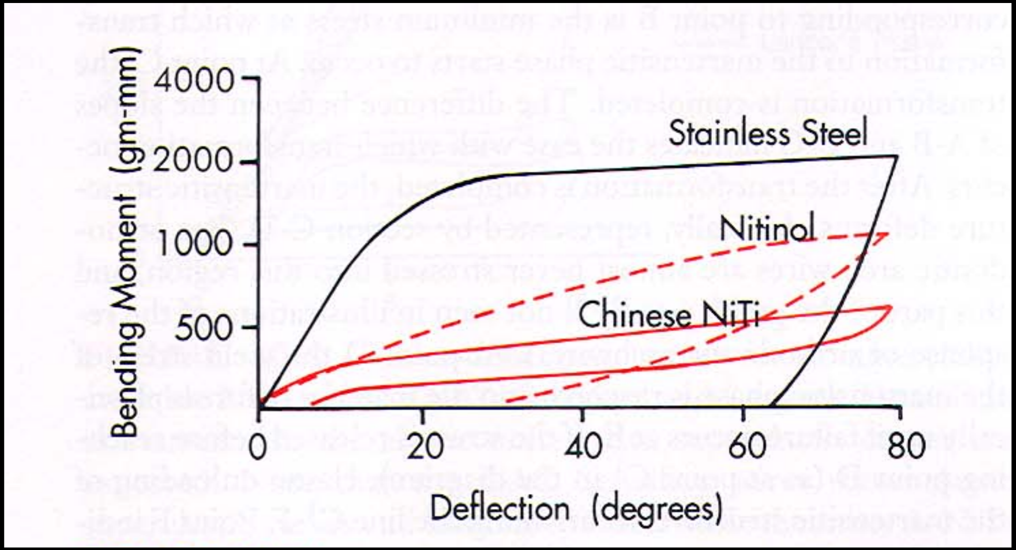
- Niti wires were marketed in a stabilized martensitic form (M-NiTi)
- No phase transition effects
- Low stiffness, high springiness
- Lack of formability was a limitation
- Initially they were brittle
- Nitinol (Unitek), Titanal (Lancer), Orthonol (Rocky Mountain)

Nickel-Titanium Wires

- Superelastic wires were introduced (Pseudoelasticity)
- They are marketed in the active austenitic form (A-NiTi) Austinitic active alloys
- Undergo phase transformation in response to mechanical loading
- Chinese Niti wires (Ni-Ti by Ormco), (Nitinol-SE by Unitek)

