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EFFECT OF FRAMEWORK IN IMMEDIATE LOADING IMPLANT-SUPPORTED FULL-ARCH FIXED BRIDGE: 3D-FINITE ELEMENT ANALYSIS

Framework materials in implant prosthodontics

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Introduction: Accuracy and rigidity of metal frameworks have been reported as fundamental prerequisites for the predictable osseointegration of implants that will be immediately loaded. In fact, splinting implants with rigid prostheses immediately after implant placement seems to protect them from overloads and micromotions. However, several full-arch immediate loading protocols provide the use of immediately loaded full-acrylic prostheses.

Objectives: The aim of this study was to analyse through a three-dimensional Finite Element Analysis (3D-FEA) stress distribution on four implants supporting a full-arch implant-supported fixed bridge (FFB) using different prosthesis design.

Material and Methods: A 3-D edentulous maxillary model was created using a customized computer software (FEMAP 8.3, Siemens). Four implants (length: 15 mm) were virtually placed into the maxilla and splinted with a FFB of 12 masticatory units *(Figure 1)*. The implant platforms were placed at the level of the canines and first molars. It was avoided distal cantilever of the prostheses. The distal implants were positioned parallel to the anterior wall of the maxillary sinus with a distal-mesial inclination of 45 degrees. Three different configurations were evaluated, keeping constant all others parameters: (1) full acrylic resin prosthesis without framework, (2) acrylic resin veneering material with cast metal framework, (3) acrylic resin veneering material with a carbon fibre framework. The only differences between the three configurations were the presence or not of the framework and the material of which the framework was made. An occlusal load of 150 N was virtually applied on the left most distal portion of the bridge and stresses transmitted to the prosthodontic components *(Figure 2)*, to the implants *(Figure 3)* and into peri-implant bone *(Figure 4)* were recorded.

Results: 3D-FEA revealed higher stresses on the implants (up to +58,27%), on peri-implant bone (up to +56,93%) and in the prosthesis (up to +91,43%) when the full-acrylic denture was simulated *(Table 1)*. The configuration with cast metal framework exhibited a more spread distribution of the occlusal load applied, transmitting part of the load also to the contralateral structures with respect to load application side. Due to the better load distribution, the maximum stress values were reduced in the configuration with the metal framework. The carbon fibre framework demonstrated an intermediate reaction compared to the other two configurations, but its behavior was more similar to the metal framework.

Discussion and Conclusions: FEA simulating a maxillary rehabilitation revealed that FFBs endowed with a stiff framework decrease stresses on implants, prosthesis and on peri-implant bone providing a better load distribution compared with all-acrylic prostheses. Based on these in vitro outcomes the carbon fibre framework appeared to be a viable alternative to the traditional metal framework, providing a sufficient stiffness of the framework for a better load distribution. Other studies are necessary to validate these preliminary results.


