Mechanical Faculty

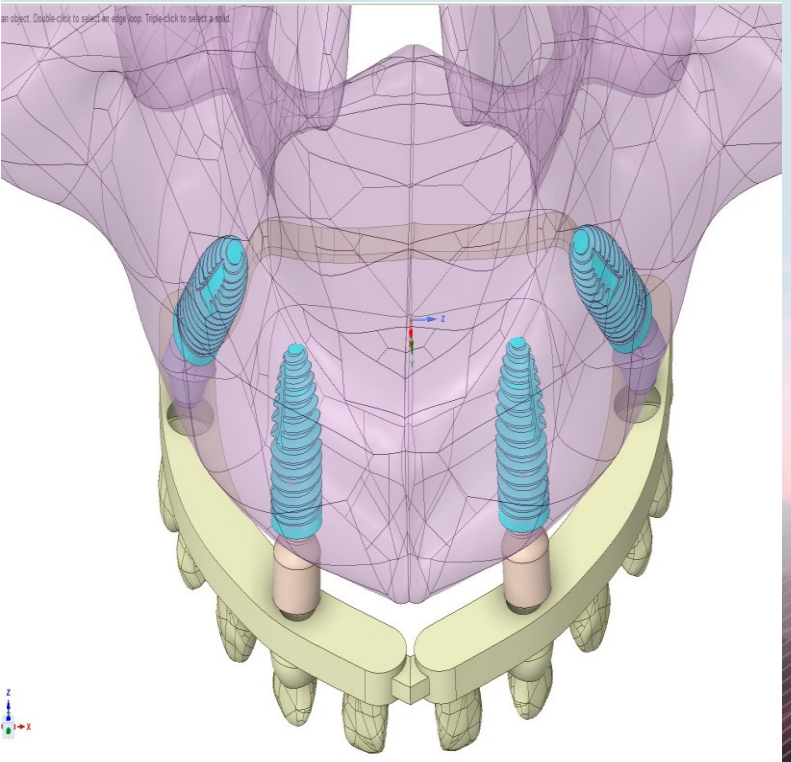
EPA European Prosthodontic Association | tpid 1976 TURKISH PROSTHODONTICS and IMPLANTOLOGY ASSOCIATION | THE 48th ANNUAL EPA CONGRESS | THE 27th SCIENTIFIC TPID CONGRESS | 11-13 SEPTEMBER, 2025 THU, FRI, SAT

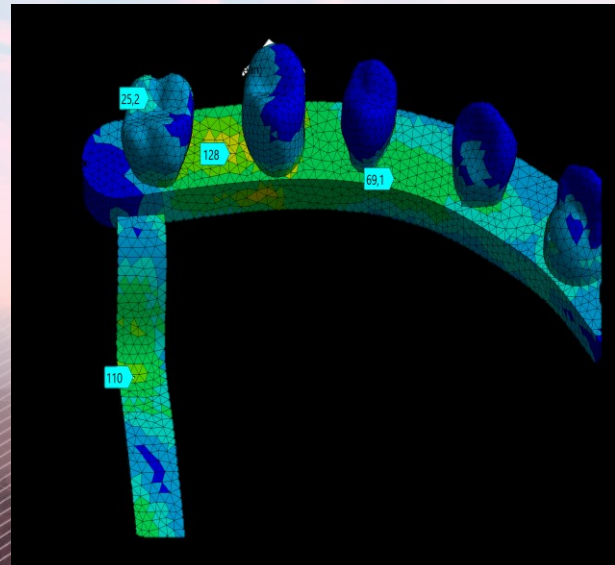
Is Closed-Bar Design a Better Option for All-on-Four Concept ?

