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Effect of bruxism-simulated dynamic loading on debonding of occlusal veneers analyzed by acoustic emission

under the supervision of:

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LECTURER, MIU & SUEZ UNIVERSITY

Statement of the problem

- **lack of data regarding the most suitable prosthetic treatment for excessive tooth loss associated with bruxism**

- **clinical decisions are based on dentist's preference, experience or materials availability**

Aim of the study

The aim of this in vitro study was to analyze the effect of bruxism-simulated dynamic loading, using acoustic emission testing, on the debonding of occlusal veneers fabricated from three CAD/CAM materials:

- **IPS e.max CAD**
- **Vita Enamic**
- **Bruxzir**

Materials & Methods

Sample grouping

Lithium disilicate

IPS e.max CAD

flexural str.= 360 MPa

Hybrid ceramic

Vita Enamic

flexural str.= 160 MPa

Translucent zirconia

Bruxzir

flexural str.= 650 MPa

Materials & Methods

Sample grouping

- Static loading test
  - IPS e.max CAD — lithium disilicate
  - VITA Enamic — hybrid ceramic
  - Bruxzir — translucent zirconia

Materials & Methods

Sample grouping

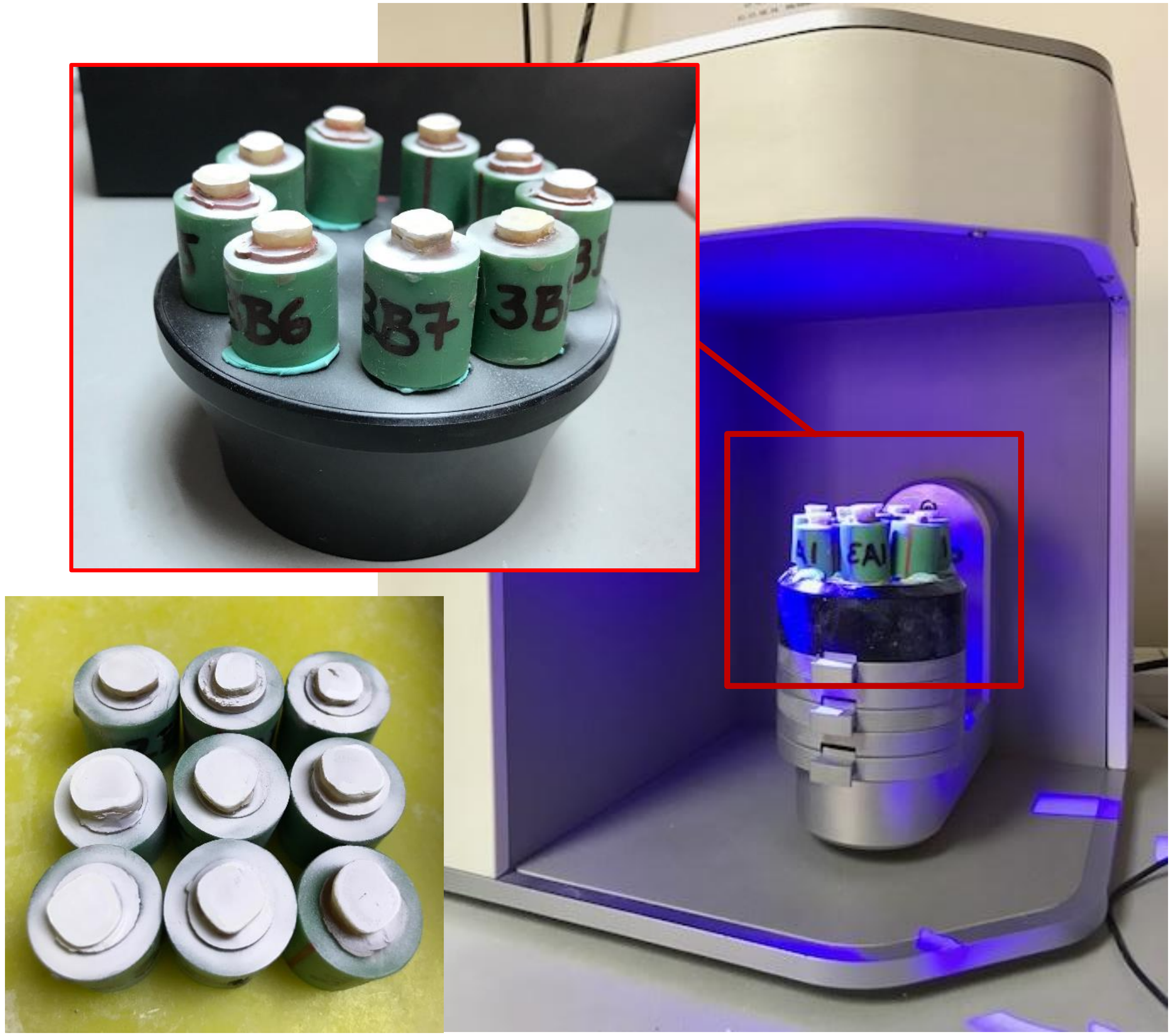
- Fatigue test
  - IPS e.max CAD – lithium disilicate
  - VITA Enamic – hybrid ceramic
  - Bruxzir – translucent zirconia