Fig. 1a

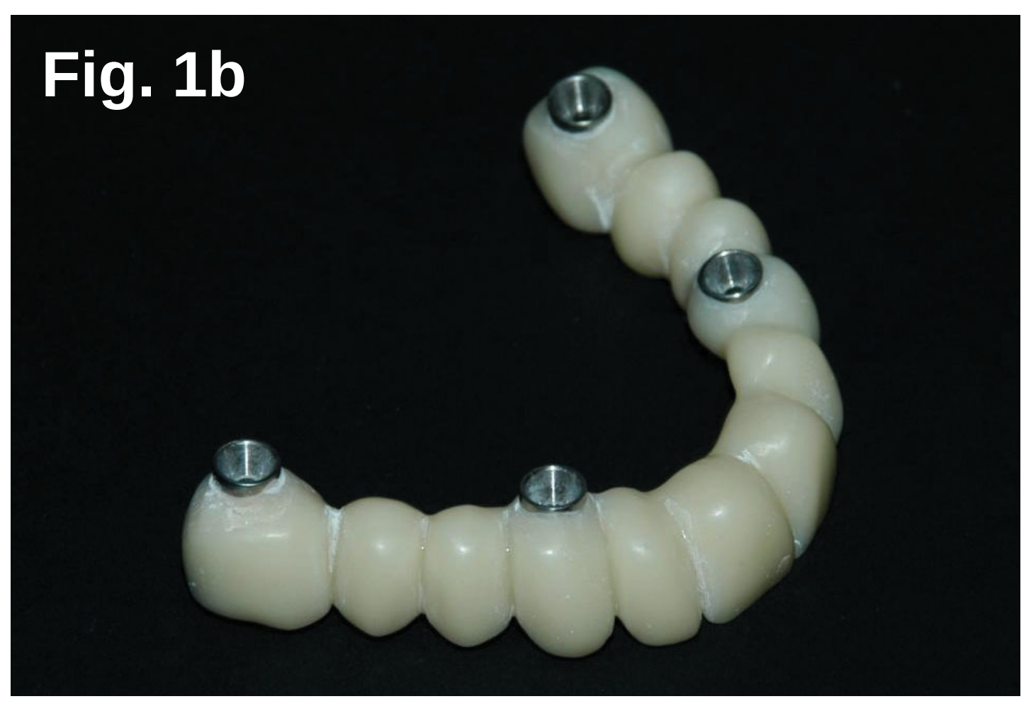
Fig. 1b

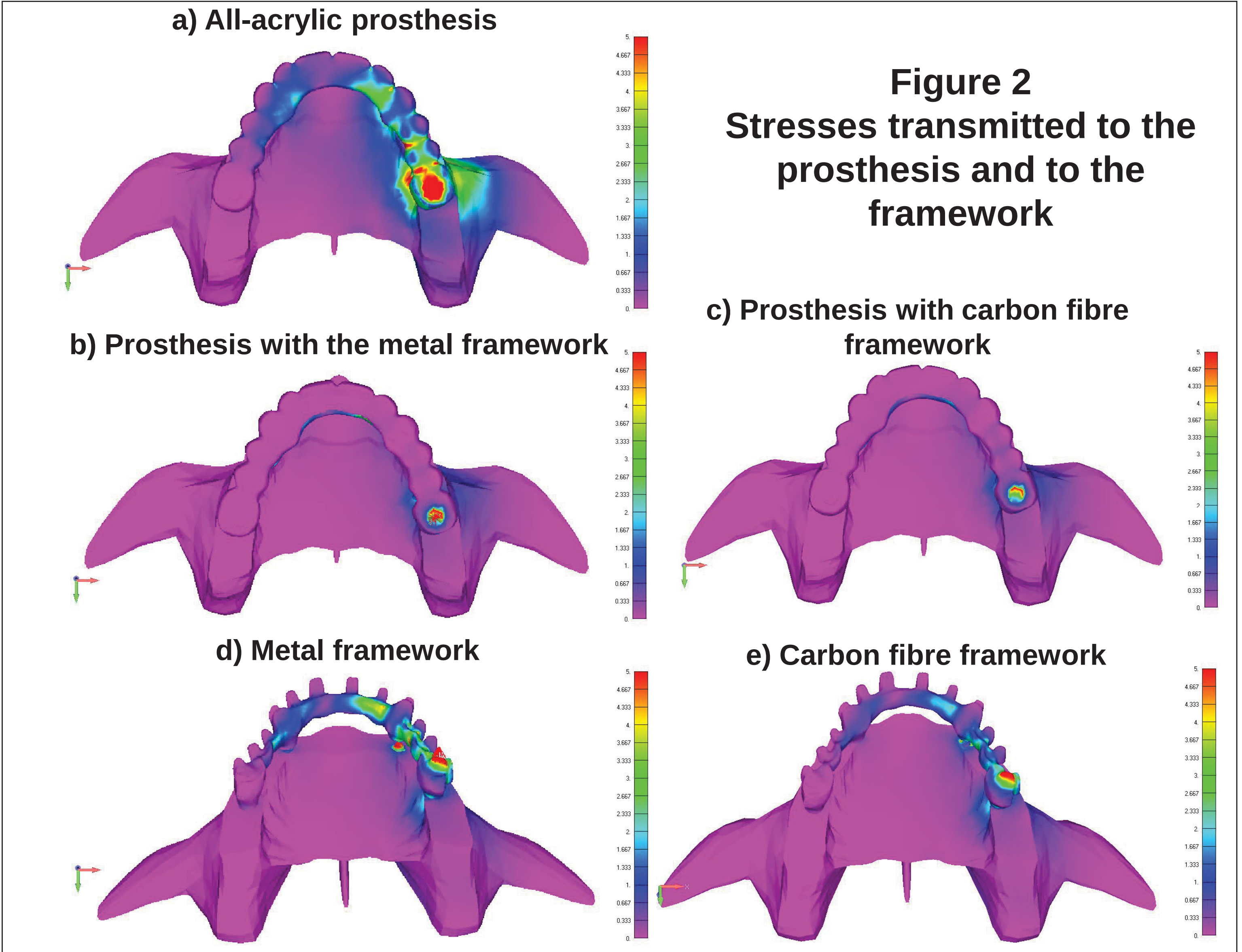

Figure 2
Stresses transmitted to the prosthesis and to the framework

Figure 3
Stresses trasmitted to the implants

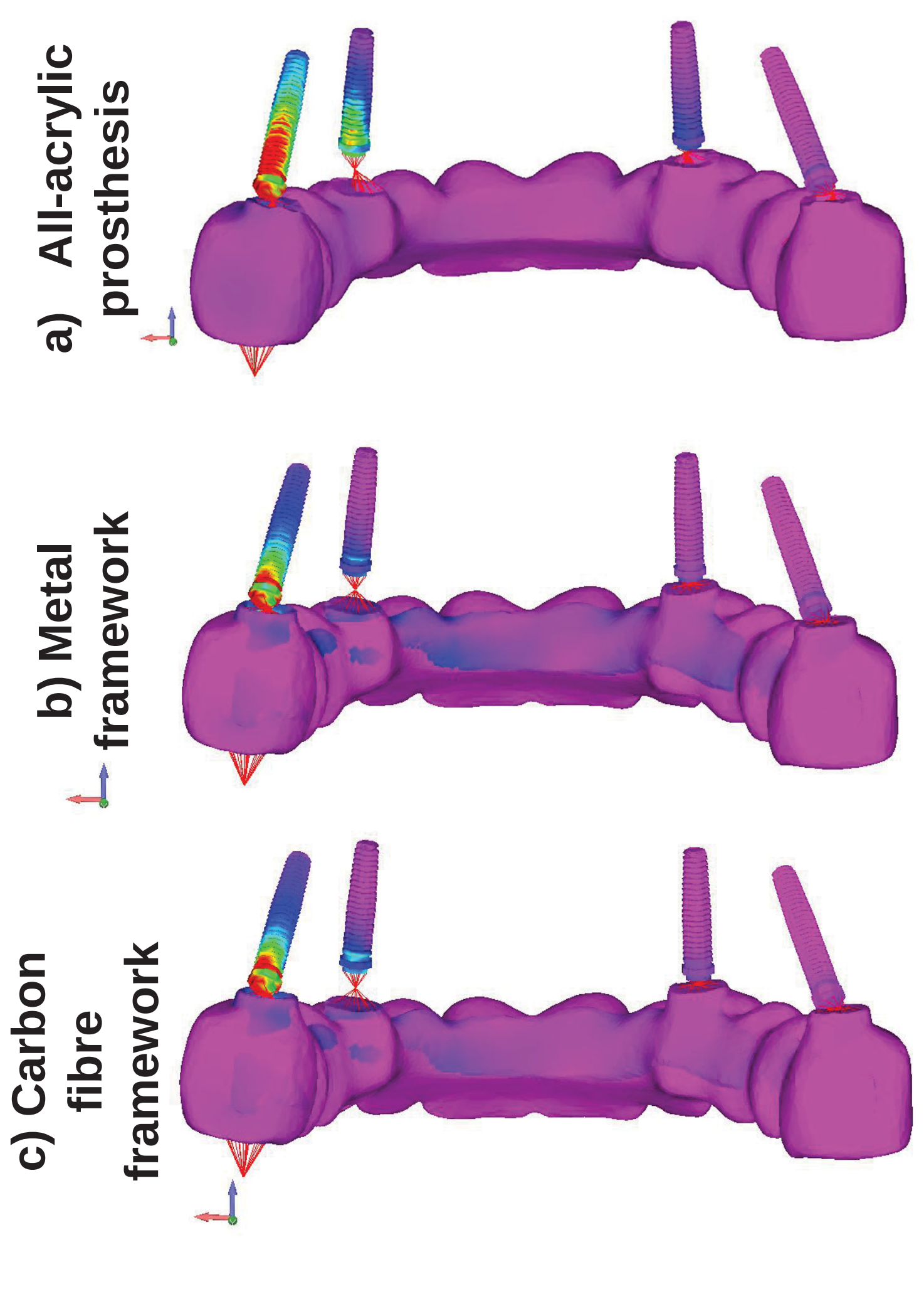

Figure 4
Stresses trasmitted to the bone

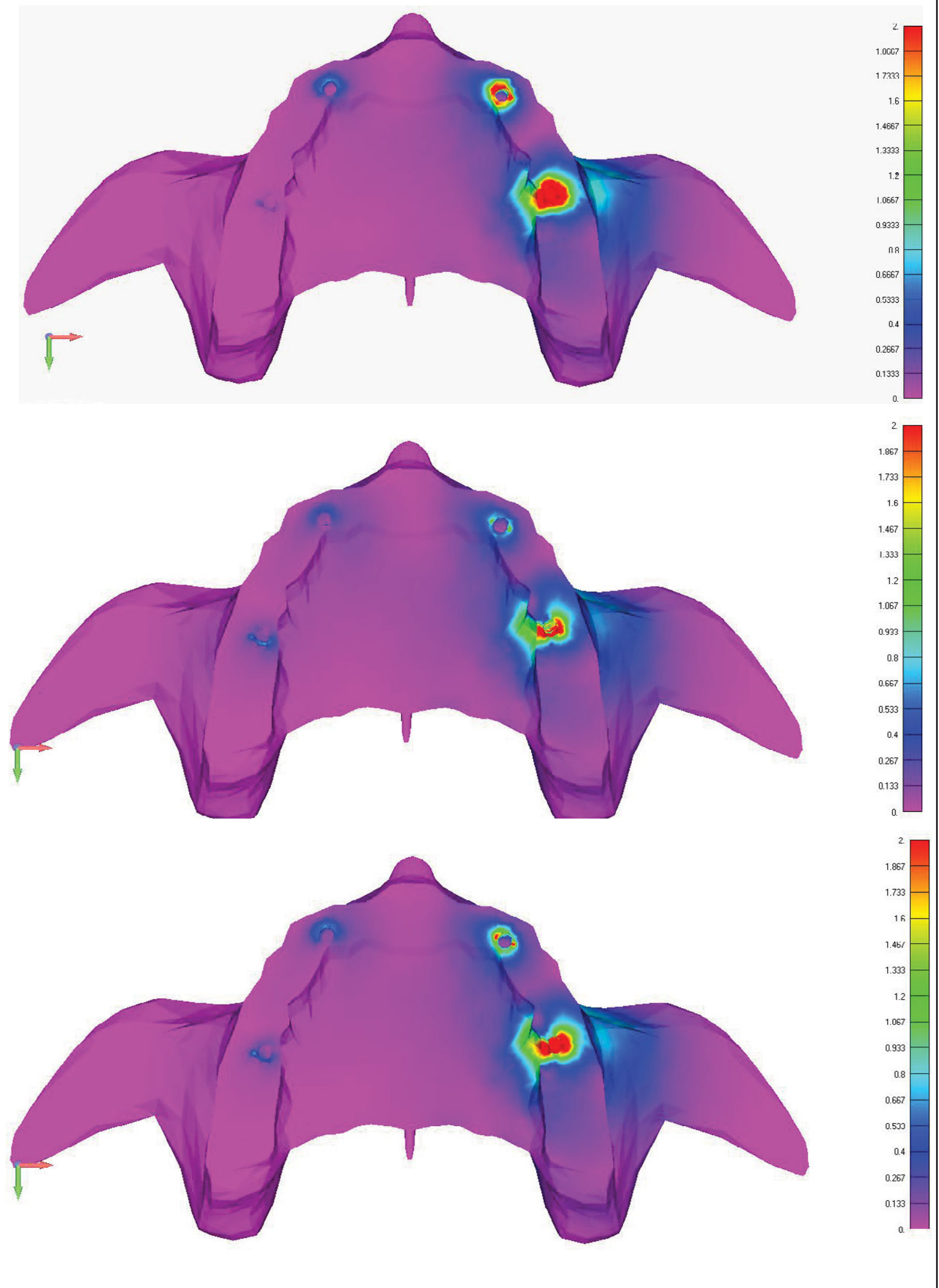

Table 1 Von Mises stress (MPa)

	COMPACT BONE				CANCELLOUS BONE			
Position	All Acrylic Prosthesis				All Acrylic Prosthesis			
	Implant	Bone	Resin		Implant	Bone	Resin	
26	91,46	25,92	12,63		89,48	11,62	12,64	
23	21,59	12,1	0,99		23,37	4,69	1,26	
13	5,1	0,84	0,5		7,45	0,61	1,16	
16	0,64	0,35	0,07		2,49	0,28	0,22	
	Metal Framework Prosthesis				Metal Framework Prosthesis			