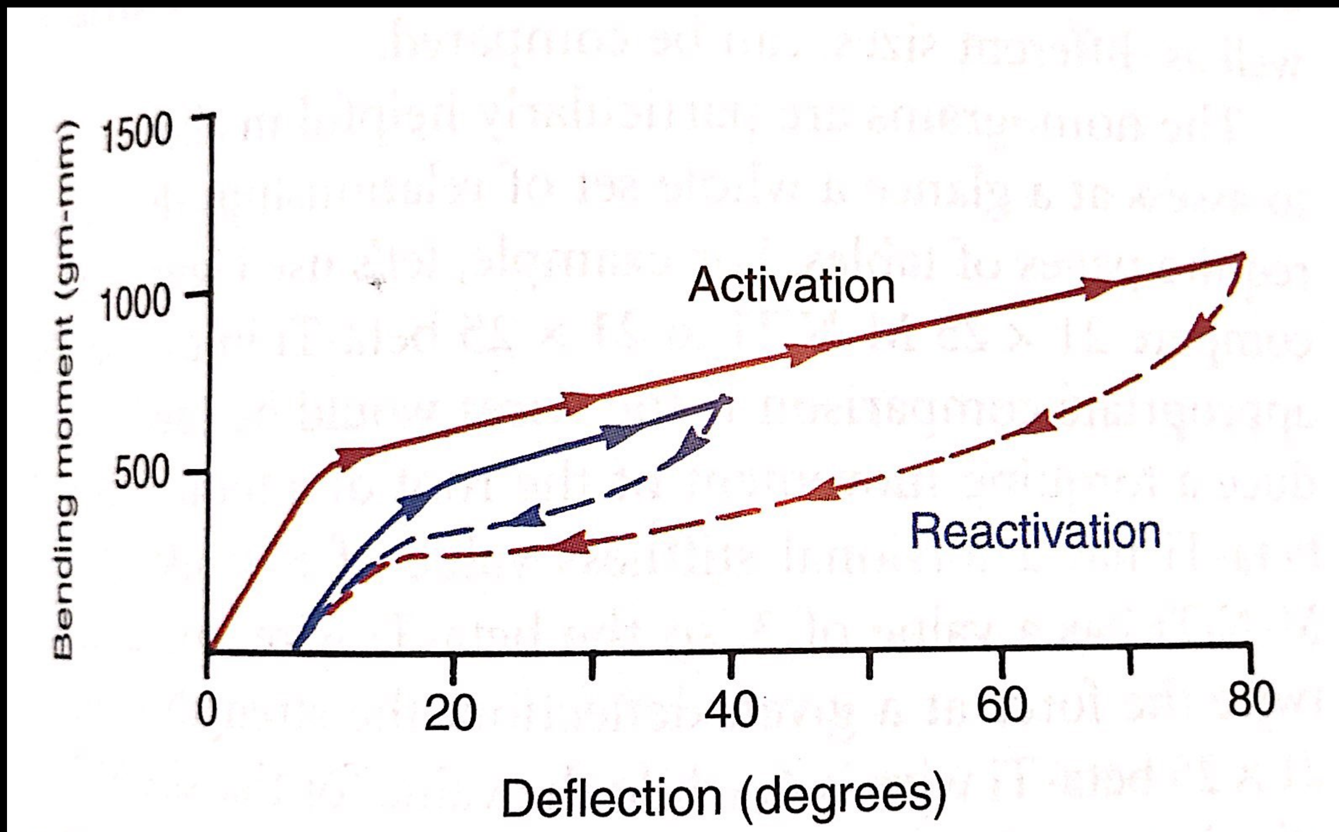
N. Talic

Superelastic A-NiTi



N. Talic

Superelastic A-NiTi



Nickel-Titanium Wires

- Thermoelastic archwires (Martensitic Active Alloys) (GAC, Sentalloy) and (3M Unitek, HA)
- It has 4 times less stiffness
- The phase transformation is triggered by the mouth temperature
- NeoSentalloy has greater heat sensitivity

Nickel-Titanium Wires (1990’s)

- Ormco introduced (Cu-NiTi) thermoelastic, shape memory wires with phase transition
- Copper increase the transformation temperature

Nickel-Titanium Wires (1990's)

- Cu-NiTi is available in three temperature variant of 27˚ C, 35˚ C, and 40˚ C

N. Talic

Nickel-Titanium Wires (1990’s)

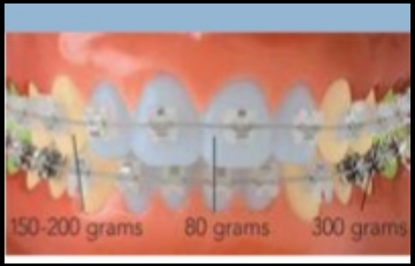
- 27˚ C would be useful in mouth breathers
- 35˚ C variant would be activated at normal body temperature
- 40˚ C variant would be activated only after consuming hot food and drinks, and used in patients that are sensitive to pain or have compromised periodontal support

Nickel-Titanium Wires (1990’s)

- **27˚ C variant contains more chromium 0.5% and less Cu**
- **40˚ C variant contains less chromium 0.2% and more copper**

Bioforce Arch wires

- It produces a gradient of force levels
- It applies gentle and low forces to the anterior teeth
- It applies increasingly higher forces across the posterior and plateauing at the molars



Clinical Selection of Wires

Property	Stainless Steel	Cobalt-Chromium-Nickel (Elgiloy Blue)	β-Titanium (TMA)	Nickel-Titanium
Cost	Low	Low	High	High
Force delivery	High	High	Intermediate	Light
Elastic range (springback)	Low	Low	Intermediate	High
Formability	Excellent	Excellent	Excellent	Poor
Ease of joining	Can be soldered. Welded joints must be reinforced with solder.	Can be soldered. Welded joints must be reinforced with solder.	Only wire alloy that has true weldability.	Cannot be soldered or welded.
Archwire-bracket friction	Lower	Lower	Higher	Higher
Concern about biocompatibility	Some	Some	None	Some

N. Talic

PREVALENCE OF NICKEL HYPERSENSITIVITY AMONG SAUDI DENTAL PATIENTS IN THE RIYADH AREA: a preliminary study

Prevalência de sensibilidade ao níquel em pacientes odontológicos Sauditas na área de Riyadh: estudo preliminar

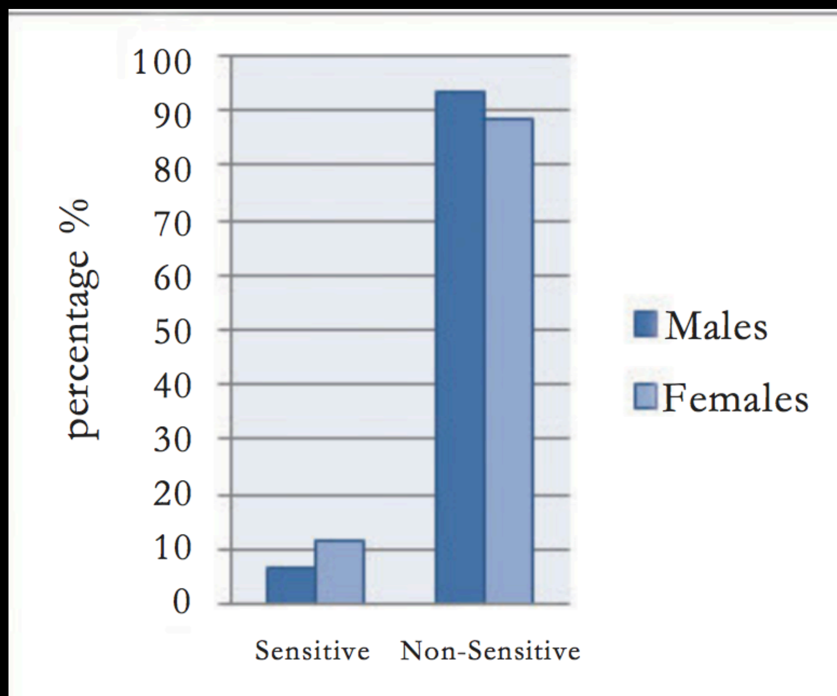
Nabeel Fouad Talic[1], Abdulaziz Al Mudhi[2], Adel Al Enzy[2], Fawaz Al Qahtani[2]

