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Wax-pattern or metallic framework investigations trough stress and deformation analysis

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Introduction

The finite element analysis is well known in dentistry. In the field of removable partial dentures were studied dental clasps, major connectors and other maintaining, support and stabilization systems [1,2,3,4,5,6,7,8,9]. The objective of the study was to test wax pattern framework optimum design of removable partial dentures [RPD], using numerical simulation. After testings, the pattern can be transformed into finite piece.

Objectives

The study aim was to utilize noninvasive experimental methods to evaluate the removable partial denture metallic framework stress and distortion areas in order to solve some conception and execution deficiencies.

Material and Methods

There were tested 30 "LiWa" (WP Dental, Beven/Hamburg Germany) wax-patterns and 30 removable partial denture metallic frameworks, and made a comparison between them. Those were 3D laser scanned with LPX 1200 (Roland) and processed with Dr. Picza program. Further processing were made using "Pixform Pro" (Roland DG Corporation) program. Imported "point clouds" are processed and transformed into one surfaces network after connection. This network was exported as DXF extension file in CAD program (Solid Work 2007 - SolidWork Corporation West) where was formed the 3D model pattern. Computer realized geometric models were meshed in finite elements and used for simulation of external forces actions on denture's component elements using Solid Work 2007 - SolidWork Corporation West program.



Fig. 1: "LiWa" Set - light curing wax



Fig. 2a: "LiWa"-Wax pattern: On model



Fig. 2b: "LiWa"-Wax pattern: Light curing wax pattern prepared for scanning

Fig. 2c: "LiWa"-Wax pattern: Metallic framework



Fig. 3a and 3b: Scanning the Wax-pattern - reverse engineering method

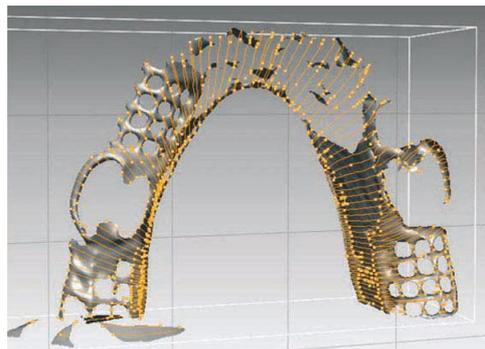
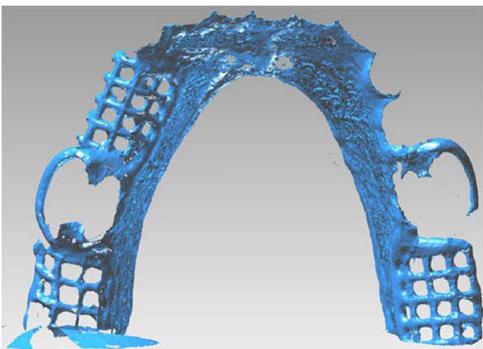


Fig. 4: Scanned Wax-pattern: program Dr. Picza (Roland DG Corporation)

Fig. 5: Point of clouds program "Pixform Pro" (Roland DG Corporation)

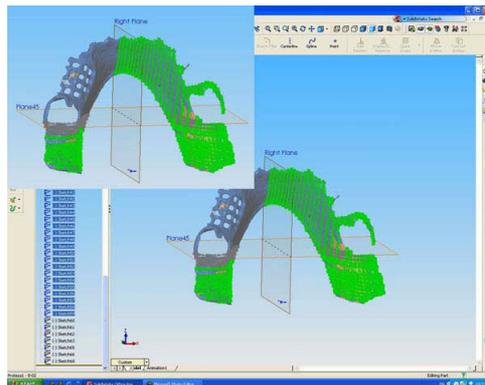
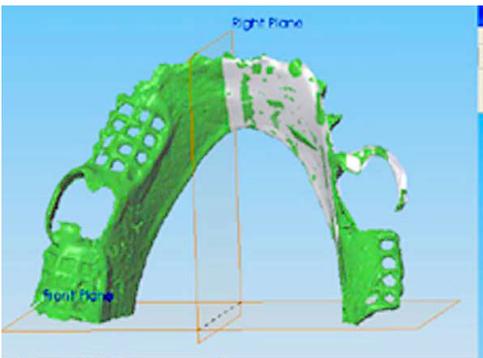


Fig. 6a and 6b: Wax-pattern processing stages programm Solid Work 2007 (SolidWork Corporation West) - sections in frontal and horizontal planes

