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Comparison of bond strength of two adhesive systems to bone under different modalities

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Authors:
Dr. Katrin Bekes,
Dr. Christian Ralf Gernhardt,
Prof. Dr. Hans-Günter Schaller,
Department of Operative Dentistry and Periodontology
Dr. Dr. Peter Maurer,
Prof. Dr. Dr. Johannes Schubert,
Department of Maxillofacial and Plastic Surgery
Martin-Luther-University Halle-Wittenberg

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Introduction

The use of miniplates has revolutionised the treatment of maxillofacial fractures within the last years. However, there are numerous potential problems using these metallic implants. Perfect adaption to bone can be time-consuming and difficult in some areas. Furthermore the drilling of screw-holes has the potential to damage associated anatomical structures.
It would be helpful to use a material that is highly maleable during the adaptation phase and rigid at the fixation stage. Recently, there have been promising developments in the field of dentin bonding agents. As the composition of dentin and bone are chemically and structurally similar, it is possible that some of the modern dentin adhesive systems may offer a suitable method of attaching rigid fixation devices to bone without the aid of screws (1-4).

Objectives

The aim of the present investigation was to evaluate tensile bond strength obtained between composite and bone and between bone and bone using two different adhesive systems (Clearfil New Bond and Histoacryl) in vitro.

Material und Methods

Six mandibles of freshly sacrificed pigs were used to prepare ten specimens from each mandible using trephane burs under constant water cooling (Fig. 3).

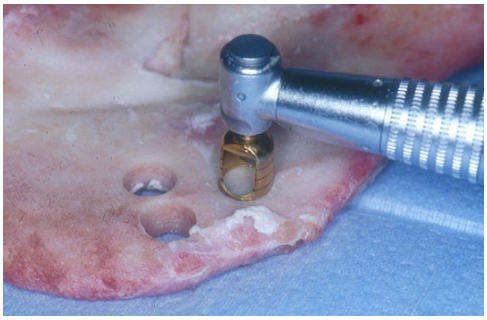

Fig. 3: Specimen preparation using a trephane bur.

Sixty bone specimens with a total thickness of 4 mm (± 0,5 mm) and a cortical layer of 1.5 mm (± 0,2 mm) were obtained under standardized conditions. Each ten specimens were randomly divided into four experimental groups (Group A: Clearfil New Bond (bone-composite); Group B: Clearfil New Bond (bone-bone); Group C: Histoacryl (bone-composite); Group D: Histoacryl (bone-bone)). These groups were assigned to one adhesive system. Both systems were applied as recommended by the manufacturers. Tensile bond strength of the above mentioned adhesive agents was measured 15 minutes after application and additional after light curing of the composite material (Tetric Ceram, colour A2, group A,C) using a universal testing machine (Fig. 1, 2).

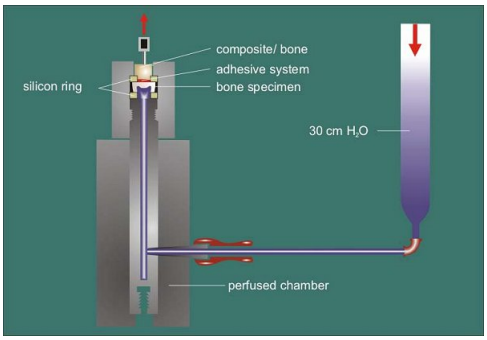

Fig. 1: Special designed apparatus to test tensile bond strength.

Fig. 2: Special designed device with installed bone specimen mounted in the universal testing machine.

For each group mean value and standard deviation were calculated. Statistical analysis was performed using ANOVA and Tukey's test. After these measurements all specimens were examined by scanning electron microscopy to evaluate different fracture modalities. Furthermore, unloaded specimens were examined. Therefore, the organic bone was removed using 50% nitric acid for 48 hours.

Results

In all groups tensile bond strength could be measured. The highest values were evaluated for group A (Clearfil New Bond (bone-composite)), while the lowest were observed in group D (Histoacryl (bone-bone)) (Tab. 1, Fig. 10).