Materials & Methods

Teeth preparation

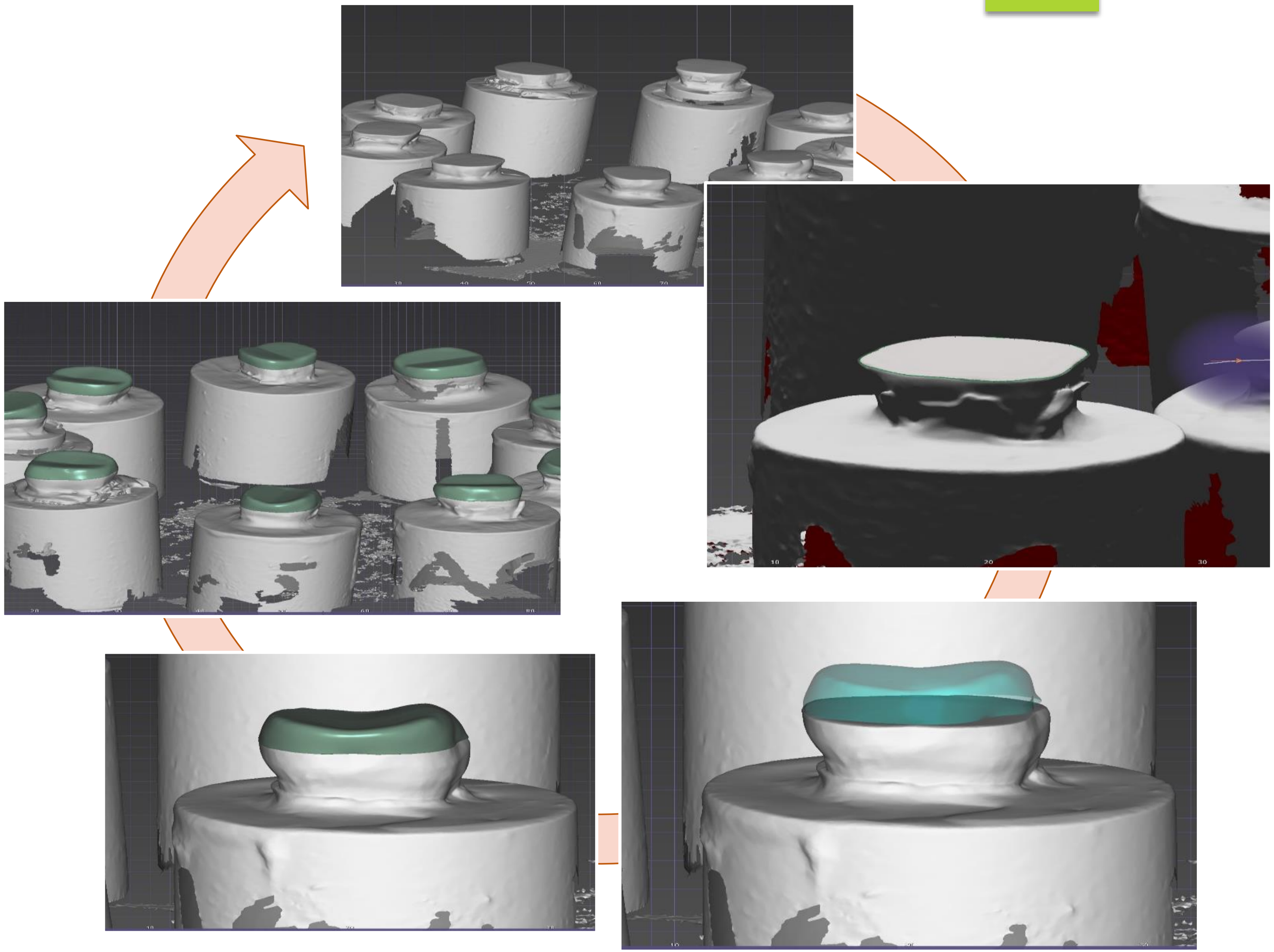
Materials & Methods

Occlusal veneer fabrication



Occlusal veneer fabrication

Materials & Methods



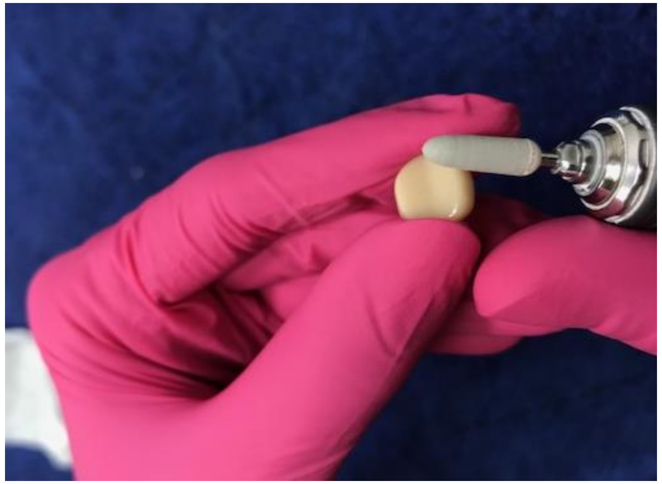
Materials & Methods

Occlusal veneer fabrication


IPS e.max CAD occlusal veneers before and after crystallization

Materials & Methods

Occlusal veneer fabrication

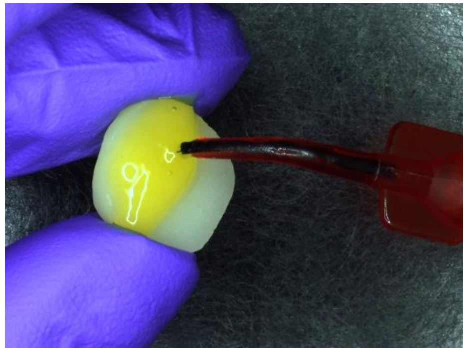


Vita Enamic occlusal veneers during polishing

Materials & Methods

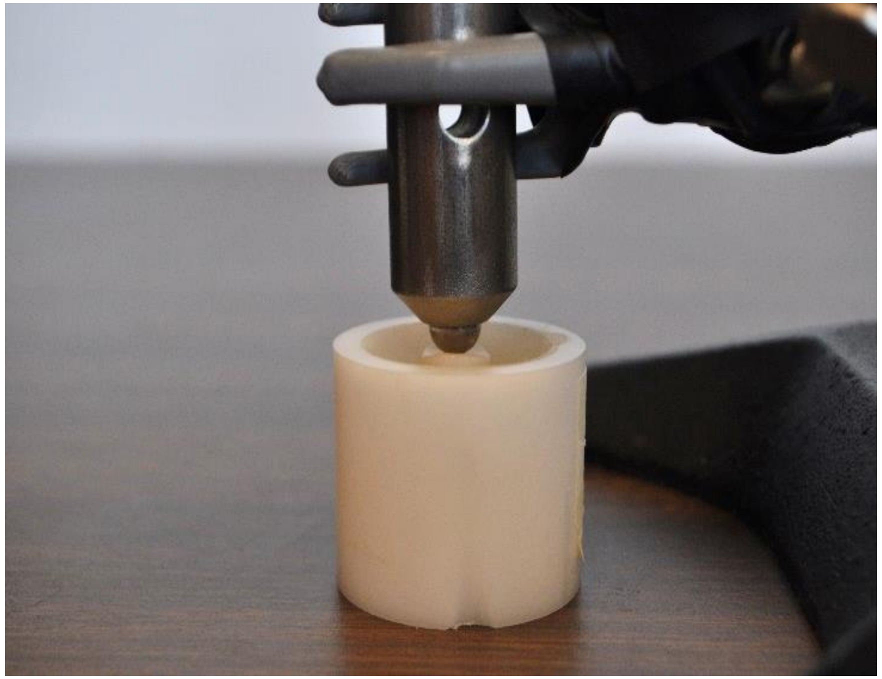
Surface treatment

- **IPS e.max CAD:** 20 sec HF acid etching & silanization
- **Vita Enamic:** 60 sec HF acid etching & silanization
- **Bruxzir:** sandblasting