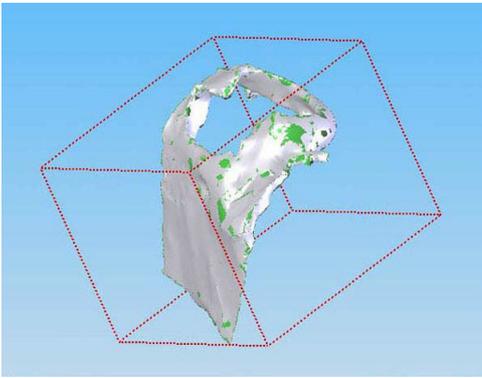


Fig. 6c: Wax-pattern processing stages programm Solid Work 2007 (SolidWork Corporation West) -Section trough major connector

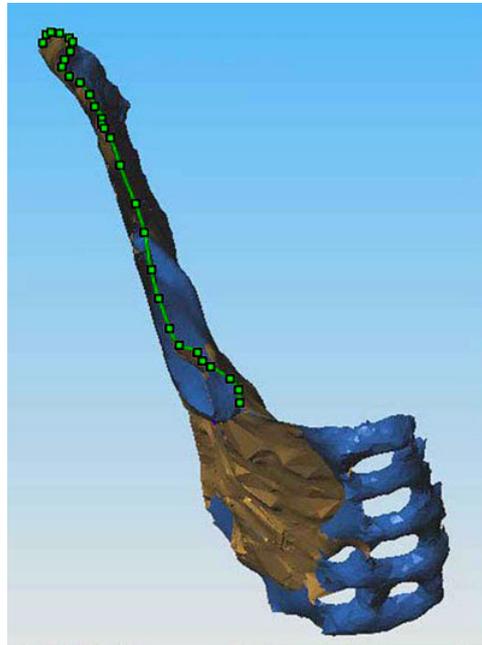


Fig. 6d: Wax-pattern processing stages programm Solid Work 2007 (SolidWork Corporation West) - Tridimensional images of circumferential clasp

Results

Scanned wax-patterns were processed through "reverse engineering" method. The load conditions and the metal characteristics were established. Wax-pattern or metallic framework stress and deformation analysis allow distinguish of minimal mechanical strength. As fragments, RPD clasps were chosen.

Conclusions

Removable partial denture testing, at wax-pattern stage is benefit for determination of the states of tensions, minimum resistance areas distinguish and appreciation the life time of future dentures. Computer experiments although allow the removable partial denture design optimization. Using light curing waxes is a novelty in the field of removable partial dentures technology. Wax pattern finite element analysis allows the design testing of future. Metallic frameworks of RPD, before achieving the prosthesis.

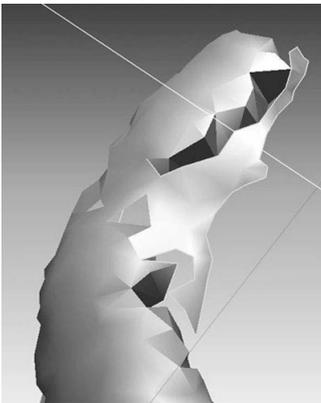


Fig. 7a: Transformation of network surfaces after their confection - brake in clasp surfaces

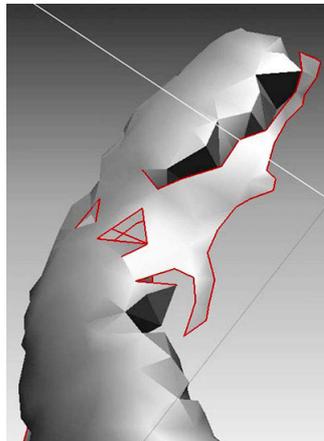


Fig. 7b: Transformation of network surfaces after their confection - red zone must be repaired

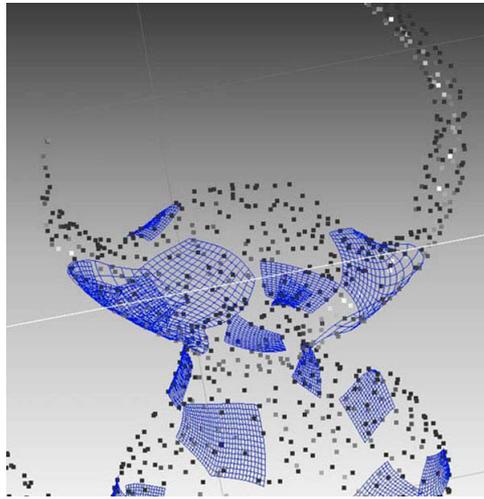
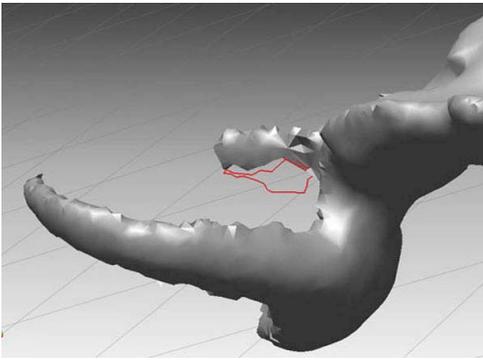