	Implant	Bone	Resin	Metal	Implant	Bone	Resin	Metal
26	67,52	16,53	10,14	20,43	66,47	9,55	10,13	20,97
	-26,18%	-36,23%	-19,71%	+61,76%	-25,71%	-17,81%	-19,86%	+65,9%
23	9,01	5,8	0,29	4,98	10,47	2,02	0,63	9,7
	-58,27%	-52,06%	-70,71%	+403,03%	-55,16%	-56,93%	-50%	+669,84%
13	6,34	0,71	0,15	3,43	10,48	0,53	0,25	5,82
	+24,3%	-15,48%	-70%	+586%	+40,67%	-13,11%	-78,45%	+401,72%
16	2,37	1,05	0,08	1,17	7,52	0,86	0,14	2,33
	+270,31%	+200%	+14,29%	+1571,43%	+202%	+207,14%	-36,36%	+959,09%
	Carbon Fiber Framework Prosthesis				Carbon Fiber Framework Prosthesis			
	Implant	Bone	Resin	Carbon fiber	Implant	Bone	Resin	Carbon fiber
26	71,68	21,04	10,25	20,81	78,66	10,34	10,24	18,95
	-21,63	-18,83%	-18,84%	+64,77%	-12,09%	-11,02%	-18,99%	+49,92%