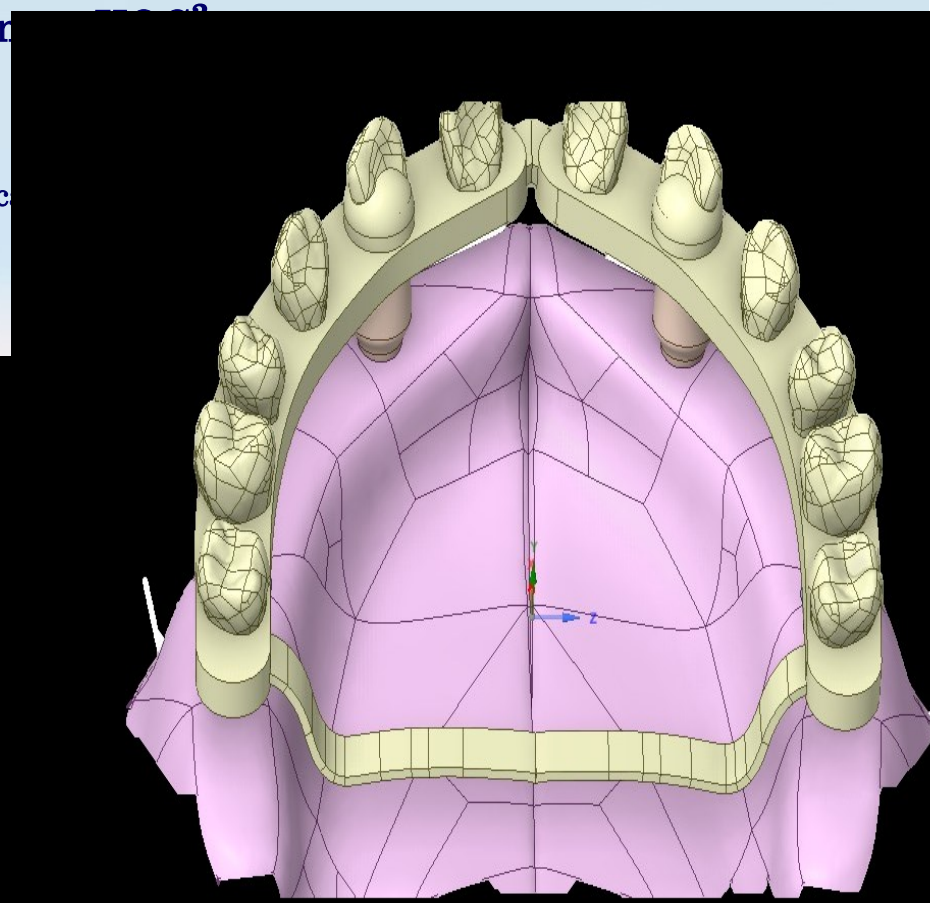
Nurşah PERVANLI[1], Ceyhun POLAT[1], Osr

Yeditepe University Faculty of Dentistry [1]

Yıldız Teknical University Faculty of Mechanic







INTRODUCTION



Edentulism...

Approaches to the management of edentulism







Indications of the All-on-4 Technique

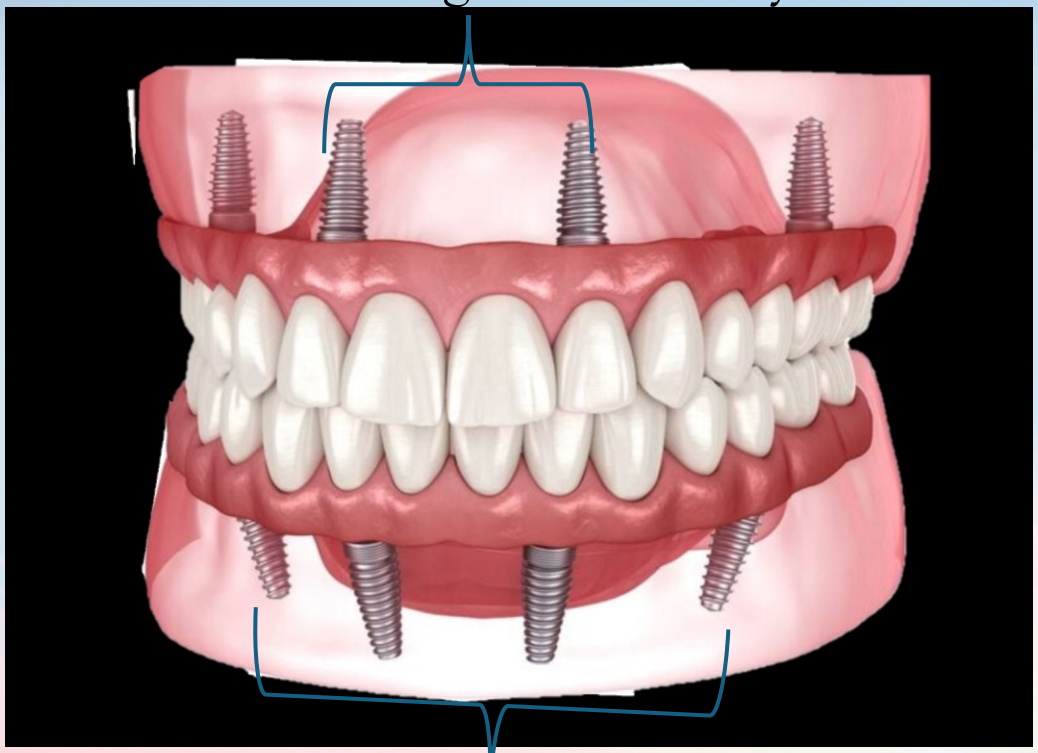
1. Patient must be in good systemic health with acceptable oral hygiene.
2. Adequate bone: at least 10 mm implant length, 5 mm width, 10 mm anterior maxillary height, and 8 mm interforaminal height.
3. Primary stability sufficient for immediate function.
4. Minimum 20 mm interarch space for abutment, framework, and prosthesis.