Fig. 7c: Transformation of network surfaces after their confection - red zone must be repaired

Fig. 8a: CAD program tridimensional model of wax-pattern of a clasp - details of meshing process

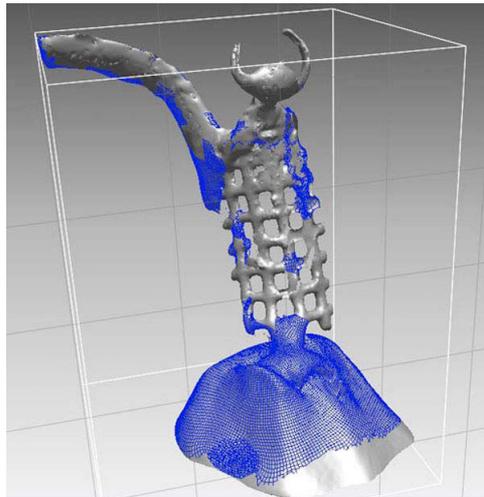
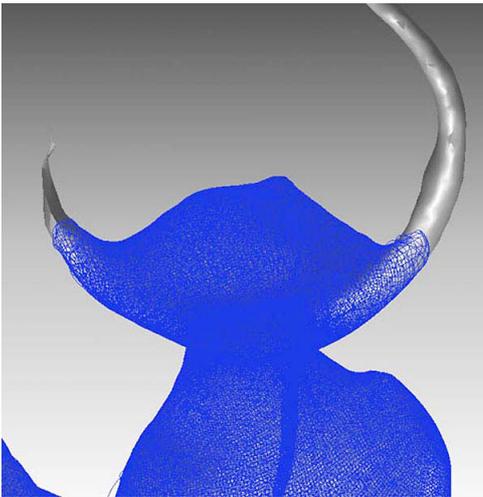


Fig. 8b and 8c: CAD program tridimensional model of wax-pattern of a clasp - details of meshing process

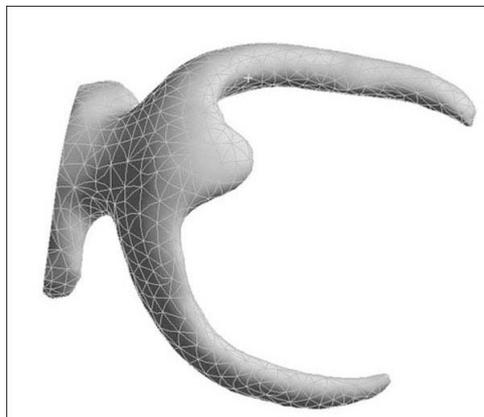
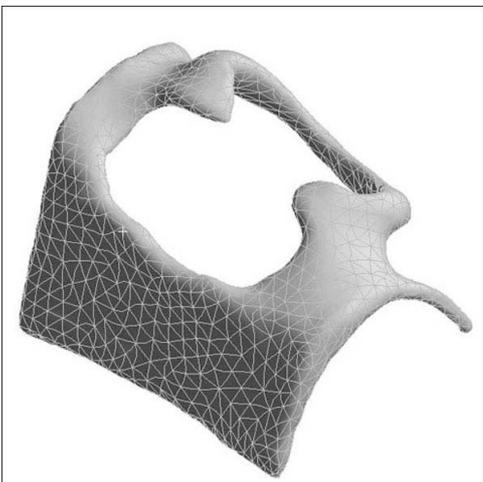