Rev. Clín. Pesq. Odontol. 2007 set/dez;3(3):159-163

Abstract

OBJECTIVES: The aim of this study was to determine the prevalence of nickel hypersensitivity in a sample of Saudi dental patients in Riyadh City. **MATERIAL AND METHOD**: Nickel sensitivity patch testing was performed on a 100 consecutive Saudi patients (50male, 50female) attending the dental clinics at the college of dentistry, King Saud University. The data were analyzed using a t-test to detect differences between males and females. The significance level was set at < 0.05. **RESULTS**: Out of 100 subjects, 88 (45males and 43 females) completed the test by attending the interpretation and photography follow-up examination. A total of eight subjects (9.1%) developed a reaction toward nickel, five females (11.6%) and three males (6.7%). There was no statistically significant difference between males and females. Relative risk for females over males was 1.7. **CONCLUSION**: Nickel hypersensitivity does exist in Saudi dental patients. Females are more likely to develop a hypersensitivity to nickel.

Keywords: Nickel hypersensitivity; Dental patients; Saudi; Riyadh City.



The Saudi Dental Journal (2013) **25**, 129–133

King Saud University
The Saudi Dental Journal
www.ksu.edu.sa
www.sciencedirect.com

ORIGINAL ARTICLE

Nickel and chromium levels in the saliva of a Saudi sample treated with fixed orthodontic appliances

Nabeel F. Talic [a,*], Hasan H. Alnahwi [b], Ali S. Al-Faraj [c]

Abstract *Aim:* The aim of this study was to measure the amount of nickel (Ni) and chromium (Cr) released into the saliva of Saudi patients treated with fixed orthodontic appliances.

Materials and methods: Ninety salivary samples were collected in a cross-sectional manner. Forty samples were collected from patients (17 males, 23 females) with fixed orthodontic appliances after different periods of orthodontic treatment ranging from the first month and up to 32 months into treatment. The fixed orthodontic appliance consisted of 4 bands, 20 stainless steel brackets, and upper and lower nickel titanium or stainless-steel arch wires. The other 50 samples were collected from people without appliances (24 males, 26 females). Samples were analyzed using Inductive Coupled Plasma/Mass Spectrometry and Inductively Coupled Plasma Optical Emission Spectroscopy to measure Ni and Cr levels, respectively. Student's *t*-test was used to compare Ni and Cr levels in the treated and untreated control groups.

Results: The mean Ni level was 4.197 µg/L in the experimental group and 2.3 µg/L in the control group ($p < 0.05$). The mean Cr level was 2.9 µg/L in the experimental group and 3.3 µg/L in the control group ($p < 0.05$).

Conclusion: Fixed orthodontic appliances resulted in a non-toxic increase in salivary levels of Ni, but no change in Cr levels. Duration of orthodontic treatment did not affect Ni and Cr levels in the saliva.

Esthetic Wires

- Coated metal wires
- Transparent non-metallic

N. Talic

N. Talic

Coated metal archwires are nickel-titanium or stainless steel wires treated with:

- polytetrafluoroethylene (PTFE)
- Epoxy-resin
- Parylene-polymer
- Palladium

N. Talic

Coated metal wires

- PTFE, commonly recognized by the DuPont Co. brand name Teflon®, is a synthetic polymer consisting wholly of carbon and fluorine.
- PTFE is nonreactive, heat-resistant, and hydrophobic.
- Most importantly, it has the third lowest coefficient of friction of any known solid, making it ideal for use as a nonstick coating or where sliding action of parts is needed.

Coated metal wires

PTFE coating is applied to an orthodontic wire by thermal spraying, a process in which finely heated materials are sprayed in a molten condition onto a surface to form a coating

Figure 2: High aesthetics of a PTFE-coated FLI® Cu-NiTi wire (Rocky Mountain Orthodontics) with FLI® ceramic twin brackets.