Contraindications of the All-on-4 Technique

1. Insufficient bone volume or height preventing stable implant placement.
2. Remaining teeth obstructing ideal implant positioning.
3. Limited mouth opening (<50 mm), hindering surgical access and instrumentation.

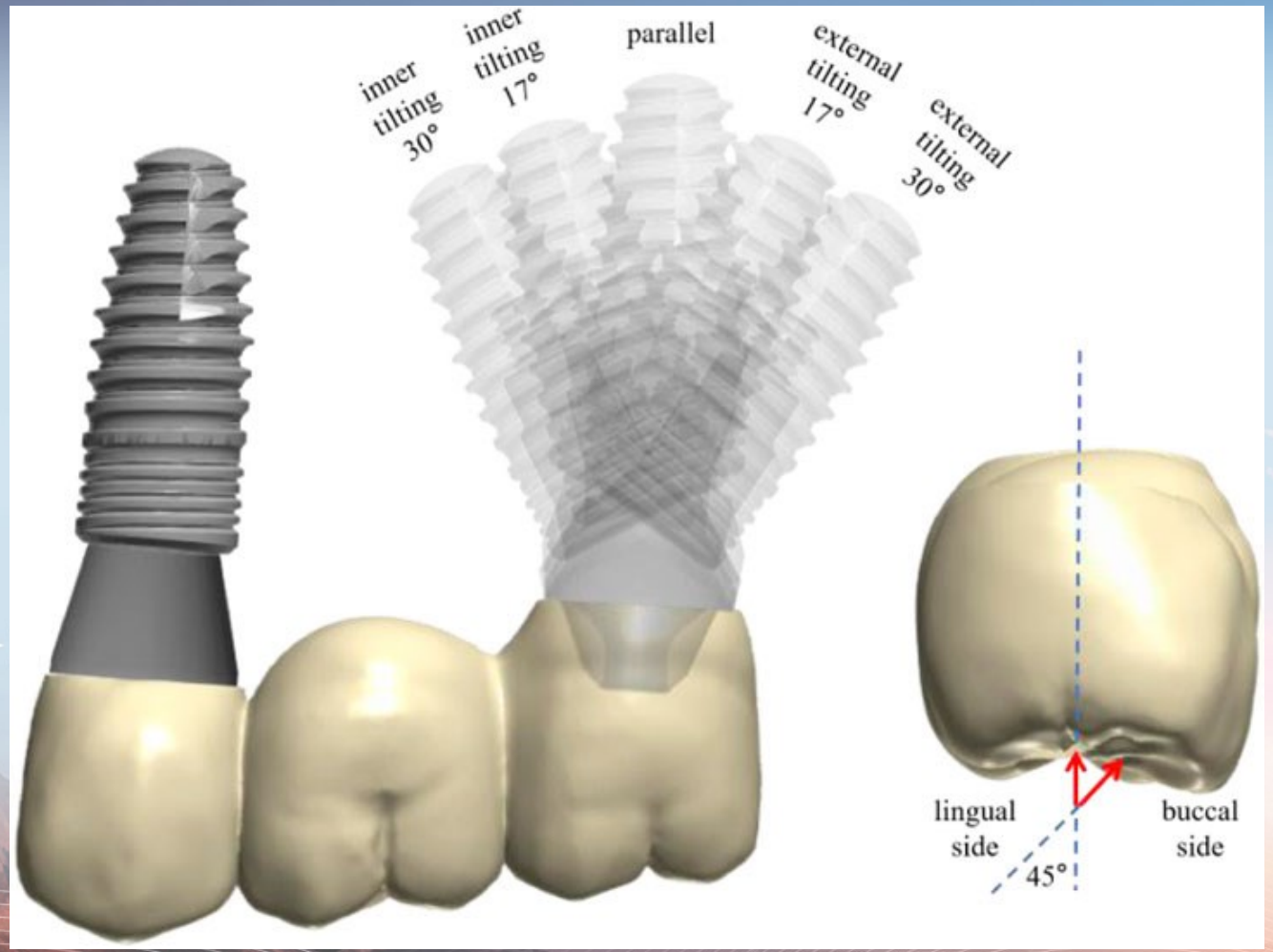
Taruna M. Prosthodontic Perspective to All- On-4 ® Concept for Dental Implants. *Journal of Clinical and Diagnostic Research*. Published online 2014. doi:10.7860/jcdr/2014/9648.5020
Ho CCK, Jovanovic SA. The "All-on-4" concept for implant rehabilitation of an edentulous jaw. *Compend Contin Educ Dent*. 2014;35(4).
Jensen OT, Adams MW, Cottam JR, Parel SM, Phillips WR. The all-on-4 shelf: Maxilla. *Journal of Oral and Maxillofacial Surgery*. 2010;68(10).
doi:10.1016/j.joms.2010.05.082

