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A Complete Denture Strength Evaluation Based On Fracture Mechanics Concepts

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Objectives

The aim of study was to evaluate the complete dentures strength and durability in case of some structural defects of complete dentures.

Material and Methods

For testing there were used samples of material and a upper complete denture, made by ECLIPSE RESIN SYSTEM (DENTSPLY International Inc. - DeguDent GmbH, Hanau Germany). Following an inspection on this denture, there were observed some defects. For strength evaluation of complete denture it was used finite element analysis and there were calculated the stress intensity factors in located points for material's mechanical parameters. There was obtained the geometric model of the complete denture by 3D scanning (Roland 3D laser scanner, model LPX-1200). This was imported into a finite element software - ABAQUS/CAE V6.6 and was determined the state of stress and the stress intensity factors for three located defects.



Fig. 1a: Zwick Roell equipment



Fig. 1b: broken Eclipse samples



Fig. 1c: Roland 3D laser scanner LPX 1200

Fig. 1d: denture with structural defects

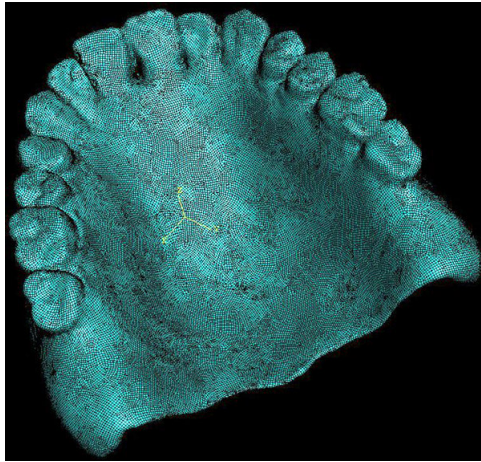
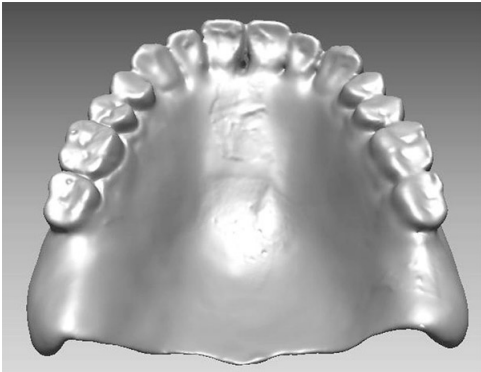


Fig. 1e: scanned denture image

Fig. 1f: geometric model

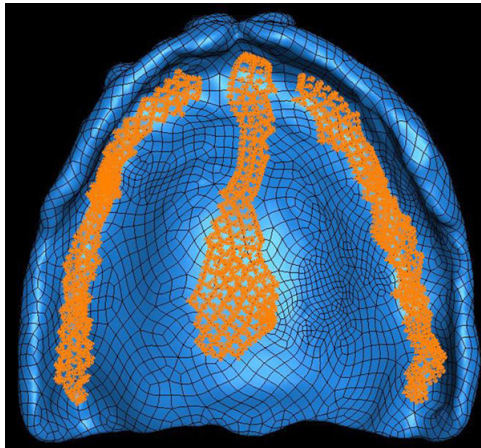
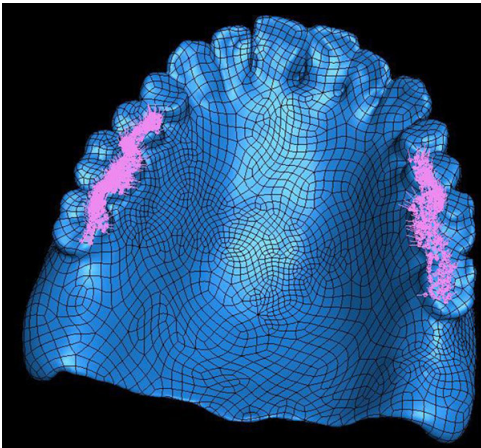


Fig. 1g: forces loading

Fig. 1h: denture's support areas on prosthetic field

Results

For Eclipse Base Plate there were obtained following mechanical properties: the tensile strength - $\sigma_U=59.49$ MPa, Young's modulus - $E=2908.45$ MPa and fracture toughness $KC=24.93$ MPa $\sqrt{\text{mm}}$. tensile strength and deformation analysis of the denture is revealed through chromatic specters, to which warm colors indicated the risk zones for fracture. Defects located on palatal mid-line of upper complete denture, especially those at the junction between different support areas, generate tensile stress and deformation which can determine possible mid-line fractures.

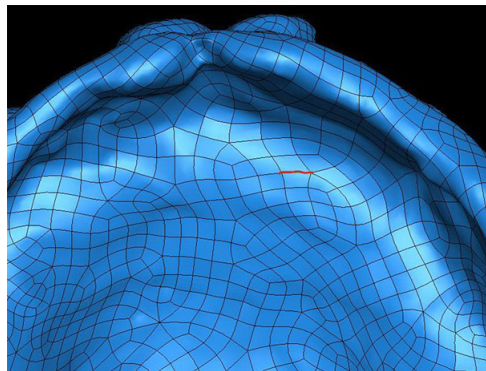


Fig. 2a: Crack in denture

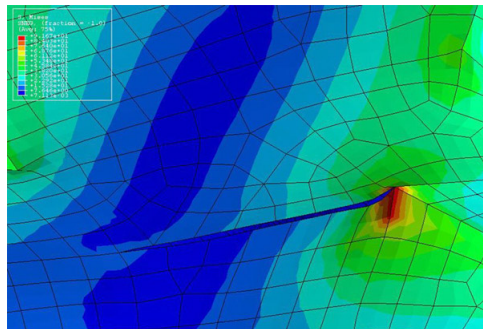


Fig. 2b: Crack detail ($K=4.32$ MPa $\sqrt{\text{mm}}$)

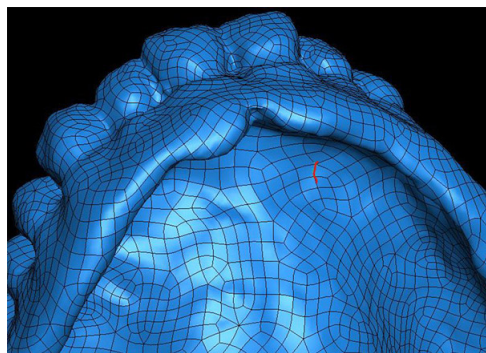


Fig. 2c: Crack in denture

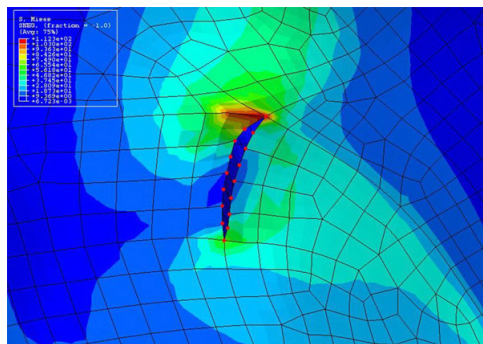


Fig. 2d: Crack detail ($K=22.8$ MPa $\sqrt{\text{mm}}$)

Conclusions

Complete dentures' defects can initiate cracks that are responsible for failure of complete denture before the expected lifetime. Experimental study of prosthesis mechanical properties by finite element analysis is used for knowledge of risk zone for fracture.

Literature

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