By Neal D. Kravitz, DMD, MS

N. Talic

Coated Metal Wires

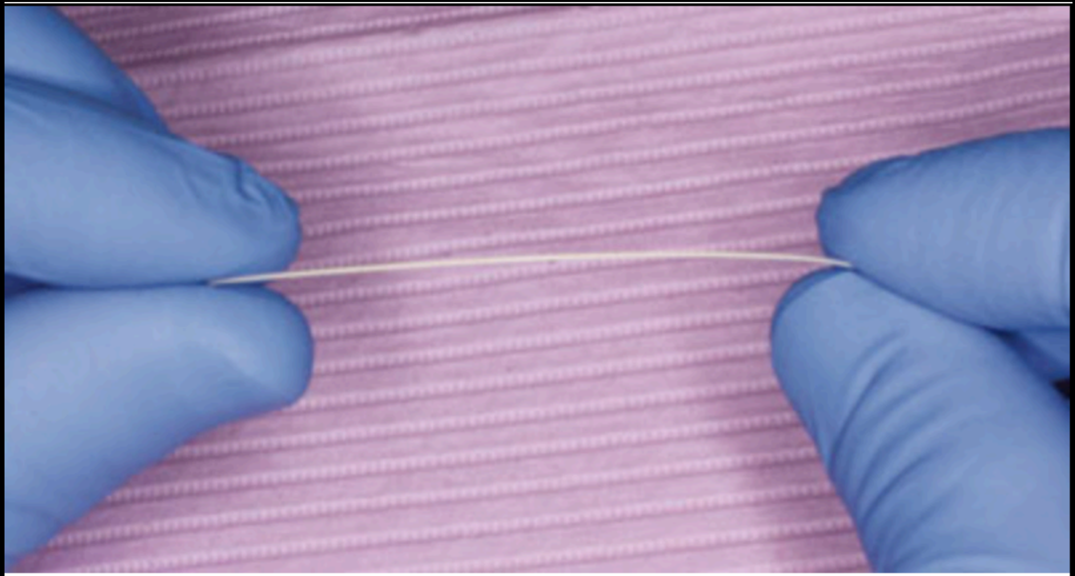


Figure 1: An 0.014-inch PTFE-coated FLI® Cu-NiTi wire (Rocky Mountain Orthodontics). The PTFE coating imparts an enamel hue. Despite the extremely low coefficient of friction of PTFE, the coating is applied only to the labial surface of rectangular wires to ensure the lowest frictional resistance.

By Neal D. Kravitz, DMD, MS

N. Talic

Esthetic Wires

Transparent Non-Metallic (Clear Polymer Archwires)

- Polymer resin matrix reinforced with glass fiber advocated by SimpliClear Braces (Biomers, Singapore)
- The resin is a modified methacrylate resin serves as the polymer matrix material
- They are available in round and rectangular cross-section
- Its not formable clinically
- A series of preformed custom made wires can be fabricated to incrementally move teeth to a predetermined position

Transparent Non-Metallic (Clear Polymer Archwires)

Home | Find a Doctor | Press Room | Contact Us | I'm a Doctor | English Page | English

SimpliClear®

Choosing SimpliClear | What is SimpliClear? | Testimonials | FAQs

What Makes SimpliClear® Practically Invisible?

SimpliClear® is the result of a breakthrough in material science that makes it possible for you to wear completely clear braces. The clear polymer composite wire, when combined with clear brackets, makes it nearly impossible to see your braces. PLUS this revolutionary technology allows teeth to move quickly and comfortably. Even those with metal allergies can get the treatment they need without the concern of a reaction to the metal wire.

The Secret is In the Wire

What's so revolutionary about the clear wire? It's so much more than just clear.

All braces are made of two parts: brackets that are placed on your teeth and the wire that connects them. It's the wire that does all the work in moving your teeth. SimpliClear® wires place gentle forces only on the teeth that need to be moved and only when the orthodontist feels it's the right time to move them.

Customized Treatment Plan

Because everyone's smile is unique, your orthodontist will create a treatment plan specifically

Transparent Non-Metallic (Clear Polymer Archwires)

- Self-reinforced polymer (SRP)
- Polyphenylene polymer
- This material can be extruded as round or rectangular cross-section archwires
- It has properties similar to small dimension beta-Ti wires and formability similar to stainless steel

Burstone CJ, Liebler SA, Goldberg AJ. Polyphenylene polymers as esthetic orthodontic archwires. *Am J Orthod Dentofacial Orthop*. 2011;139(4 Suppl):e391-8.

Esthetic Wires

Disadvantages of Aesthetic Archwires

Coated Metal Archwires

- Deliver statistically lower loading and unloading force levels than uncoated wires of the same nominal sizes
- The lower force levels of coated wires may be attributed to:
  - 👉🏼Thick aesthetic coating having a negative effect on the load-deflection properties
  - 👉🏼Manufacturer’s use of a smaller-diameter wire to compensate for the thick coating
- Fragmentation of the coating adds increased frictional resistance and diminishes the aesthetic benefit