Lateral region/Vertically



Premolar region/ Angled 30°to 45°

Babbush CA, Kutsko GT, Brokloff J. The All-on-Four immediate function treatment concept with nobelactive implants: A retrospective study. *Journal of Oral Implantology*. 2011;37(4). doi:10.1563/AAID-JOI-D-10-00133

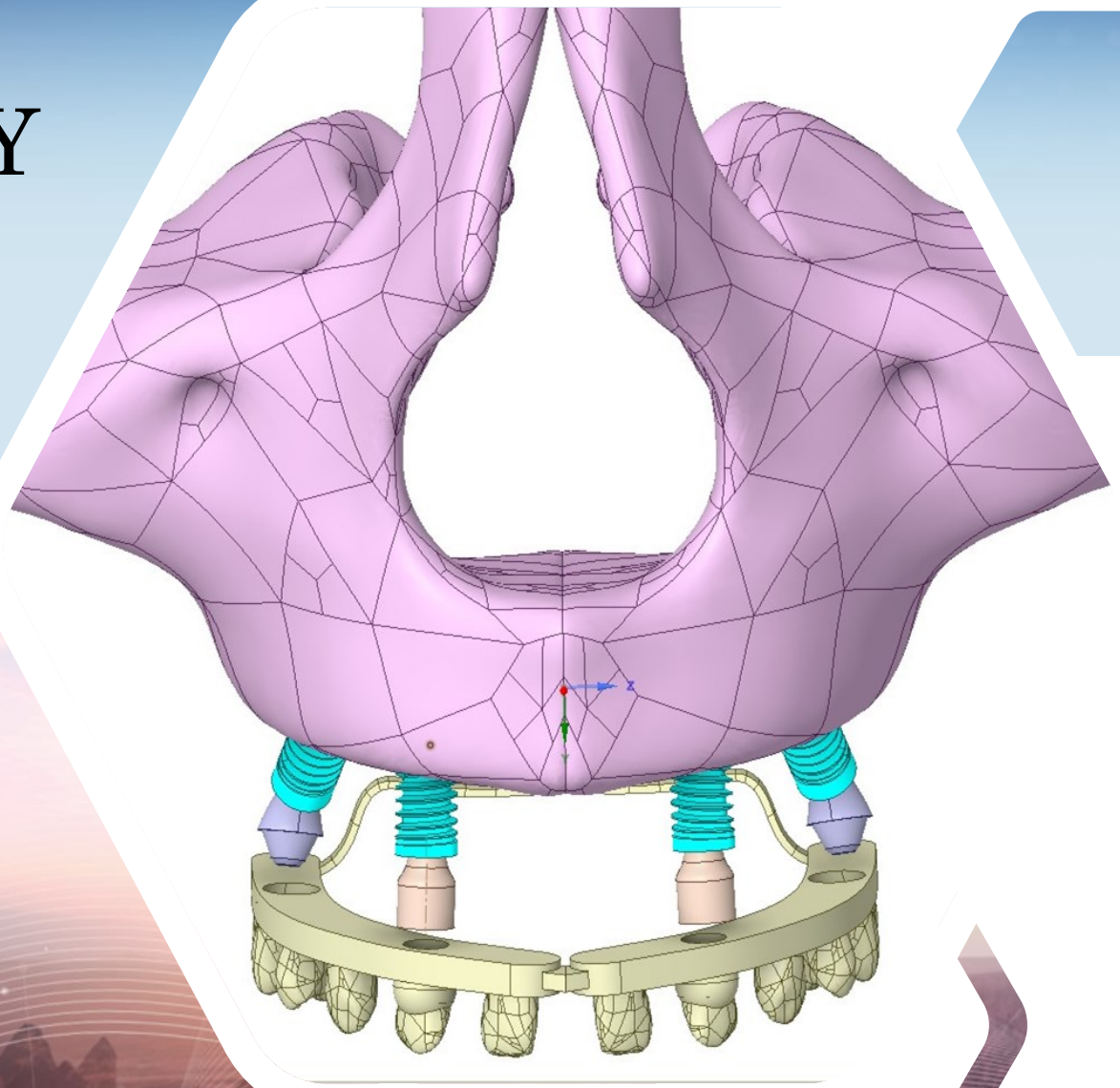


When tilted implants are incorporated into a multi-implant prosthesis, the distribution of implants and prosthetic rigidity help reduce or modify these bending forces, lowering their negative impact.

Daellenbach K, Hurley E, Brusnki JB, et al: Biomechanics of in-line vs. offset implants supporting a partial prosthesis. J Dent Res 1996;75:183

AIM OF THE STUDY

Analyse the stress distribution in the implant, bone and prostheses with distal implants placed at 30 and 45 degrees and evaluate the effectiveness of a bar-supported design.



