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3D modeling and stress distribution in cast and combination dental clasps

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Introduction

Because of the various kinds of clasp patterns commercially available, their selection in practice is very difficult. In clinical use the clasp arms may be chosen within the limits of the real conditions, but the most important parameter is a less stress producing design. Cast and combination clasps are widely used in removable partial dentures technology [1-3]. Their choice and design depends on several factors: clasp material, clasp form, amount of undercut. Among this, only the clasp form is under control of the dentist or dental technician. The mechanical properties of the clasp material are normally determined by the alloy to be used, commonly a cobalt-chromium alloy or wipla wire. The undercut is between 0.25 and 0.5 mm.

Objectives

The AIM of the study was to achieve 3D models in order to develop applications for basic research use, to design and optimize dental clasps.

Material and Methods

Enlarged plaster teeth (scale 10:1) were scanned using LPX-1200 Laser Scanner (RolandDG Corporation, Japan). For most situations, a single scan will not produce a complete model of the object. Multiple scans, from many different directions are usually required to obtain information about all sides of the object (Fig. 1).
These scans were brought in a common reference system, a process that is usually called alignment, and then merged to create a complete model.
Resulted files were imported in LeiosMesh (Enhanced Geometry Solutions Corporations, Italy), where the point clouds from the teeth surfaces were cleaned and assembled. The collected data were used to construct three dimensional models using Rhinoceros (McNeel North America) NURBS (Nonuniform Rational B-Splines) modeling program. The models were reduced to the natural size in order to obtain a normal size of the teeth and clasps. The resulted solid was tilt in order to obtain functionally effective tooth contours.
The height of contour was designed and an adjuvant plane was generated to relieve the surface located ± 0.25 mm from the height of contour (Fig. 2).
The 3D models were used as a support for clasp modeling (Fig. 3).

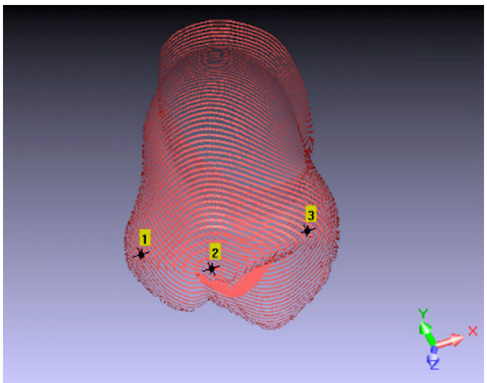

Fig. 1a: Multiple scans, from different directions, to obtain information about all sides of the tooth

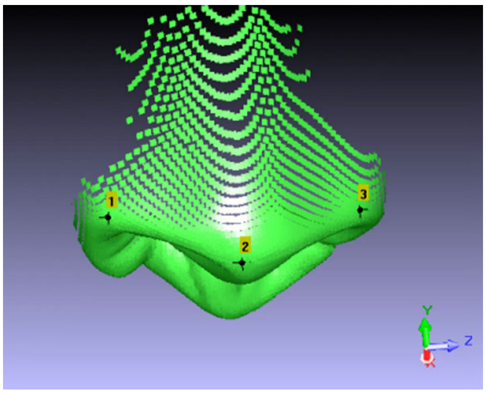

Fig. 1b: Multiple scans, from different directions, to obtain information about all sides of the tooth

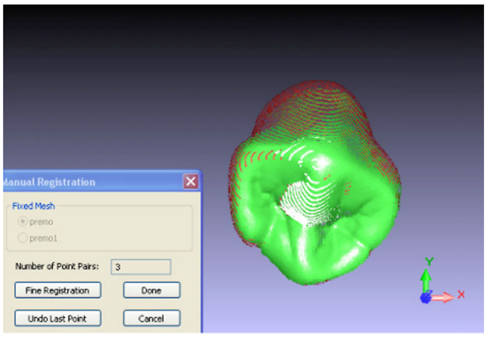

Fig. 1c: Multiple scans, from different directions, to obtain information about all sides of the tooth