Materials & Methods

Cementation of occlusal veneers



Customized loading apparatus

Materials & Methods

Loading

30 samples

Static loading test

- static lateral loading

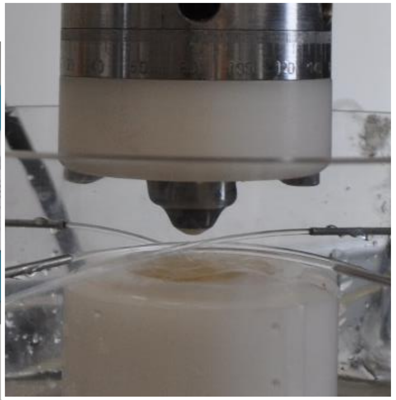
30 samples

Fatigue test

Bruxism-simulation:

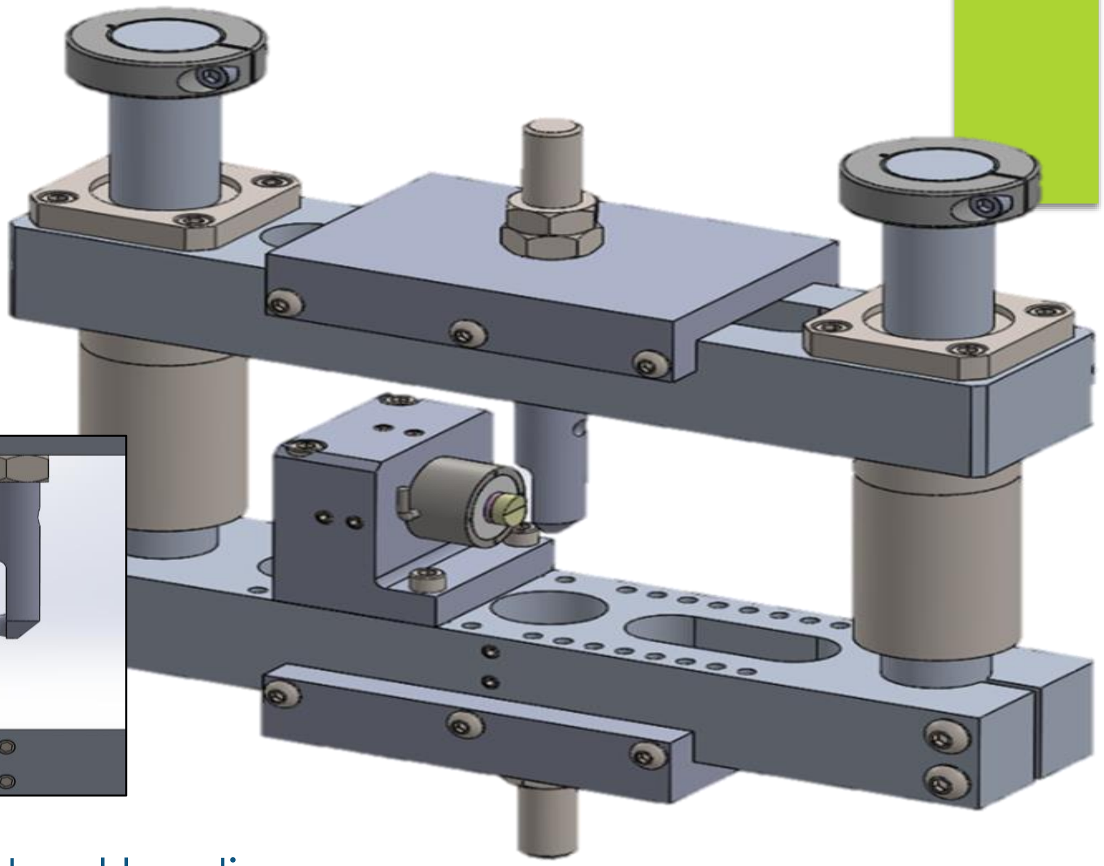
- chewing simulation
- cyclic lateral loading (accelerated fatigue)