Fig. 9a and 9b: Meshed model for a circumferential clasp

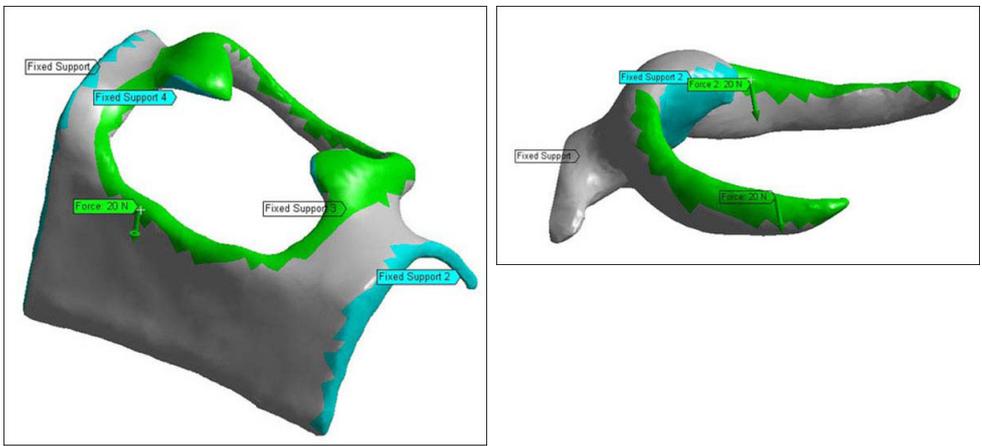


Fig. 10a and 10b: Force application and support distribution

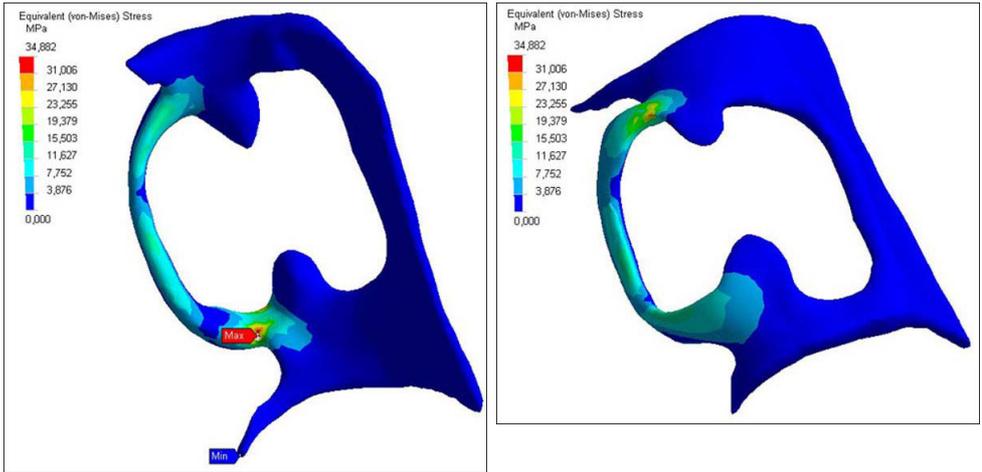


Fig. 11a and 11b: Stress of clasps of RPD

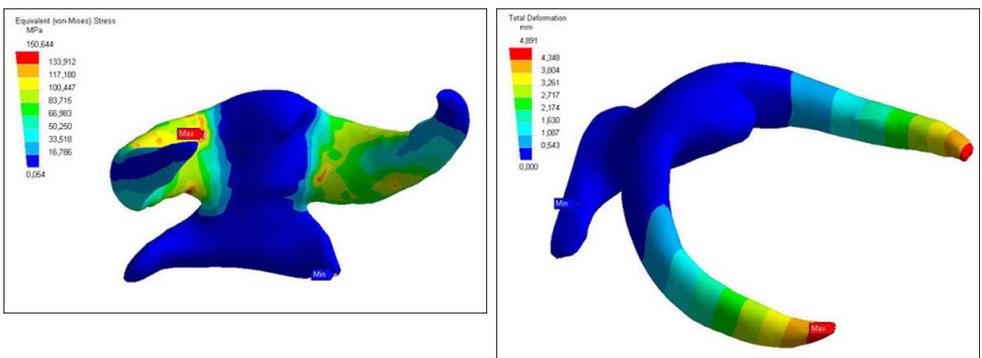


Fig. 11c: Stress of clasps of RPD

Fig. 12a: Total deformation OD clasps

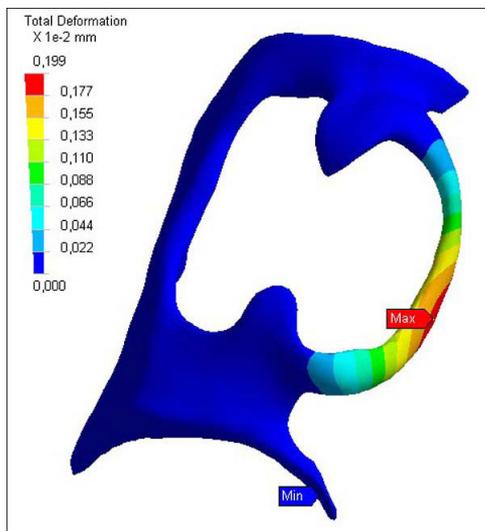


Fig. 12b: Total deformation OD clasps

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WAX-PATTERN OR METALLIC FRAMEWORK INVESTIGATIONS THROUGH STRESS AND DEFORMATION ANALYSIS

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Introduction

The finite element analysis is well known in dentistry in the field of removable partial dentures, where attached denture clasps, major connectors and other supporting support and stabilisation systems [1, 2, 3, 4, 5, 6, 7, 8]. The objective of this study was to test wax pattern framework optimum design of removable partial dentures (RPD) using mechanical simulation. After casting, the pattern can be transformed into finite mesh.

Aim

The study aim was to utilize noninvasive experimental methods to evaluate the removable partial denture metallic framework stress and distortion areas in order to solve some conception and execution deficiencies.

Results

Scanned wax-patterns were processed through "reverse engineering" method. The load conditions and the metal characteristics were established.

Alloy	Co	Cr	Ni
Yield strength	200	100	100
Tensile strength	300	150	150
Elongation	10	5	5
Modulus of elasticity	200000	200000	200000
Poisson's ratio	0.3	0.3	0.3

Wax-pattern or metallic framework stress and deformation analysis allow distinguish of minimal mechanical strength. As fragments, RPD clasps were chosen.



Fig. 10. FEM TOTAL DEFORMATION OF CLASP.

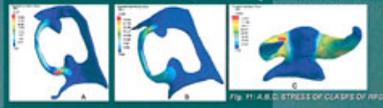


Fig. 11. A, B, C) STRESS OF CLASP OF RPD.



Fig. 12. A, B) Force application and support distribution.



Fig. 9. FINISHED MODEL FOR A CIRCUMFERENTIAL CLASP.

Conclusions

Removable partial denture testing, at wax-pattern stage is benefit for determination of the states of tensions, maximum resistance areas, distal-jack and approximation the life time of future dentures.