N. Talic

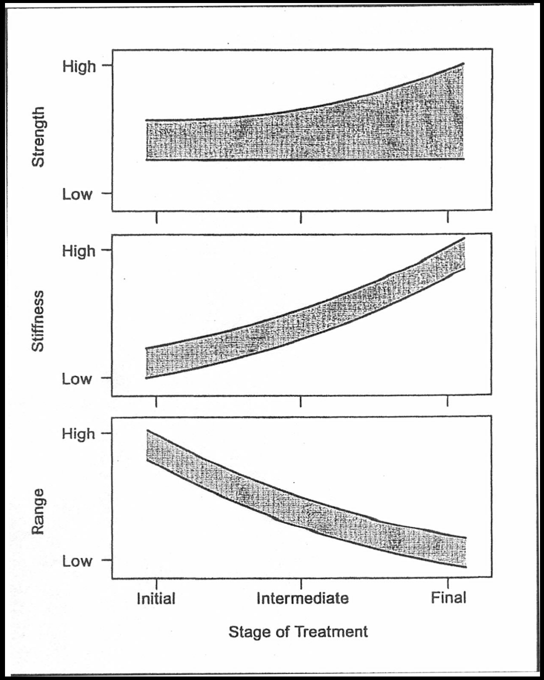
Esthetic Wires

Disadvantages of Aesthetic Archwires

Nonmetallic Archwires

- Brittle and allow for only moderate deformation
- Excess deformation or forceful grip with pliers can lead to permanent deformation and irreversible cracks

Properties of Ideal Wire Material



N. Talic

Friction in Orthodontics

Dental, Oral and Craniofacial Research

oat
open access text

Research Article
ISSN: 2058-5314

Variables affecting the frictional resistance to sliding in orthodontic brackets

Mai AlSubie[1] and Nabeel Talic[2]*

[1]Orthodontic Specialist at Prince Sultan Armed Forces Hospital, Riyadh, Saudi Arabia
[2]Department of pediatric Dentistry and Orthodontics, College of Dentistry, King Saud University, Riyadh, Saudi Arabia

Dent. Oral. Craniofac. Res. 2016; 2(3): 271-275

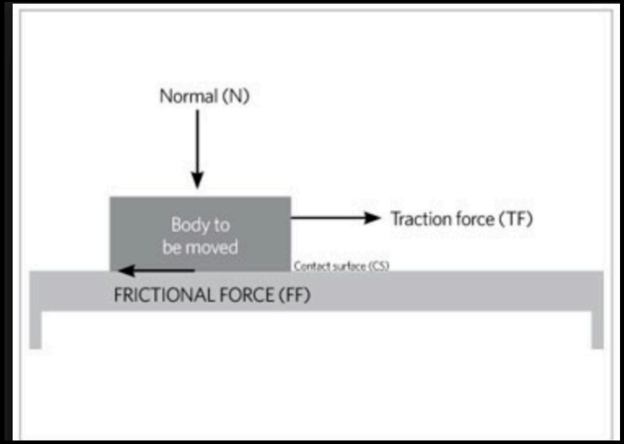
Importance of friction on orthodontics

- Friction impedes tooth movement
- It should be controlled during all stages of orthodontic treatment
- If the friction resistance is high, slow progress and unnecessary elongation of the treatment time might result
- Friction force cannot be eliminated
- The loss of the applied force due to friction as reported in the literature ranges from 12% to more than 70%

N. Talic

Friction in Orthodontics

- Friction is defined as the force that retards the movement of two objects sliding against each other
- As the two objects are moving against each other, two forces arises other than the initial force that generated the movement
- The friction force is opposite to the direction of the movement force



Friction in Orthodontics

- The friction force (F) is proportional to the applied normal force (N) multiplied by a constant, which is the coefficient of friction (ɥ), such that **F= N X ɥ**
- The coefficient of friction is a characteristic of each specific material

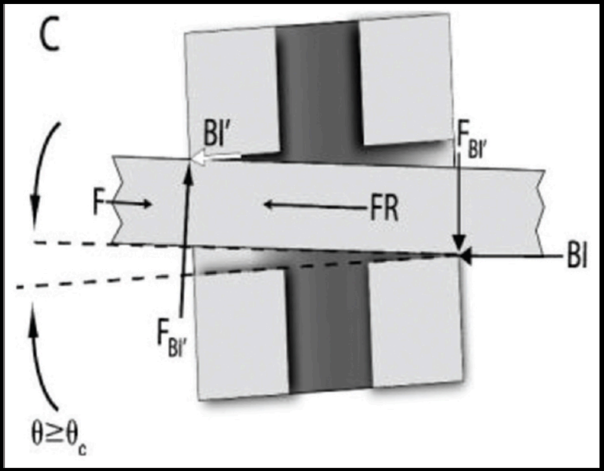
Friction in Orthodontics

Static Friction	Kinetic Friction
• The force that exists between the contacting objects while they are at rest • It resists the initiation of the movement between the two objects	• Arises after the movement has started between the two objects • It needs to be overcome to maintain efficient movement

N. Talic

Friction in Orthodontics

- RS (Resistance to sliding) is divided into three phenomena:
  - 👉Classic friction (FR)
  - 👉Binding (BI)
  - 👉Notching (NO)
- RS=FR+BI+NO.