	Clearfil New Bond (bone-composite)	**Clearfil New Bond (bone-bone)**	**Histoacryl (bone-composite)**	**Histoacryl (bone-bone)**
Mean value (in MPa)	8.00	6.39	5.22	1.95
Standard deviation	(± 1.36)	(± 2.05)	(± 2.01)	(± 0.49)

Tab. 1: Mean value and standard deviation within the different groups.

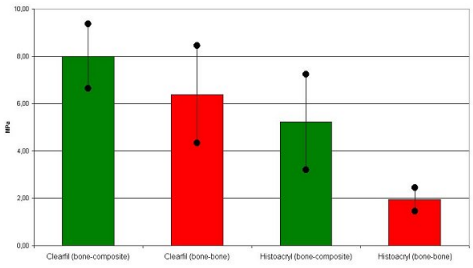

Fig. 10: Mean value and standard deviation within the different groups.

Statistical analysis showed a significant influence of the used adhesive system on tensile bond strength within the four groups ($p < 0.001$, ANOVA). In group A tensile bond strength was significantly increased compared to group C and D ($p < 0.05$, Tukey's test). The values in group D were significantly reduced compared to all other groups ($p < 0.05$, Tukey's test). The SEM evaluation of unloaded specimens showed no comparable tag formation as known from dentin (Fig. 8, 9).

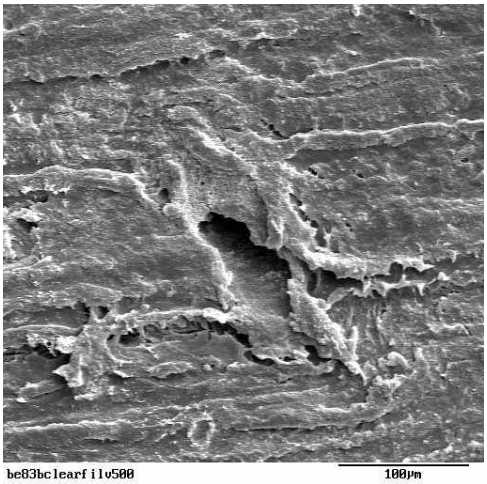

Fig. 8: Unloaded specimen treated with Clearfil New Bond after removal of organic bone. SEM; 500 x.

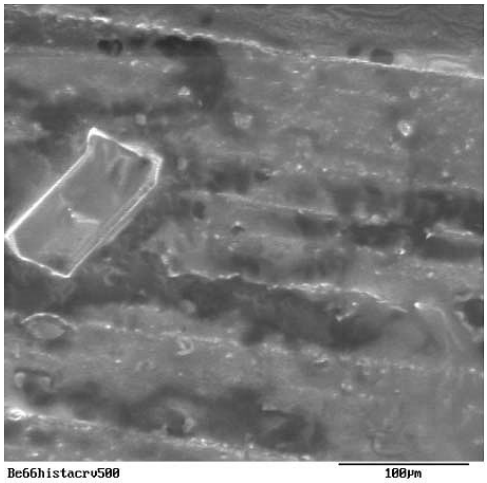

Fig. 9: Unloaded specimen treated with Histoacryl after removal of organic bone. SEM; 500 x.

The examination of loaded specimens showed in all cases cohesive fractures within the used adhesive (Fig. 4- 7).

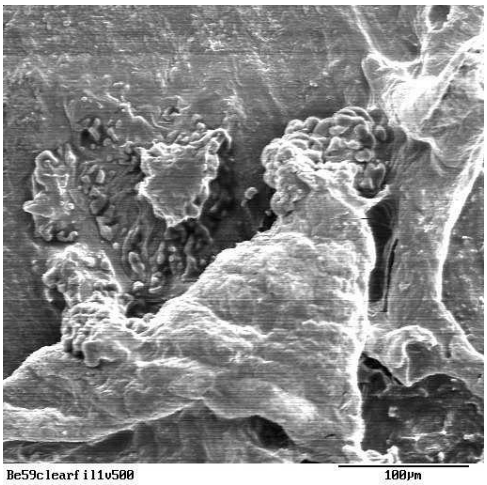

Fig. 4: Specimen treated with Clearfil New Bond, group A (bone-composite) after loading. SEM; 500 x.