Computer experiments although allow the removable partial denture design optimization.

Using 3D printing allows to a novelty in the field of removable partial dentures technology. Wax-pattern finite element analysis allows the design testing of future Metallic frameworks of RPD, before achieving the prostheses.



Fig. 8. CAD PROGRAM 3D DIMENSIONAL MODEL OF WAX PATTERN OF A CLASP. A, B, C) details of meshing process.



Fig. 7. FEM DEFORMATION OF NETWORK SURFACES AFTER TWO INJECTIONS. A. Brake in sleep conditions, B, C. not zone must be repair.



Fig. 1. LDM 1007 right curing unit.



Fig. 2. "LDM" WAX PATTERN: A. Co-molded, B. Right curing wax pattern prepared for scanning, C. Metallic framework.



Fig. 3. SCANNING THE WAX PATTERN - reverse engineering method.



Fig. 4. SCANNED WAX PATTERN. Program: D. Pott (Microsoft 3D Converter).



Fig. 5. POINT CLOUD OF SCANNED WAX PATTERN. Program: Pott (Microsoft 3D Converter).

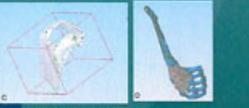


Fig. 6. WAX PATTERN PROCESSING STAGES. PROGRAM: SOLID WORKS (SolidWorks Corporation) (Word). A, B) sections in frontal and horizontal plane, C) Section through major connector and D) 3D-dimensional layout of circumferential clasp.

Material and Method

There were tested 30 "LDM" (Dental Technology Company) wax patterns and 30 removable partial denture metallic frameworks, and make a comparison between them. These were 3D laser scanned with LIX 1200 (Roland DG Corporation) program. Further processing were made using "Potam Pro" (Roland DG Corporation) program. Imported "point clouds" are processed and transformed into 3D surfaces before mesh construction. This network was exported in DXF extension file in CAD program (SolidWorks 2007 - SolidWorks Corporation) where was formed the 3D model pattern. Computer realized geometric models were meshed in finite elements and used for simulation of external forces actions on denture's component elements using Solid Work 2007 - SolidWorks Corporation latest program.

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