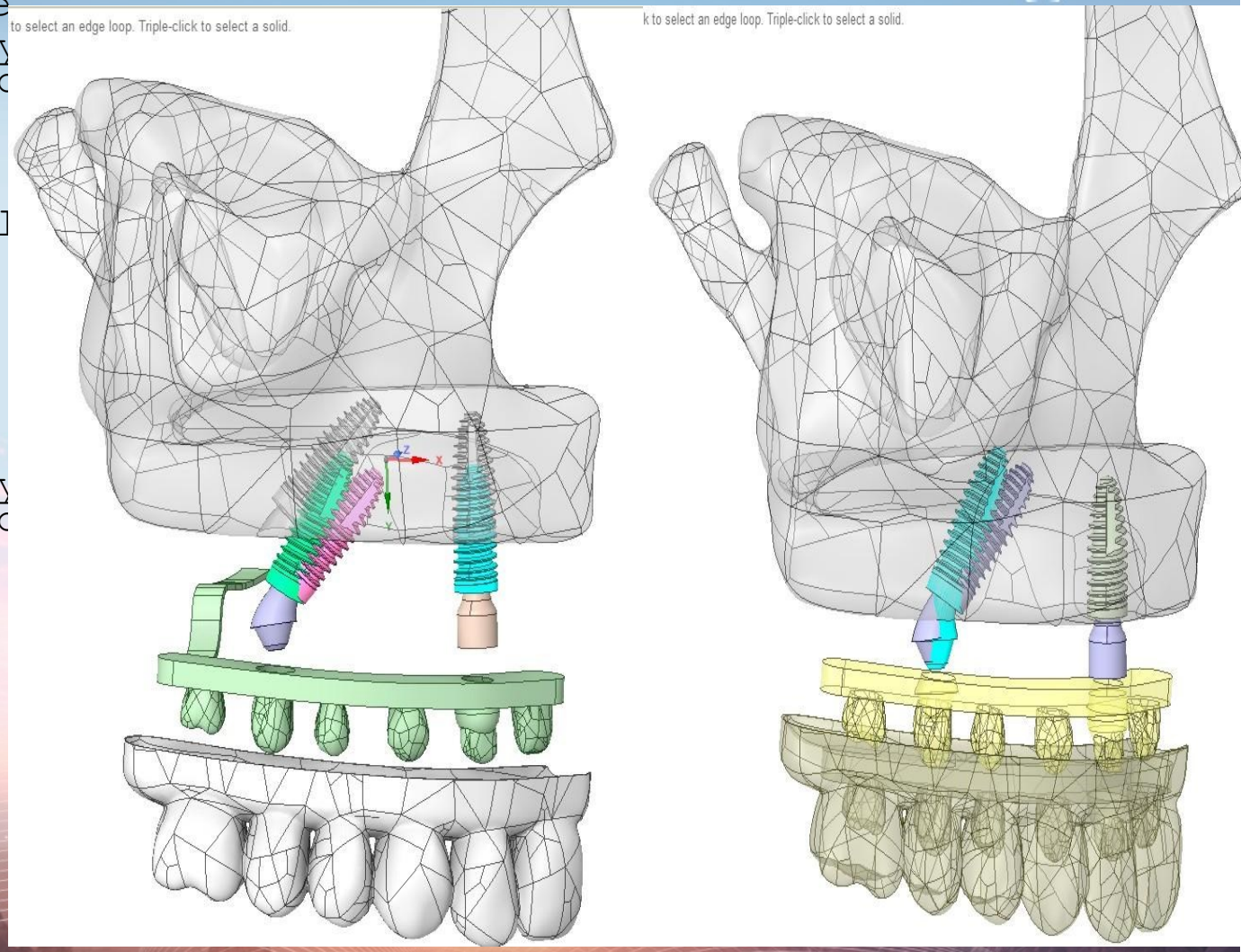
MATERIALS AND METHODS

Model I: A straight implant and abutment were placed at a 30° angulation in the maxillary bone, positioned at the level of the second premolar.