Factors Affecting Friction

- Arch wire properties
- Bracket properties
- Bracket-wire angulation
- Methods of ligation

N. Talic

Arch Wire Properties
Smoothest Surface

Stainless Steel Wires

↓

Cobalt-chromium (CO-Cr) Wires

↓

Beta-titanium (β-Ti)

↓

Nickel titanium wires (Ni-Ti)

N. Talic

Arch Wire Properties

Generation of the least amount of friction

Stainless Steel Wires

↓

Cobalt-chromium (CO-Cr) Wires

↓

Nickel titanium wires (Ni-Ti)

↓

Beta-titanium (β-Ti)

N. Talic

Bracket Properties

Generation of the least amount of friction

Stainless Steel Brackets

↓

Titanium Brackets

Due to the formation of a passive layer of chromium and oxygen on the slot surfaces in both the passive and active wire configurations

↓

Plastic Brackets

When metal inserts were added to these brackets, their frictional characteristics were improved

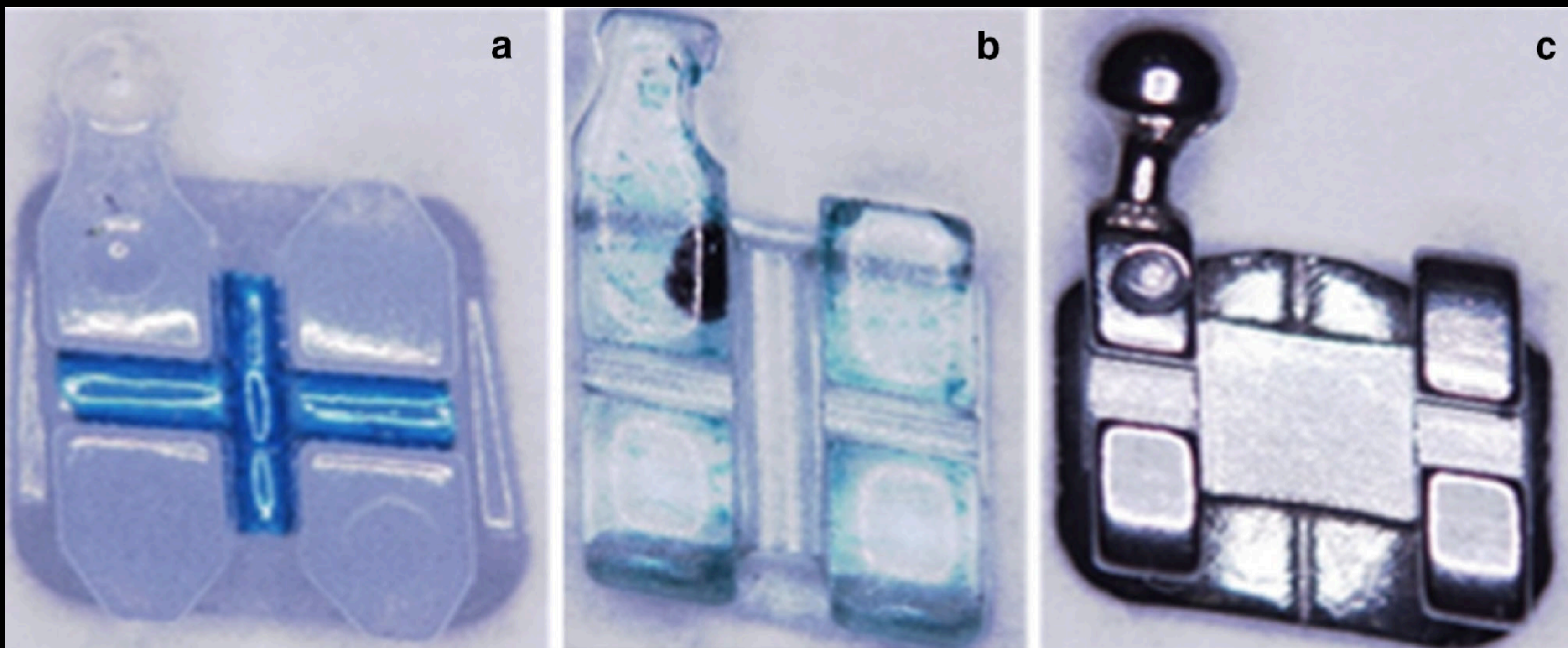
↓

Ceramic Brackets

N. Talic

COMPARISON OF THE STATIC FRICTIONAL RESISTANCE AND SURFACE TOPOGRAPHY OF CERAMIC ORTHODONTIC BRACKETS: AN IN-VITRO STUDY

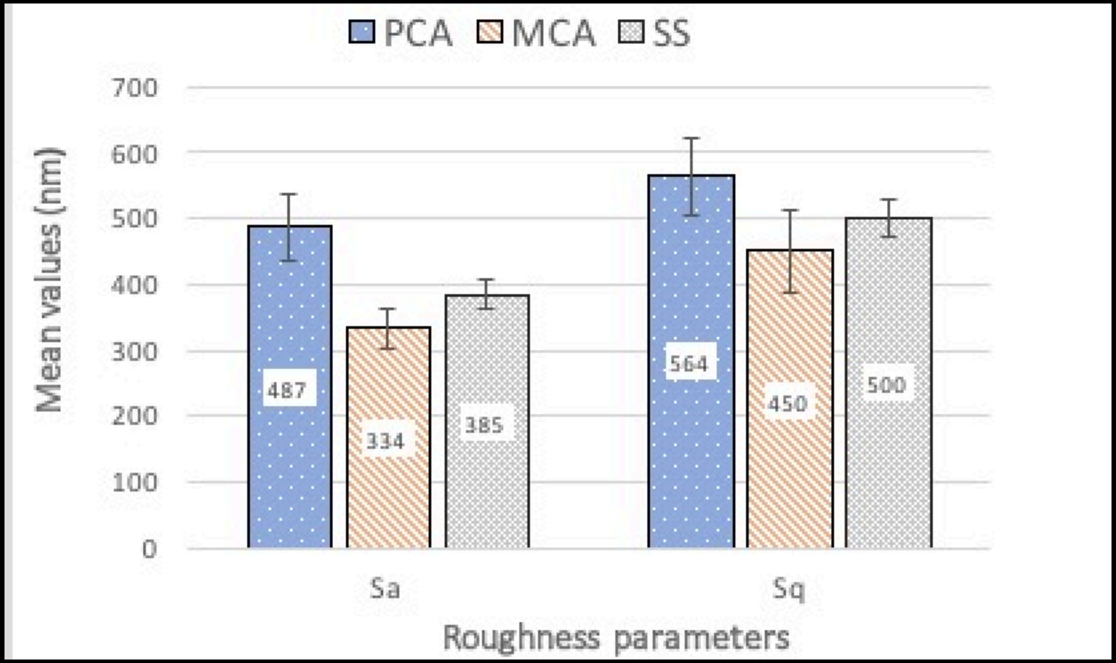
Mai AlSubaie *, BDS, MS and Nabeel Talic**, BDS, MS, PhD, FICD



(Aust Orthod J 2017; 33: 24-34)

COMPARISON OF THE STATIC FRICTIONAL RESISTANCE AND SURFACE TOPOGRAPHY OF CERAMIC ORTHODONTIC BRACKETS: AN IN-VITRO STUDY

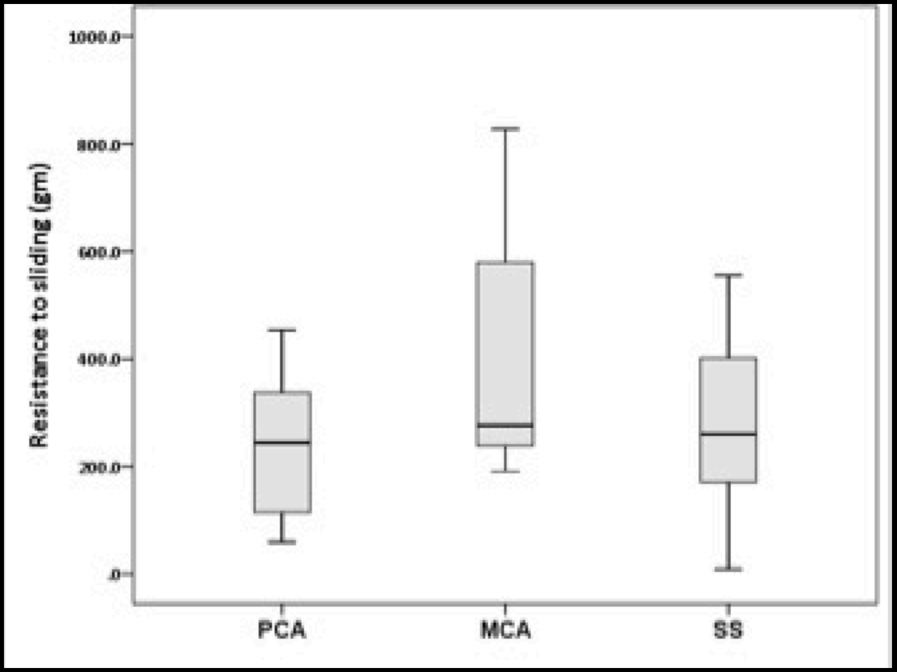
Mai AlSubaie *, BDS, MS and Nabeel Talic**, BDS, MS, PhD, FICD



(Aust Orthod J 2017; 33: 24-34)