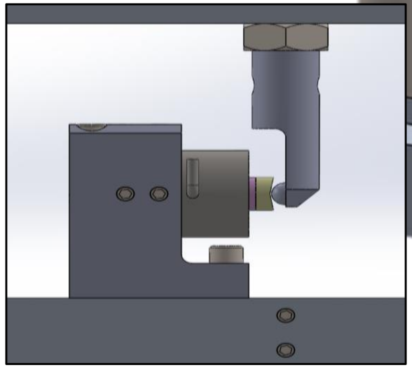
Materials & Methods



- chewing simulation

Materials & Methods



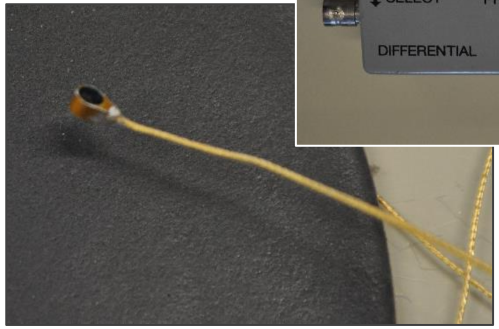


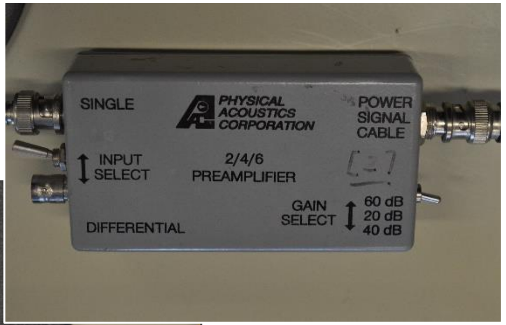
- static lateral loading

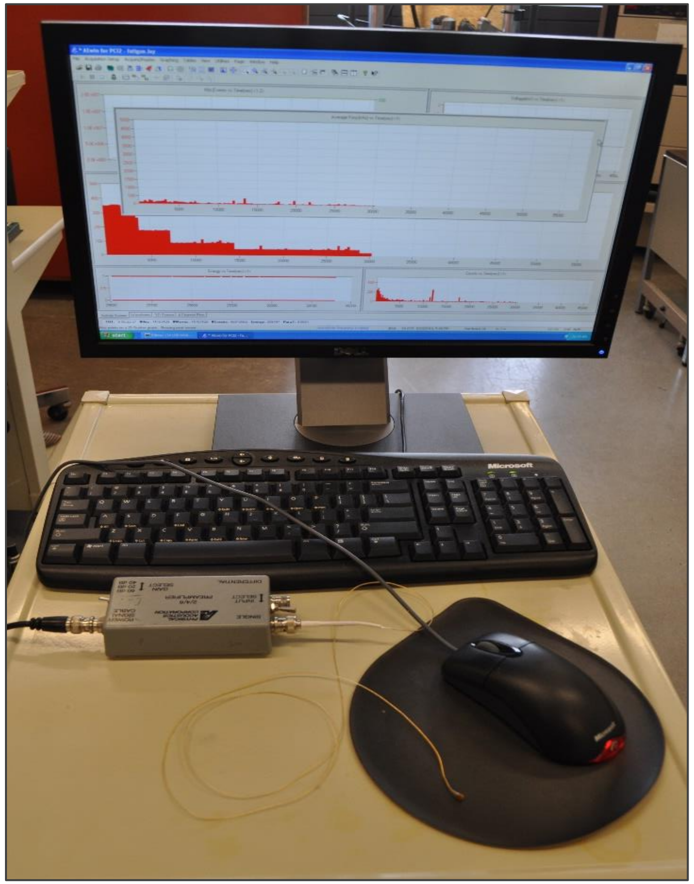
- cyclic lateral loading
  (accelerated fatigue)

Materials & Methods

Acoustic emission testing

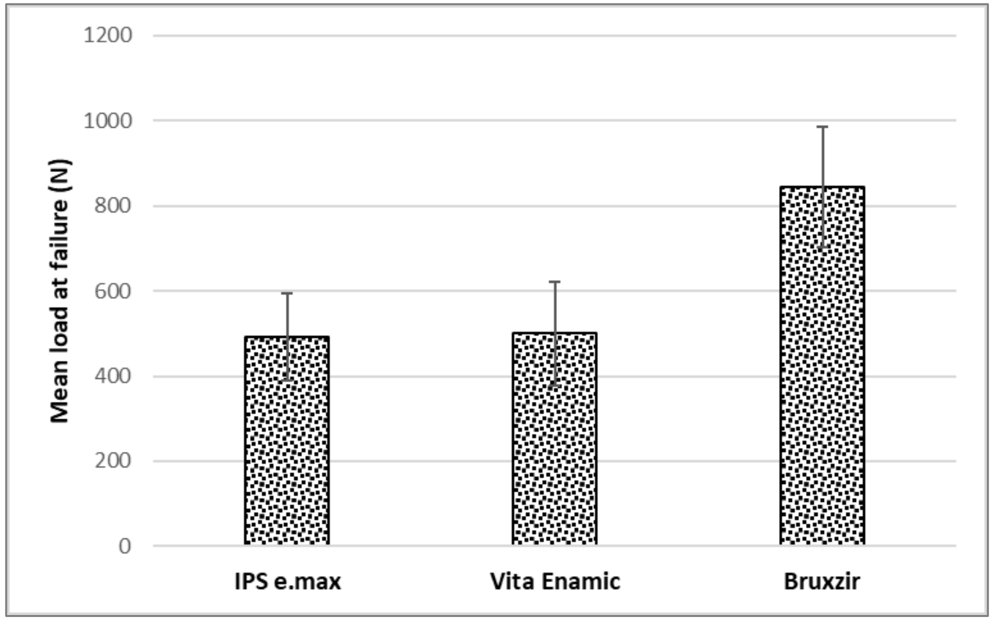






Results

Static loading test results

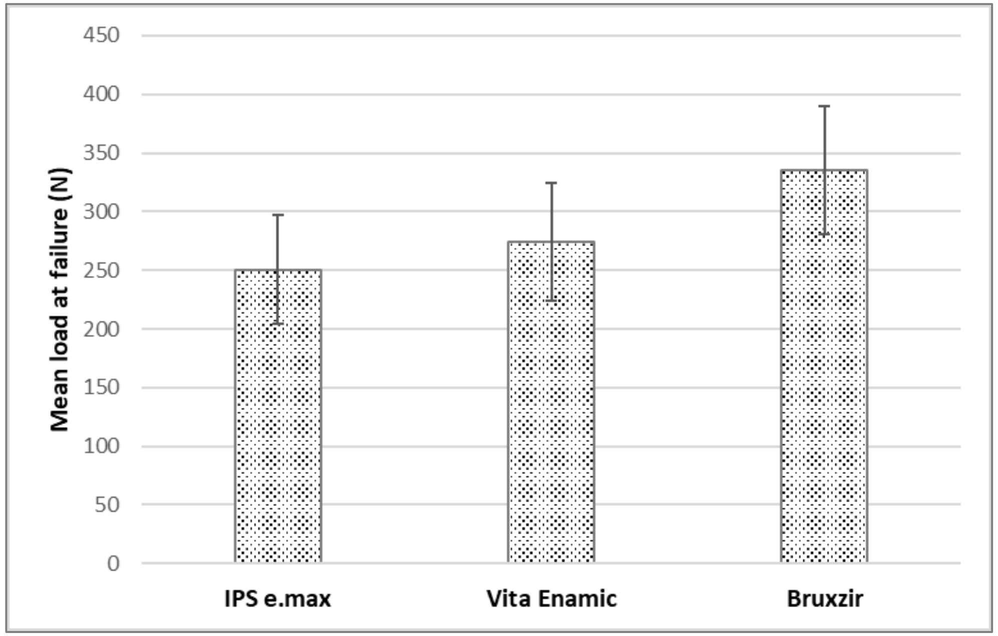


Mean and SD of load at failure in the static loading test

	Mean	Std. deviation	p-value
IPS e.max	493.2105	102.2413	2.97E-15
Vita Enamic	499.5789	123.1247	
Bruxzir	843.1111	141.4916	
IPS e.max * Vita Enamic			0.863268
Vita Enamic * Bruxzir			1.58E-11
Bruxzir * IPS e.max CAD			5.02E-13

