Comparative Evaluation on the Bonding Strength and Debonding Behaviour of Various Metal and Ceramic Brackets

Excerpt from the inaugural – dissertation from the Polyclinic for Orthodontics of the Julius-Maximilian University Würzburg
presented by Christian Mihlan from Magdeburg in June 2012* to obtain his doctorate

1. Materials

1.1 Metal brackets

Forestadent Quick 2.0:
The self-ligating, nickel-free, stainless steel metal bracket is fitted with a hook base. The individual struts are undercut in hook-form so that more adhesive bonds the base of the bracket during removal.

Forestadent Mini Mono:
The Mini Mono Bracket is a metal bracket with a retentive sand-blasted net base.

Forestadent Mini Sprint:
The Mini Sprint Bracket is a metal bracket made of nickel-free stainless steel with hook base.

Dentaurum Discovery SL:
The Discovery SL metal bracket is a self-ligating bracket with a rhomboid laser-structured base.

GAC InOvation R:
The metal bracket of the InOvation series is a self-ligating bracket with an active clip.

3M Unitek Smartclip SL:
This is a self-ligating metal bracket.

1.2 Ceramic brackets

Forestadent QuicKlear of the first generation:
This is a self-ligating active ceramic bracket. The bracket base consists of an inverted hook base with diametrically opposed hole retention, so providing purely mechanical support.

Dentaurum Fascination 2:
This ceramic bracket has a base with a silanised stud structure fabricated with the aid of CAD/CAM support.

GAC InOvation C:
The ceramic bracket of the InOvation series is self-ligating and anchored mechanically only to the adhesive.

3M Unitek Clarity SL:
This is a self-ligating bracket with a micro-crystalline base for mechanical retention of the adhesive.

2. Fabrication of the test specimens

2.1 Test teeth

264 non-fractured, surgically removed, human third molars from patients aged between 16 and 40 were used.

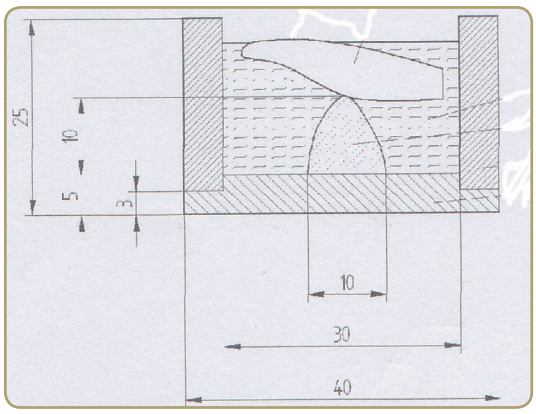

Figure 2.2: Plastic round blank

2.2 Embedding of the teeth

The teeth were embedded successively in a standardised polytetrafluoroethylene (PTFE) device, consisting of a base plate and a ring.

Embedding of the teeth in such a manner, that only the buccal enamel surface protruded from the plastic as later bonding area.

*Abridged and summarized by Forestadent

2.3 Fabrication of the overall bracket-adhesive-tooth enamel combination
The cleaned teeth were thoroughly dried with oil- and moisture-free compressed air. The adhesive Transbond XT by 3M Unitek was used as bonding material, whereby bonding of the bracket was performed precisely according to the instructions for use.

The adhesive was then cured with the aid of a Translux CL halogen lamp by Heraeus Kulzer with a performance of 800 mW/cm².

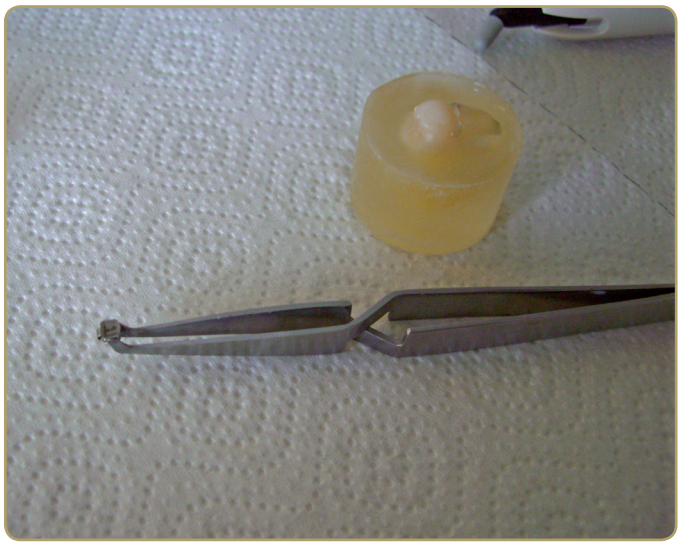

Figure 2.3.1: Clamping tweezers, with which the brackets could be bonded accurately to the tooth