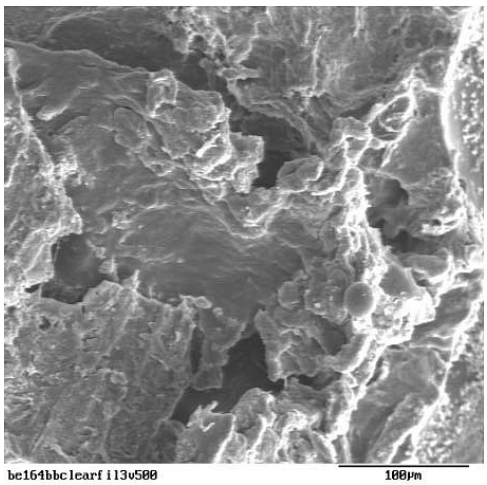

Fig. 5: Specimen treated with Clearfil New Bond, group B (bone-bone) after loading. SEM; 500 x.

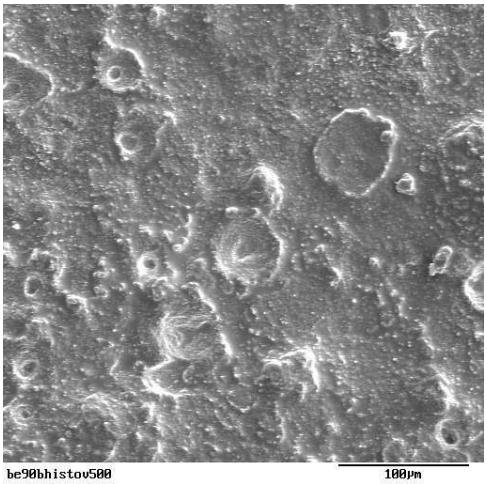

Fig. 6: Specimen treated with Histoacryl, group C (bone-composite) after loading. SEM; 500 x.

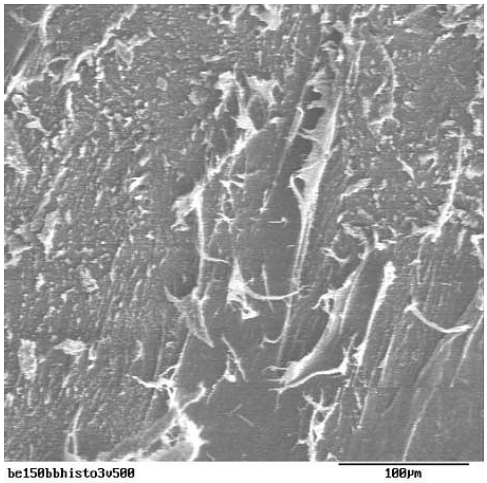

Fig. 7: Specimen treated with Histoacryl, group D (bone-bone) after loading. SEM; 500 x.

Discussion and Conclusions

Regarding the adhesive systems tested in this study, differences in tensile bond strength could be observed. The specimens treated with Clearfil New Bond showed higher bond strength than those treated with Histoacryl. Bond strength between bone and bone (group B, D)was generally lower compared to values observed between bone and composite (group A, C). Within the limitations of an in vitro investigation, it can be concluded that adhesive systems might be useful in bone bonding. Measured tensile bond strength of the adhesive systems tested on bone are comparable to those evaluated on dentin in former investigations. The use of dentin adhesives seemed to produce higher bond strength to bone compared to the cyanoacrylate adhesive. Further investigations will have to focus on biocompatible and toxicological aspects.

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Abbreviations

MPa = Megapascals
Fig. = Figure
Tab. = Table

This poster was submitted by Dr. Katrin Bekes.

Correspondence address:
Dr. Katrin Bekes
Department of Operative Dentistry and Periodontology
University School of Dental Medicine
Martin-Luther-University Halle-Wittenberg
Grosse Steinstrasse 19
06108 Halle (Saale)
Germany

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