Results

Fatigue test results

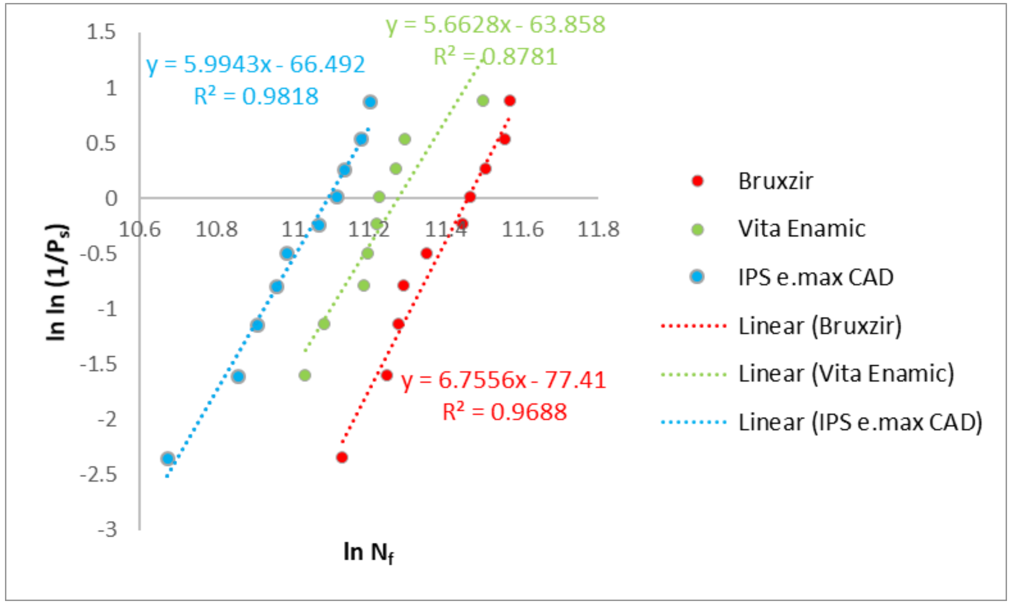


Mean and SD of load at failure in the static loading test

	Load			Number of cycles		
	Mean	**SD**	**p-value**	**Mean**	**SD**	**p-value**
IPS e.max	250.70	46.13	0.008835	61200	9598	0.001139
Vita Enamic	274.10	50.29		72072	15069	
Bruxzir	335.30	55.00		88848	12707	
IPS e.max CAD * Vita Enamic			0.29253			0.07028
Vita Enamic * Bruxzir			0.01822			0.01492
Bruxzir * IPS e.max CAD			0.00154			3.255E-05

Results

Weibull statistical analysis



Weibull distribution of the fatigue test results

Weibull statistical analysis

Results

Weibull modulus for fatigue

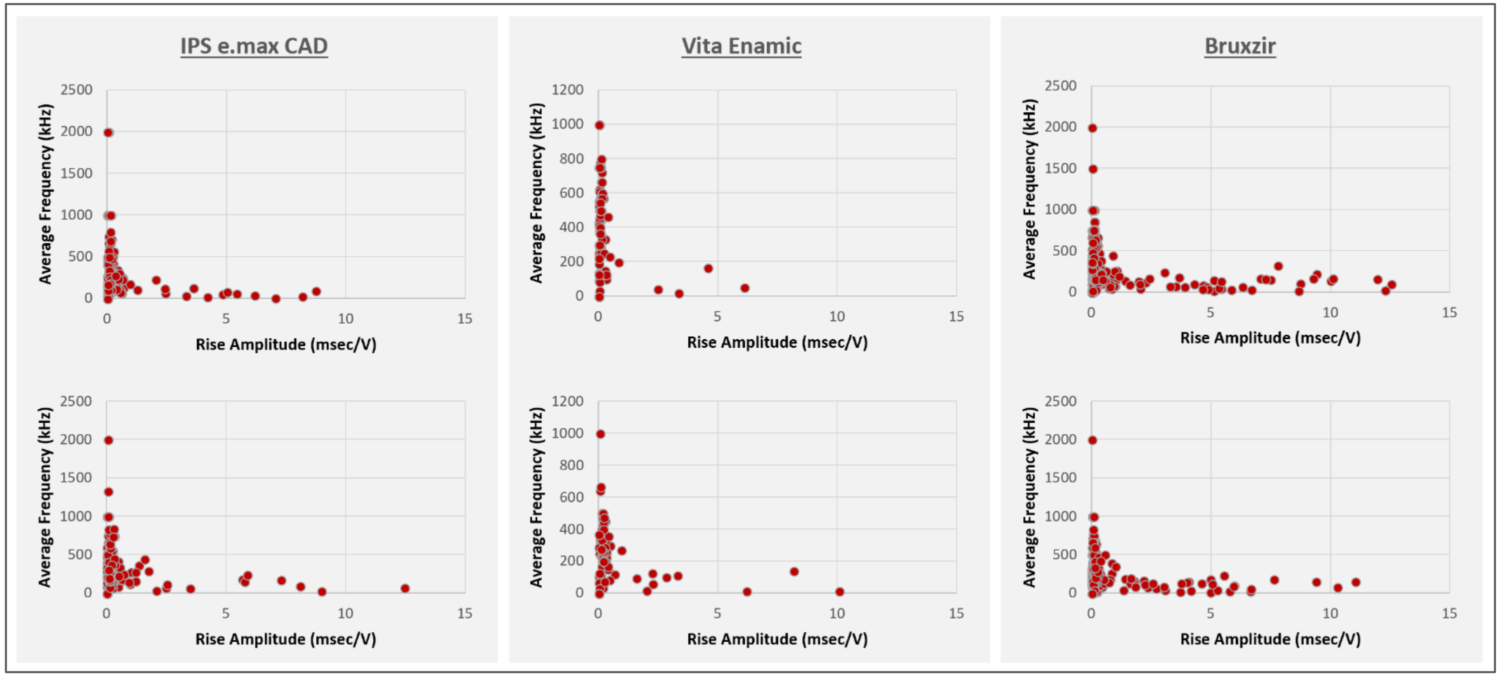
Weibull parameters

	k (N)	α	m	μ	β	σ_0	R
IPS e.max CAD	0.0078	1	4.45	1.21	3.677686	543.9604	7270.671
Vita Enamic	0.0078	1	4.28	1.38	3.101449	549.17	703891.3
Bruxzir	0.0078	1	5.62	1.14	4.929825	909.75	135244.8