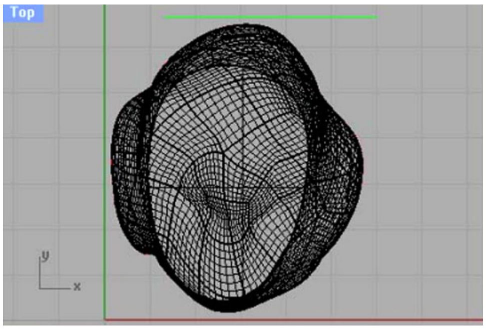

Fig. 2a: Height of contour designed on the tooth surface

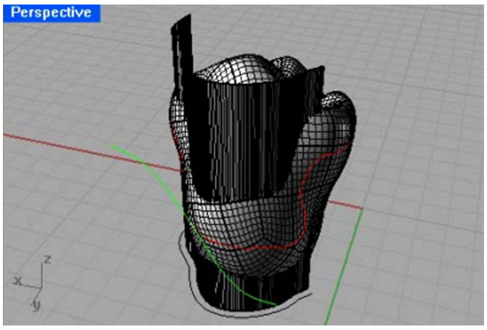

Fig. 2b: Height of contour designed on the tooth surface

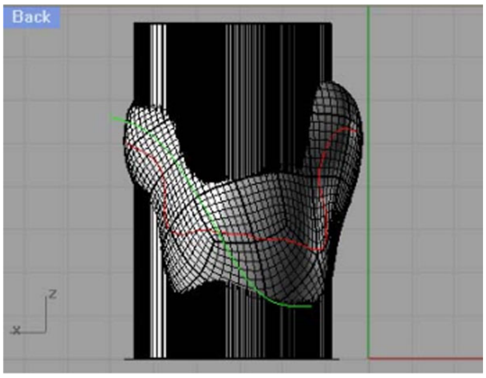

Fig. 2c: Height of contour designed on the tooth surface

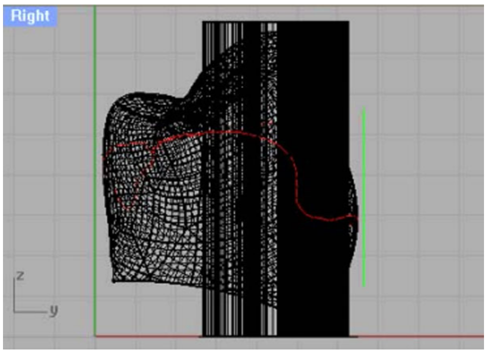

Fig. 2d: Height of contour designed on the tooth surface

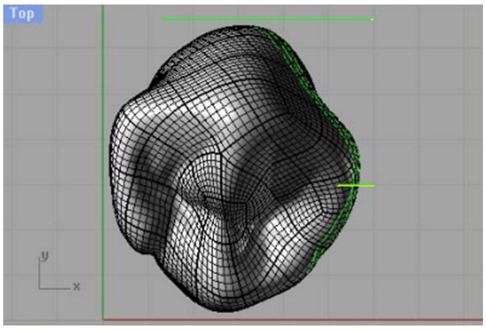

Fig. 3a: Tooth as support for clasp modeling

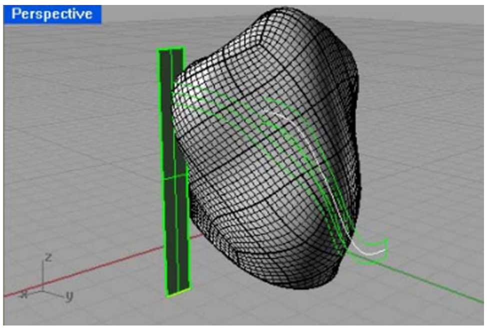

Fig. 3b: Tooth as support for clasp modeling

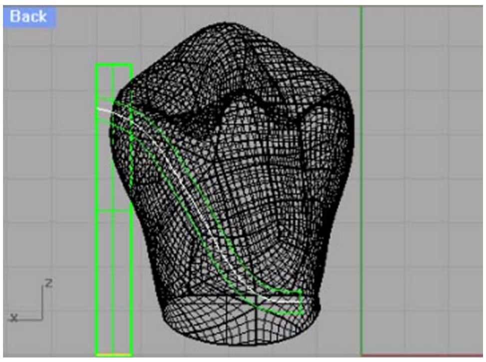

Fig. 3c: Tooth as support for clasp modeling

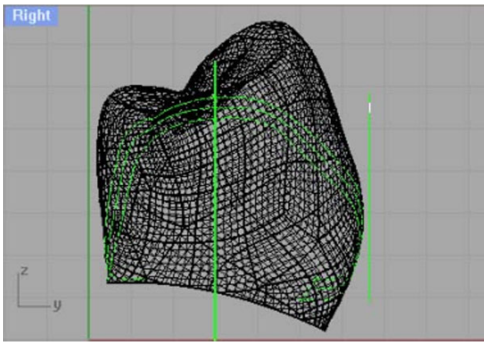

Fig. 3d: Tooth as support for clasp modeling

Different preformed clasp wax patterns for circumferential clasps were selected and taken as models. Parameters of the clasp arms were measured, like length (L), thickness at the base (T1) and tip (T2) and width at the base (W1) and tip (W2) (Table I).

Case	W1	T1	W2	T2	L
1	2.0	0.80	1.0	0.40	8.546
2	1.8	0.72	0.9	0.36	8.546
3	1.6	0.64	0.8	0.32	8.546
4	2.0	1.00	1.0	0.50	8.546
5	1.8	0.90	0.9	0.45	8.546
6	1.6	0.80	0.8	0.40	8.546
7	2.0	1.20	1.0	0.60	8.546
8	1.8	1.08	0.9	0.54	8.546
9	1.6	0.96	0.8	0.48	8.546
10	2.0	1.60	1.0	0.80	8.546
11	1.8	1.44	0.9	0.72	8.546
12	1.6	1.28	0.8	0.64	8.546

Tab. 1: Parameters of the experimental models of the cast clasp arms