23	12,45	8,73	0,1	3,95	10,00	2,81	0,40	5,45
	-42,33%	-27,85%	-89,90%	+289,99%	-57,21%	-40,09%	-68,25%	+332,54%
13	4,33	0,77	0,06	1,79	7,98	0,58	0,42	3,76
	+15,1%	-8,33%	-88%	+258%	+7,11%	-4,92%	-63,79%	+224,14%
16	1,60	0,8	0,006	0,40	2,50	0,70	0,20	1,11
	+150%	+128,57	-91,43%	+471,43%	+0,40%	+192,86%	-9,09%	+404,55%

LEGENDS

Figure 1 Castable resin framework **(a)** and full fixed bridge **(b)** that were scanned to create the finite element model.

Figure 2 The occlusal view show stresses transmitted to the prosthesis and to the framework. The color scale reflects von Mises' values (red: the most stressed areas; purple: the least stressed areas; colors in between show intermediate values). **a)** All-acrylic prosthesis; **b)** Prosthesis with the metal framework; **c)** Prosthesis with the carbon fibre framework; **d)** Metal framework; **e)** Carbon fibre framework.

Figure 3 Stresses transmitted to the implants. **a)** All-acrylic prosthesis; **b)** Prosthesis with the metal framework; **c)** Prosthesis with the carbon fibre framework.

Figure 4 Stresses transmitted to bone. **a)** All-acrylic prosthesis; **b)** Prosthesis with the metal framework; **c)** Prosthesis with the carbon fibre framework.

Table 1 Von Mises stress (Mpa). The percentage difference of stress vs. all-acrylic resin configuration is reported (%).

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