Figure 2.3.2: Technovit plastic
Embedded tooth with bonded bracket

3 Testing of shearing strength

A material testing machine, type 1445 by Zwick/Roell was used to test the shear bonding strength (Figures 3.1.1 and 3.1.2) to detach the bonded bracket from the enamel surface. The plastic round blank was mounted in a round vice and placed in the material testing machine such, that the bonded surface to be tested could be positioned parallel to the shearing direction. The plastic round blank was rotated such, that the shearing forces acted from occlusal to gingival. A tension shearing bracket made of rust-proof, spring-hardened steel with a square opening of 6 mm side lengths and a thickness of 0.5 mm, was used to transfer the shearing forces onto the bracket-adhesive combination.

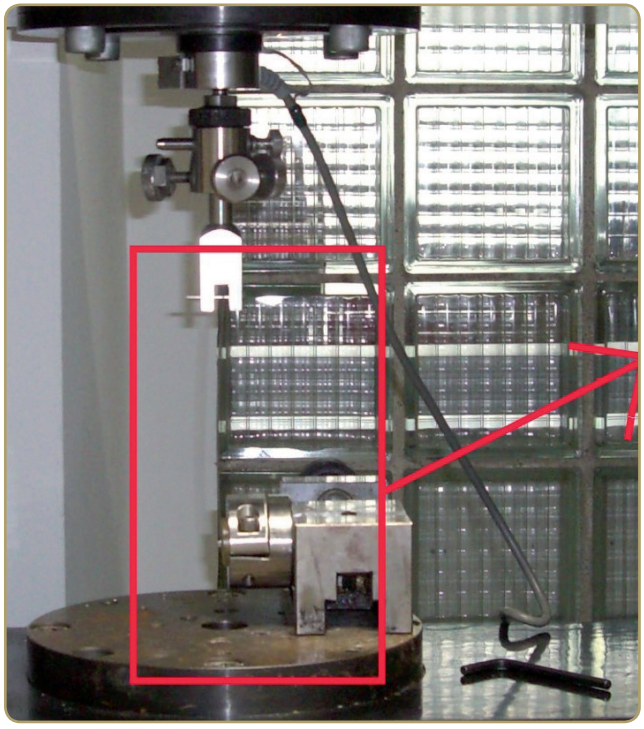

Figure 3.1.1: Material testing machine, Type 1445, by Zwick/Roell - frontal view

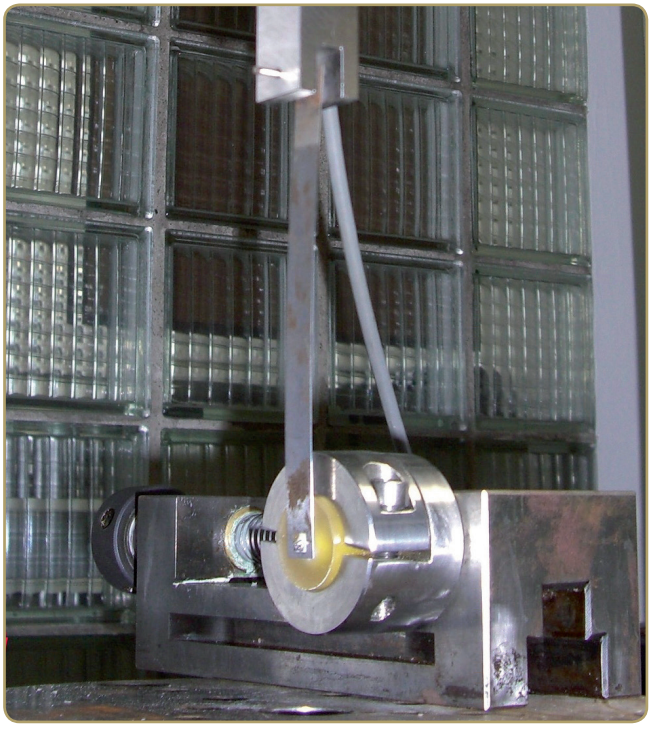

Figure 3.1.2: Material testing machine, Type 1445, by Zwick/Roell - side view

3.2 Shearing strength of metal brackets