μ	Weibull modulus for cyclic fatigue test
m	Weibull modulus for static fracture test
a	constant (acceleration)
k	constant (load increase per cycle)
σ_0	material's characteristic strength
R	constant (needs to be determined)

Results

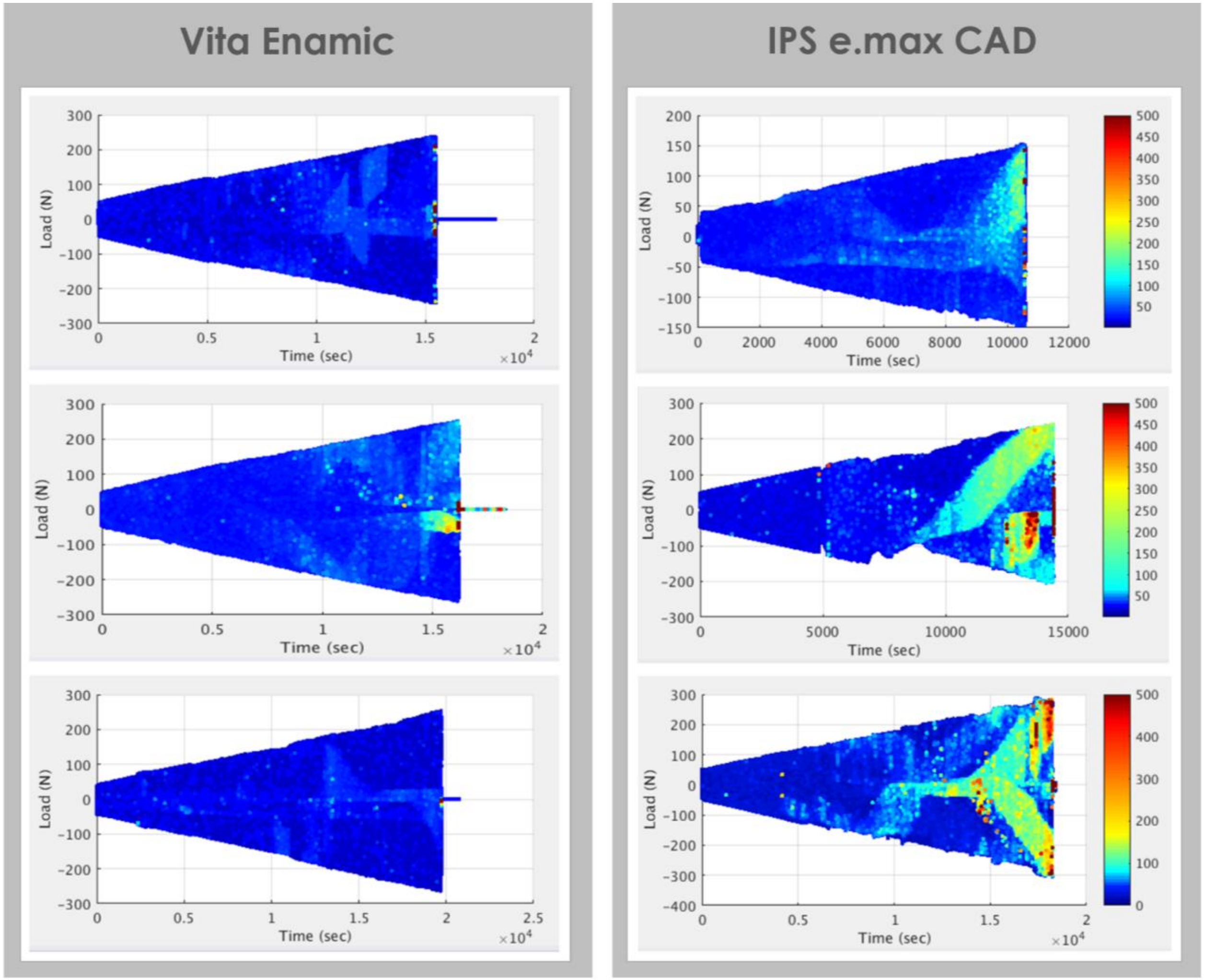
Acoustic emission testing (static loading test)



Average frequency vs. rise amplitude plots showing more distribution of signals along the x-axis in debonded samples: Bruxzir samples and more distribution of signals along the y-axis in fractured samples: Vita Enamic more than IPS e.max CAD

Results

Acoustic emission testing (fatigue test)



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Load capacity of occlusal veneers of different restorative CAD/CAM materials under lateral static loading

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A R T I C L E I N F O

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Debonding

A B S T R A C T

Objective: The aim of this in vitro study was to analyze the failure of occlusal veneers made of three different restorative CAD/CAM materials under lateral static loading.

Materials and methods: Sixty standardized semi-anatomical occlusal veneers were fabricated on natural lower molars from three different CAD/CAM materials: hybrid ceramic (Vita Enamic), lithium disilicate (IPS e. max CAD) and translucent zirconia (Bruxzir). The specimens were mechanically loaded by a custom-made device attached to a universal testing machine (MTS 858 Mini Bionix II, MN, USA). Static lateral loading was applied on the buccal cusp of the occlusal veneer until failure. Failure loads were recorded, and the types of failure noted for each group. 3D finite element (FE) models simulating the actual test set-up were further employed to evaluate the stresses within the tooth-restoration complex to help interpret the experimental results.