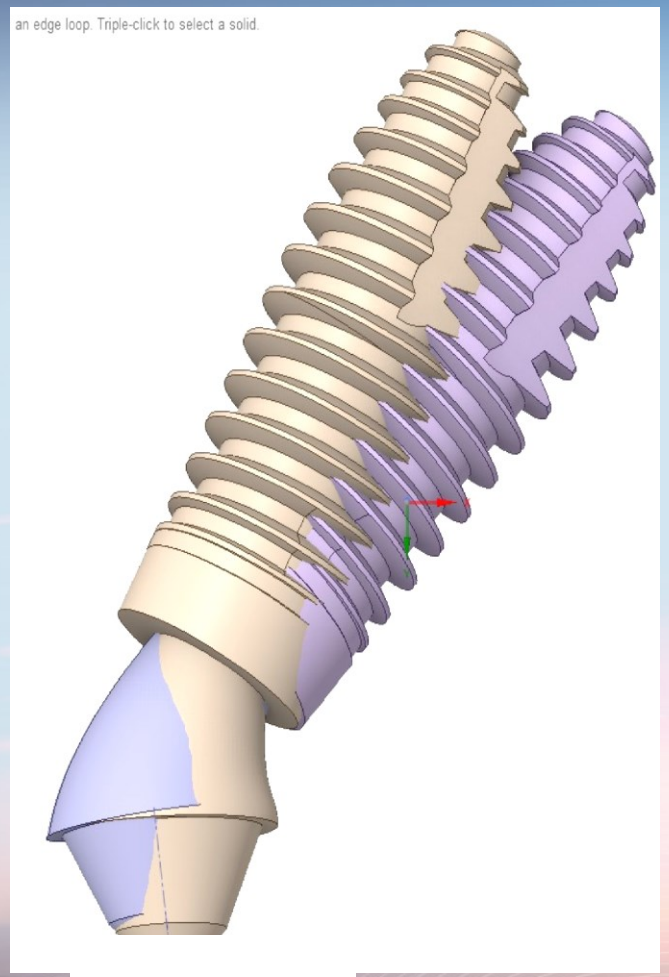
Model II: The implant placement were identical to Model I. In addition, a palatal bar design was incorporated into the framework at the level of the first molar.

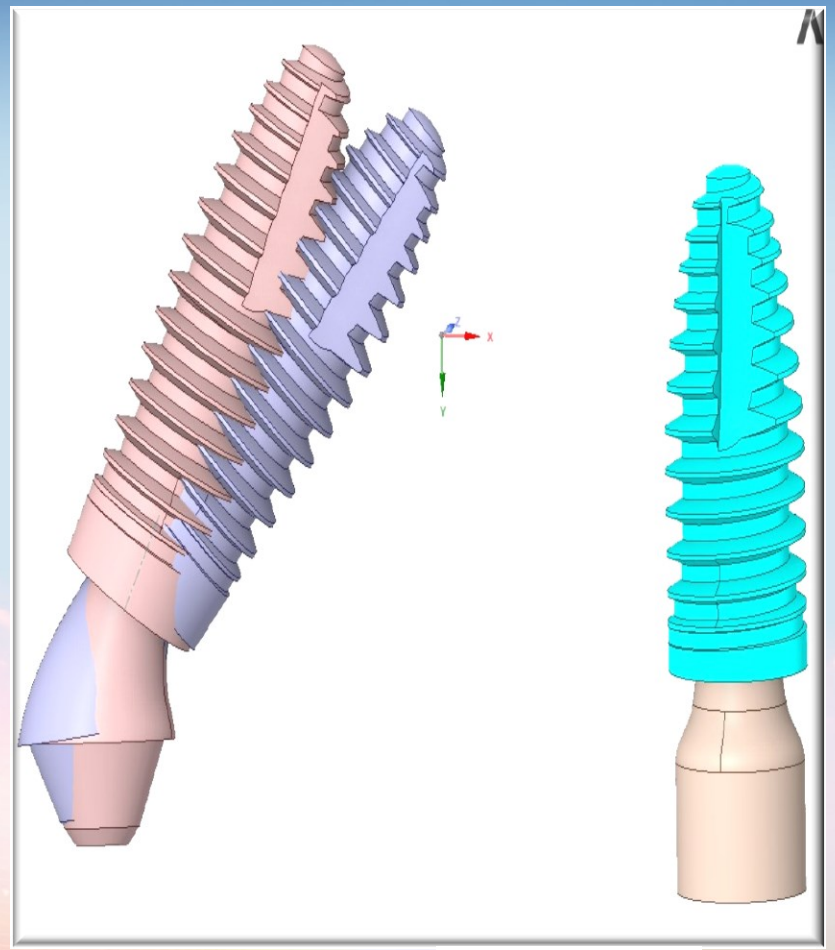
Model III: A straight implant and abutment were placed at a 45° angulation in the maxillary bone, positioned at the level of the second premolar.

Model IV: The implant placement were identical to Model III. Additionally, a palatal bar design was incorporated into the framework at the level of the first molar