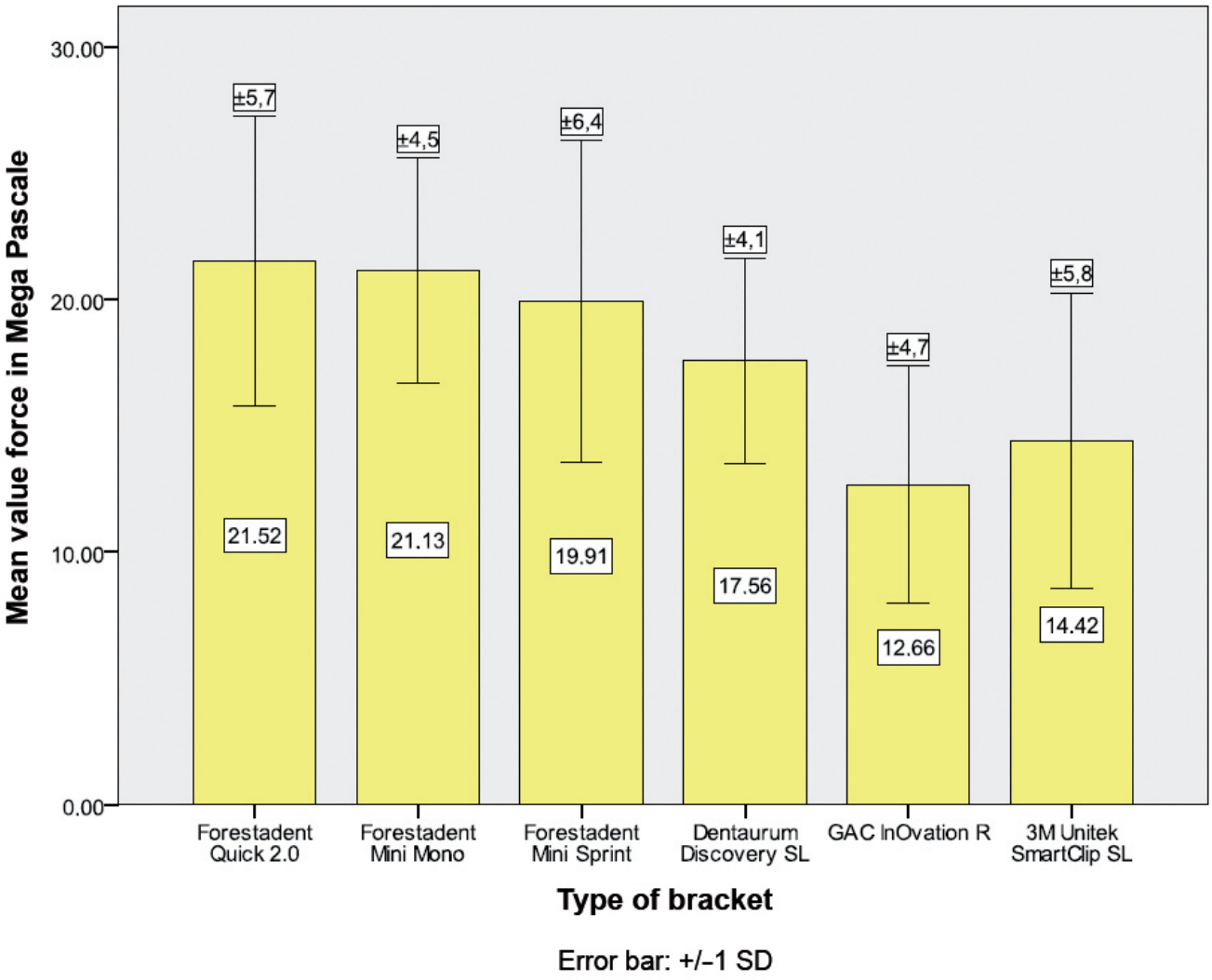

Figure 3.2: Measurement results for the metal brackets without thermocycling

With 21.5 MPa, the Quick 2.0 bracket achieves the highest value. The other brackets by Forestadent show similarly high values. With 12.7 MPa, the InOvation R bracket shows the lowest average value. A significant difference was only observed between the bracket types InOvation R and the Quick 2.0 and Mini Mono brackets.

In terms of percentages:

Forestadent Quick 2.0 is 18.40% higher than Dentaurum Discovery SL
Forestadent Quick 2.0 is 41.17% higher than GAC InOvation R
Forestadent Quick 2.0 is 32.99% higher than 3M Unitek SmartClip SL

Forestadent MiniMono is 16.89% higher than Dentaurum Discovery SL
Forestadent MiniMono is 40.08% higher than GAC InOvation R
Forestadent MiniMono is 31.75% higher than 3M Unitek SmartClip SL

Forestadent MiniSprint is 11.08% higher than Dentaurum Discovery SL
Forestadent MiniSprint is 36.41% higher than GAC InOvation R
Forestadent MiniSprint is 27.57% higher than 3M Unitek SmartClip SL