Results: Occlusal veneers made from zirconia recorded a significantly higher mean failure load (843.1 ± 141.5 N) than specimens of the other two materials ($p < 0.05$). There was no statistically significant difference between the lithium disilicate (493.21 ± 102.24 N) and the hybrid ceramic (499.6 ± 123.1 N) groups ($p = 0.863$). 74% of the hybrid ceramic and 84% of the lithium disilicate specimens showed veneer fracture, whereas 78% of the zirconia veneers showed debonding. Comparison of the FE-predicted stresses with the different failure strengths corroborated with the experimental results.

Conclusion: Lateral loading caused failure of occlusal veneers at loads significantly lower than those reported for axial loading. Among the materials tested, zirconia veneers showed the highest resistance to failure, with the main failure mode being debonding under lateral loading. The other two material groups failed mainly by veneer fracture at lower loads.

1. Introduction

The development of computer-aided design and computer-aided manufacturing (CAD/CAM) technology, high-strength ceramics, reliable cementation materials, as well as refined bonding techniques have facilitated the production and application of strong and thin dental restorations (Beuer et al., 2008; Tinschert et al., 2001). Occlusal veneers are one of the treatment modalities that have evolved to preserve sound tooth structure and to achieve optimum adhesion. These extra-coronal restorations require simple tooth preparations mainly driven by inter-occlusal clearance and anatomical considerations. Together with their ease of fabrication, their indications have expanded to include the restoration of lost tooth structure in cases of advanced erosion and severe attrition caused by bruxism, and the management of oral rehabilitation cases with lost functional occlusion (Vailati and Belser, 2008).

As new CAD/CAM blocks are introduced to the market, the debate about the best restorative material to use for indirect restorations continues. Lithium disilicate had been considered the strongest glass ceramic before the introduction of zirconia-reinforced lithium silicate. Over the years, the former has shown predictable and successful results for the restoration of anterior and posterior teeth (Fabbri et al., 2014). However, a high flexural strength does not necessarily mean high damage tolerance. Occlusal veneers made of a CAD/CAM composite showed higher resistance to fracture under cyclic isometric loading compared to two CAD/CAM glass ceramics (Magne et al., 2010; Schlichting et al., 2011). Also, monolithic posterior crowns fabricated

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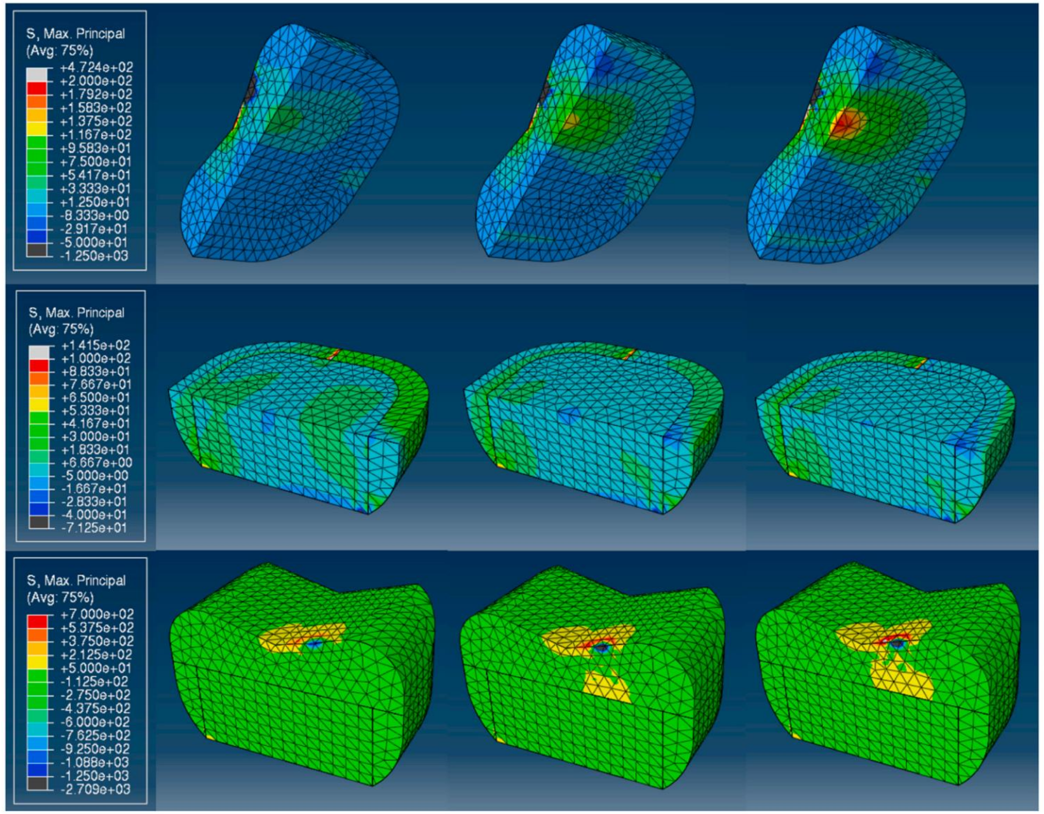

Fig. 11. Results from FEA of models with the hybrid ceramic (left), the lithium disilicate (middle) and the zirconia (right) veneers showing the maximum principal stress (MPa) distributions on the intaglio surface of the veneer (1st row), on the tooth surface (2nd row) and on the occlusal surface (3rd row) at 500 N.