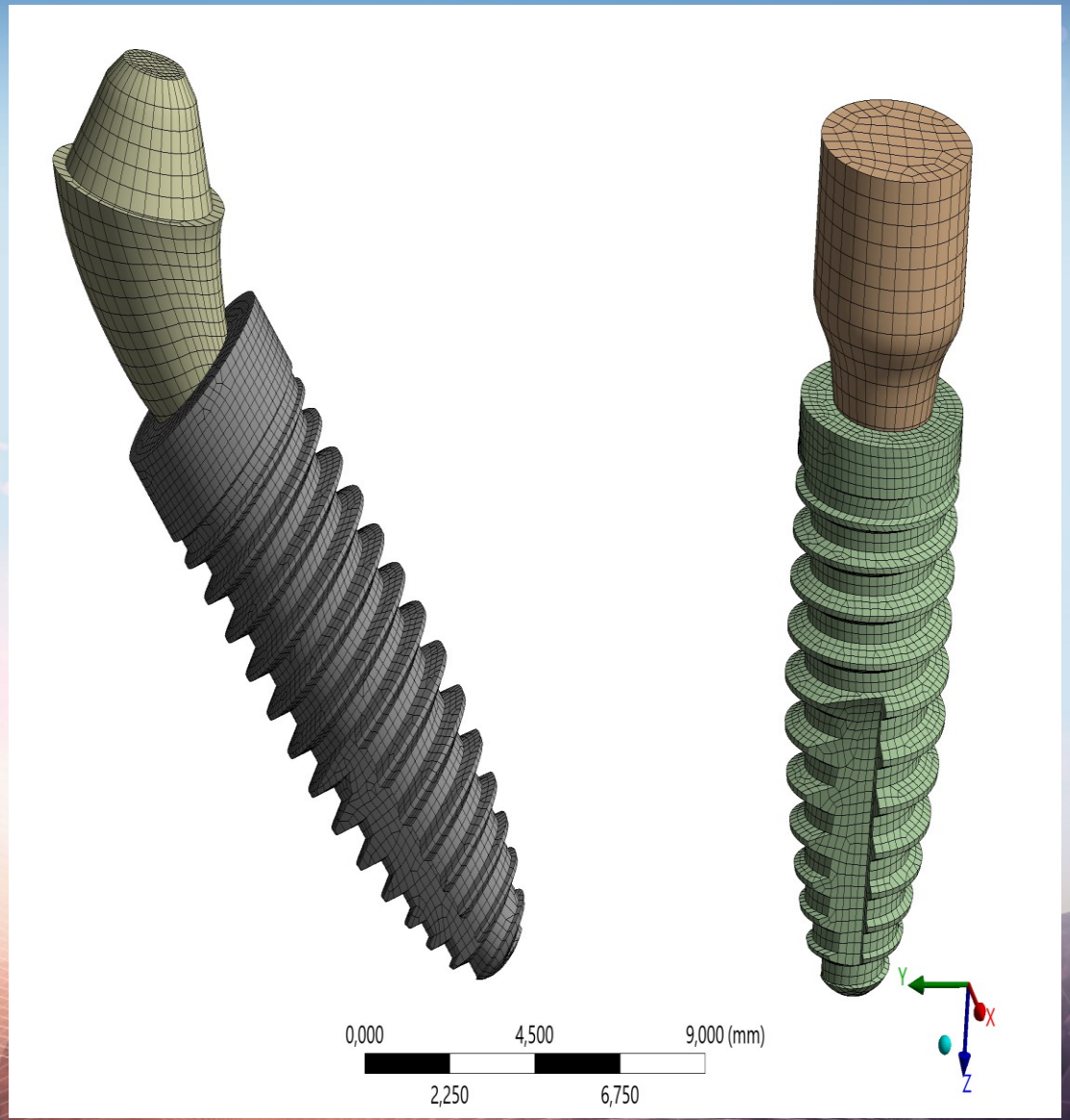


4×13mm
4×10mm

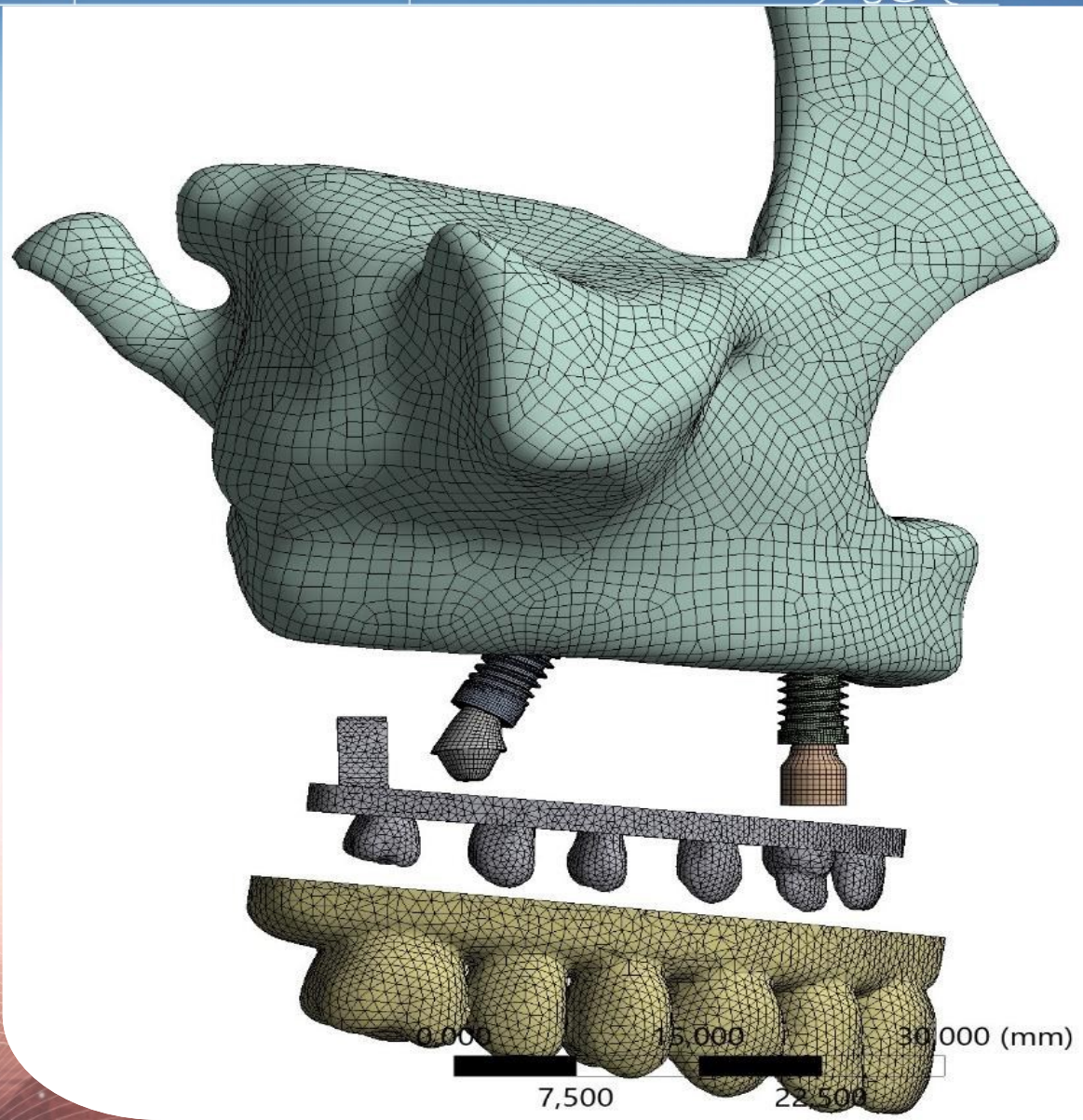




Material properties (Mpa)	Elastic modulus	Poisson's ratio	Shear modulus
Cortical Maxillary bone	Ex: 12000	Vxy: 0.18	Gxy: 3600
	Ey:11640	Vyz: 0.40	Gyz: 5400
	Ez:15600	Vxz: 0.30	Gxz: 4100