3.3 Shearing strength of ceramic brackets

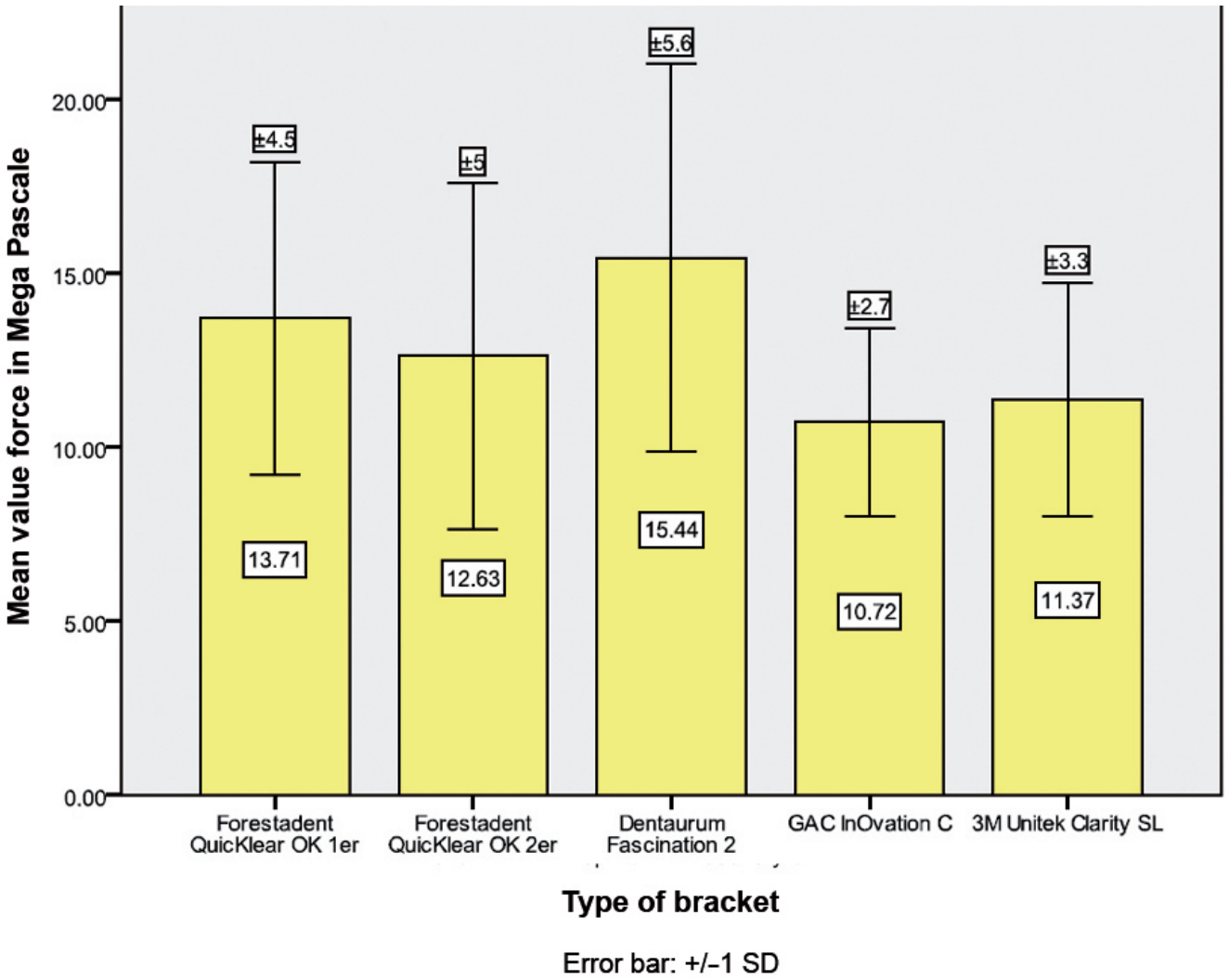

Figure 3.3: Measured results for the ceramic brackets without thermocycling

With 15.4 MPa, the Fascination 2 bracket achieves the highest mean value. With 10.7 MPa, the bracket by GAC achieves the lowest mean bonding strength value. The factor bracket type has no significant effect on the results.

In percentage terms:

Forestadent QuicKlear max 1 is 21.8% higher than GAC InOvation C
Forestadent QuicKlear max 1 is 17.06% higher than 3M Clarity SL

Forestadent QuicKlear max 2 is 15.12% higher than GAC InOvation C
Forestadent QuicKlear max 2 is 9.97% higher than 3M Clarity SL

Summary

All measured brackets achieved the minimum bonding values for clinical application as required by the literature. With lower bonding strength values and no occurrence of enamel defects, the purely mechanically bonded ceramic brackets proved superior to the metal and chemically bonded ceramic brackets. The values of the newly launched QuicKlear bracket lies within the range of other common commercial ceramic brackets and can be regarded as a potential alternative. Due to higher shearing forces and ARI values, the silanised Fascination 2 ceramic bracket demonstrates a poor ratio between sufficient bonding and safe removal.