Purposely designed experimental three-dimensional models of the clasp arms were constructed on the teeth surface and exported in Ansys finite element analysis software (Ansys Inc., Philadelphia, USA), to be used for structural simulations. In making the finite element models, the characteristics of the Co-Cr alloy (Wironium®; Bego, Bremen, Germany) used for the cast clasps were entered into the computer program: tensile strength: 940 MPa; ductile Yield: 640 MPa; modulus of elasticity: 2.2 x 105 MPa; Vickers hardness: 360 HV; Poisson's ratio: 0.3.
The finite element models were subdivided into solid 7266 elements, connected at 1709 nodes.
All nodes at the base of the clasp retentive arm were restrained in all directions and a concentrated load of 5 N was applied at the inner tip of the clasp arm.

Results

Generated stresses and deformations were calculated numerically and plotted graphically. Results were displayed as colored stress contour plots to identify regions of different stress concentrations. High stress values were present on the inner surface of the clasp arm, in the part located above the height of contour for the cast arm (Fig. 4). Stress values are presented in Table II.

Case	Von Mises (min) [MPa]	Von Mises (max) [MPa]	Displacement [mm]
1	2.6676	398.63	0.13302
2	3.6327	521.61	0.19706
3	4.6440	731.28	0.30673
4	1.5878	285.26	7.3347e-002
5	2.1903	368.45	0.10805
6	1.0859	506.86	0.16721
7	1.2959	215.27	4.5622e-002
8	1.2843	285.90	6.6834e-002
9	1.4426	387.58	0.10287
10	0.4726	142.39	2.2821e-002
11	0.7623	185.85	3.3109e-002
12	1.2121	245.06	5.0453e-002

Tab. 3: Stress values in the cast clasp arm

For the wire clasps 7 load cases were taken. As optimal parameter one of 0.8 mm was found. Stesses and displacements are shown in the figure 5 and table III.