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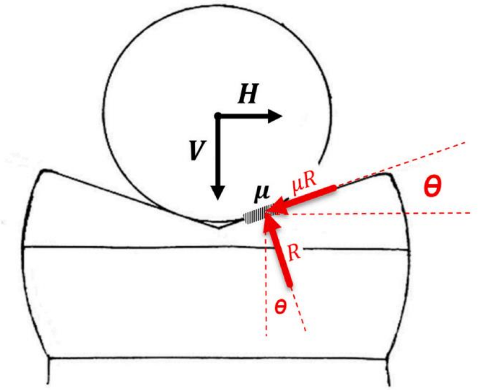
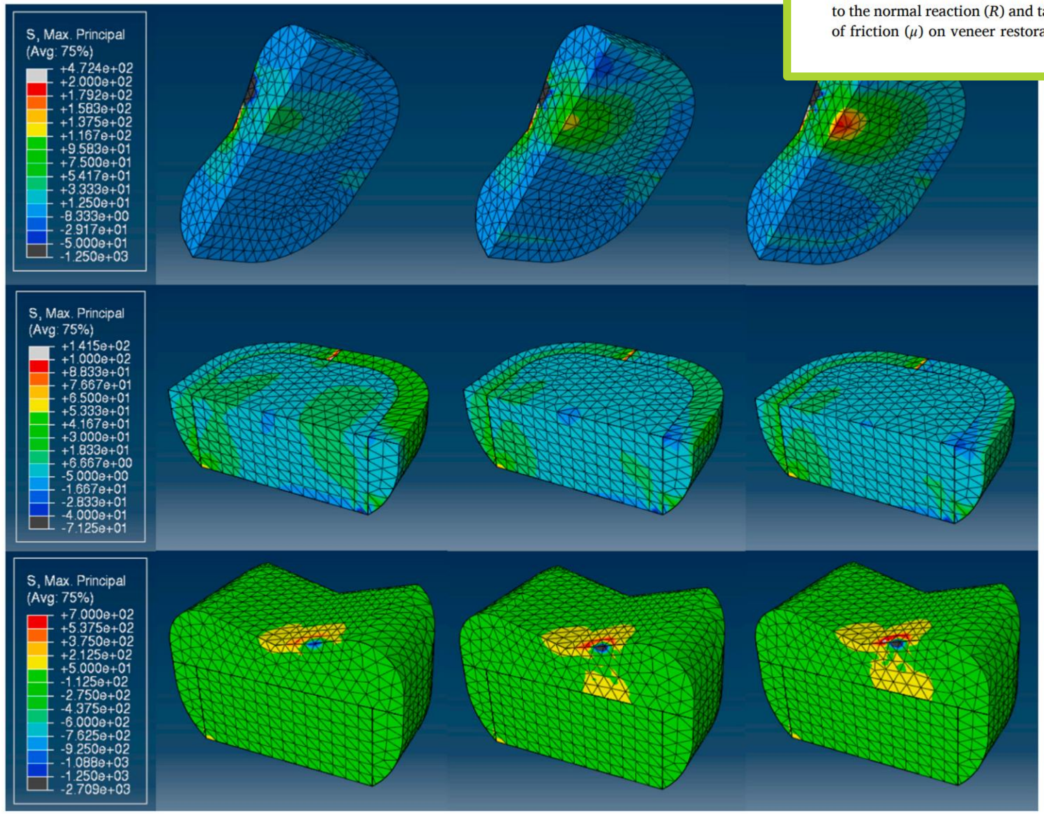


Fig. 4. Sketch showing vertical (*V*) and horizontal (*H*) force vectors in relation to the normal reaction (*R*) and tangential frictional force (*μR*) via the coefficient of friction (*μ*) on veneer restoration with an angle of inclination (*θ*).



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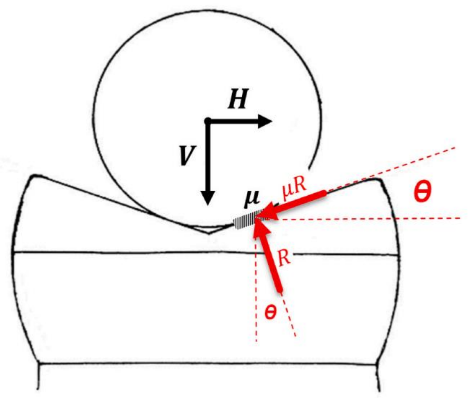

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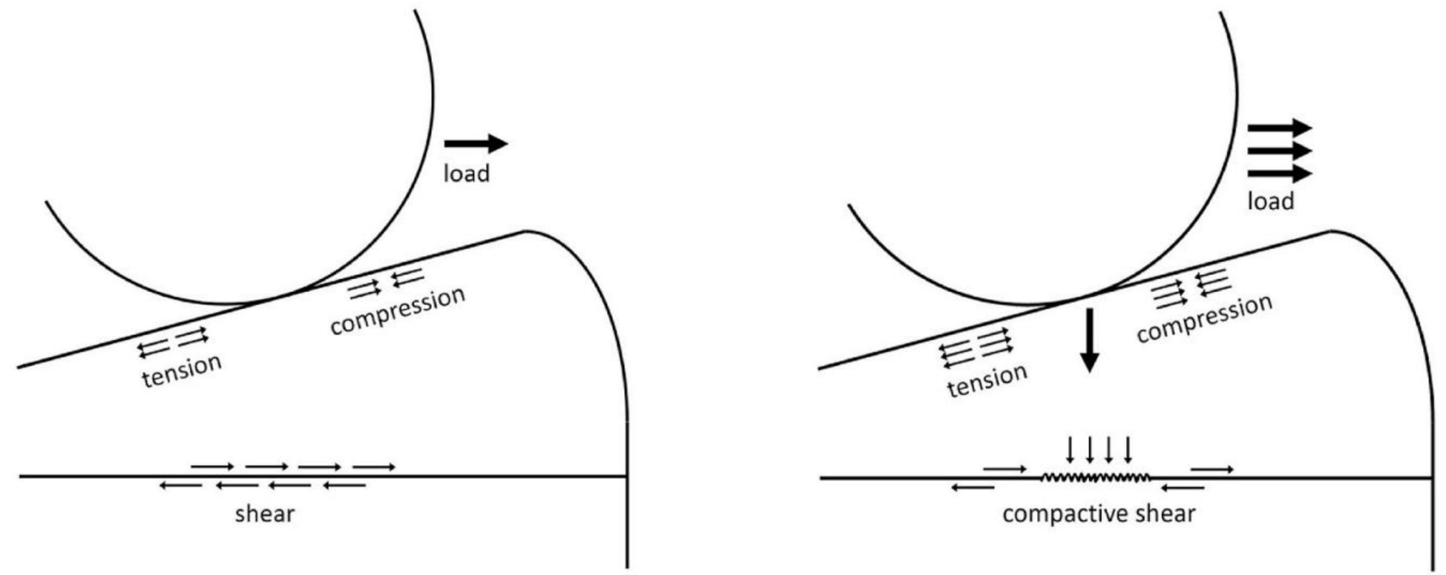

Fig. 17. Sketch showing the interplay of stresses during lateral loading that leads to compactive shear.

Thank you