COMPARISON OF THE STATIC FRICTIONAL RESISTANCE AND SURFACE TOPOGRAPHY OF CERAMIC ORTHODONTIC BRACKETS: AN IN-VITRO STUDY

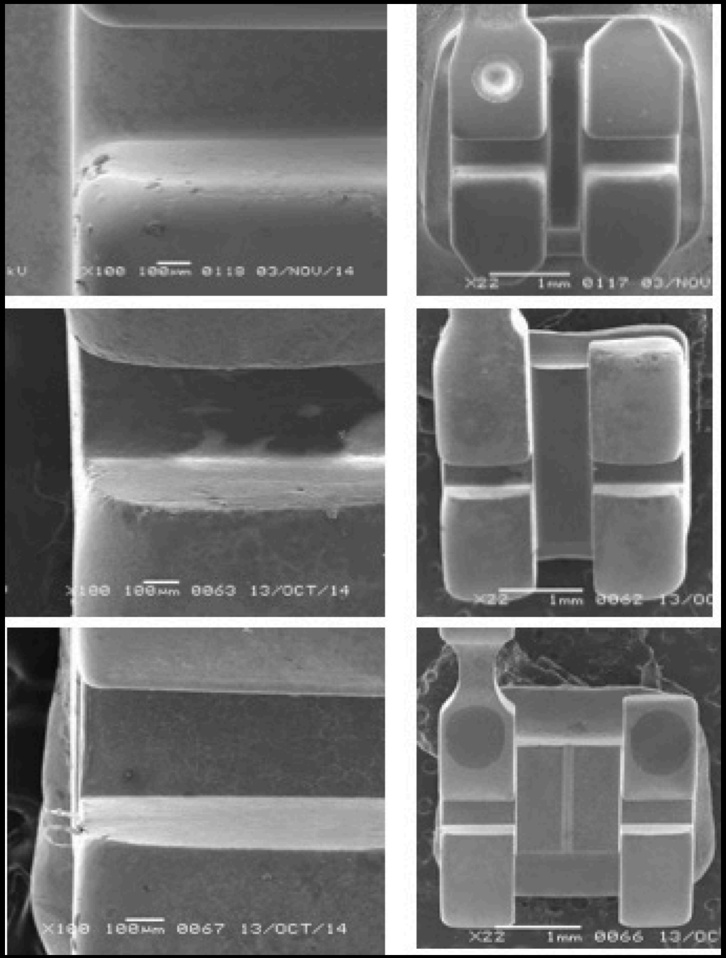
Mai AlSubaie *, BDS, MS and Nabeel Talic**, BDS, MS, PhD, FICD



(Aust Orthod J 2017; 33: 24-34)

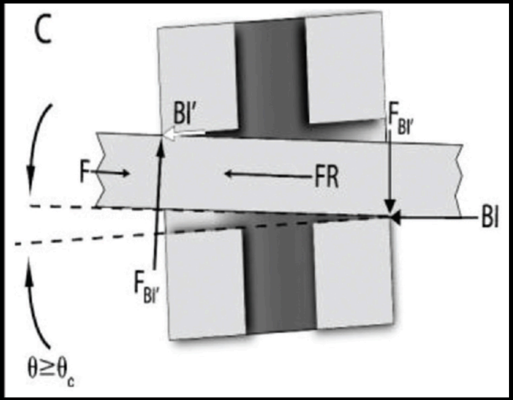
COMPARISON OF THE STATIC FRICTIONAL RESISTANCE AND SURFACE TOPOGRAPHY OF CERAMIC ORTHODONTIC BRACKETS: AN IN-VITRO STUDY

Mai AlSubaie *, BDS, MS and Nabeel Talic**, BDS, MS, PhD, FICD



Bracket-Wire Angulation

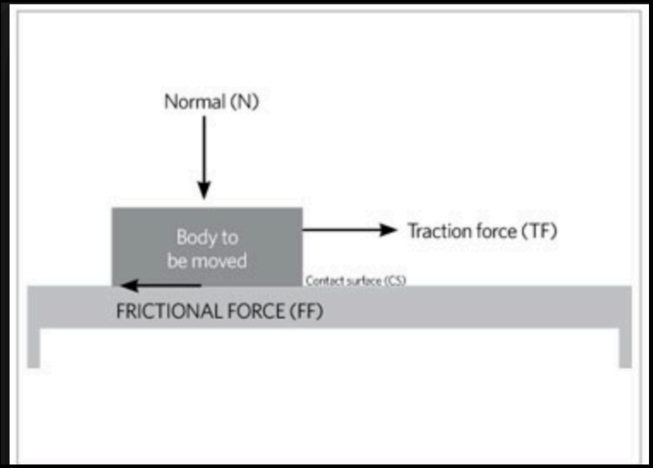
- Sliding tooth movement is more efficient when the bracket and the arch wire are in passive configuration
- The contact angle (Φ) between the arch wire and bracket is less than the level of critical angulation (Φc)
- During the early stages of sliding, when the Φ either just equal to the Φc, classical friction contributes more to the RS
- In the intermediate stages, defined by having the Φ greater than the Φc, the binding dominates the RS.
- However, in the late stages, when the Φ is extensively beyond the Φc, notching of the arch wire occurs and the sliding movement is inhibited



N. Talic

Methods of Ligation

- The friction resistance is proportional to the normal force that is applied perpendicularly over the two sliding objects and pressing them together
- In the case of a bracket and an arch wire, the normal force is the force of ligation
- The force of normal ligation was estimated to be from 50 – 300 gm



Methods of Ligation

- Studies results were controversial. Some of the studies demonstrated that loose SS ligatures were found to generate less frictional forces compared with elastomeric modules
- Matarese et al. found no differences in the frictional forces between elastic ligatures and SS ligatures; however, the large standard deviation in the SS ligature group highlighted the difficulties in standardizing the force of ligation