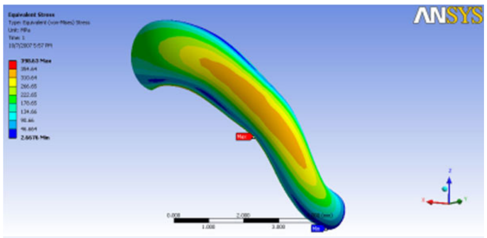

Fig. 4a: Stress distribution in the cast clasp arm

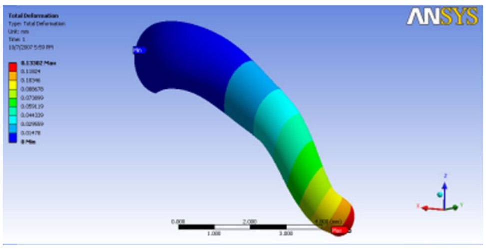

Fig. 4b: Stress distribution in the cast clasp arm

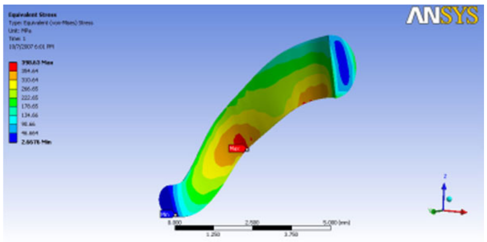

Fig. 4c: Stress distribution in the cast clasp arm

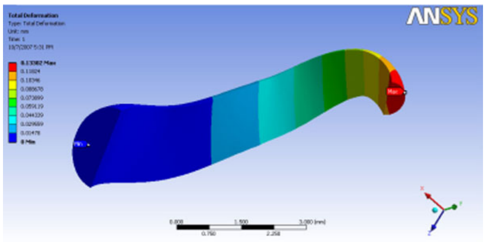

Fig. 4d: Stress distribution in the cast clasp arm

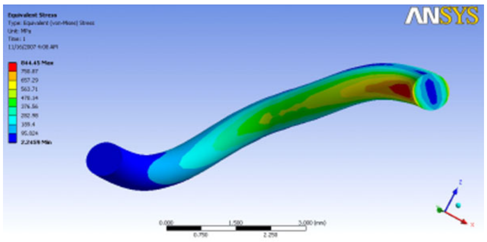

Fig. 5a: Stress distribution in the retentive arm of the combination clasp

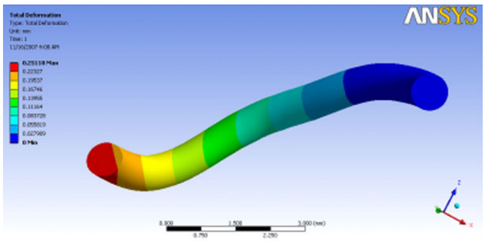

Fig. 5b: Stress distribution in the retentive arm of the combination clasp

Case	Diameter [mm]	Von Mises (min) [MPa]	Von Mises (max) [MPa]	Displacement [mm]
1	0,6	3.7236	1854.8	0.72043
2	0,7	3.1629	1201.2	0.40836
3	0,8	2.2459	844.45	0.25118
4	0,9	1.684	611.55	0.16441
5	1	0.9341	452.73	0.113
6	1,1	0.3537	354.89	8.0821e-002
7	1,2	0.5422	280.66	5.971e-002

Tab. 3: Stress values in the wright wire clasp arm

Conclusions

This in vitro study demonstrated that structural analyses of cast clasps may offer a powerful tool in order to vizualize fracture risk areas. It ensures optimal performance in selection of an adequate clasp design according to each clinical case.

Acknowledgements

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Literature

1. A. A. Mahmoud, N. Wakabayashi, H. Takahashi (2007) Dent Mater 23(3):317-24.
2. R. C. S. Rodrigues, R. F. Ribeiro, M. G. Chiareloo de Mattos, O. L. Bezzon (2002) J Prosthet Dent 88:290-296.
3. L.Sandu, C. Borţun, N. Faur, S. Porojan (2006) Saudi Dental Journal 18(2):100-4.

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