Cancellous bone	Ex:1448	Vxy: 0.32	Gxy: 434
	Ey: 1448	Vyz: 0.05	Gyz: 68
	Ez: 210	Vxz: 0.05	Gxz: 68
Acrylic Resin	3000	0,35	
Framework Bar (Cobalt-chrome)	235.000	0.33	88.300
Implant and Abutment (Titanium)	105000	0,37	

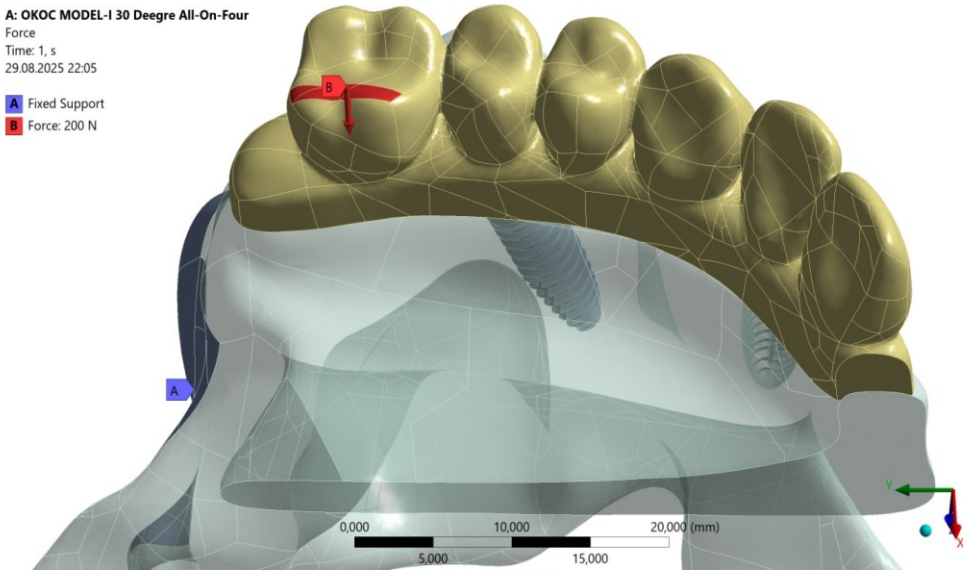


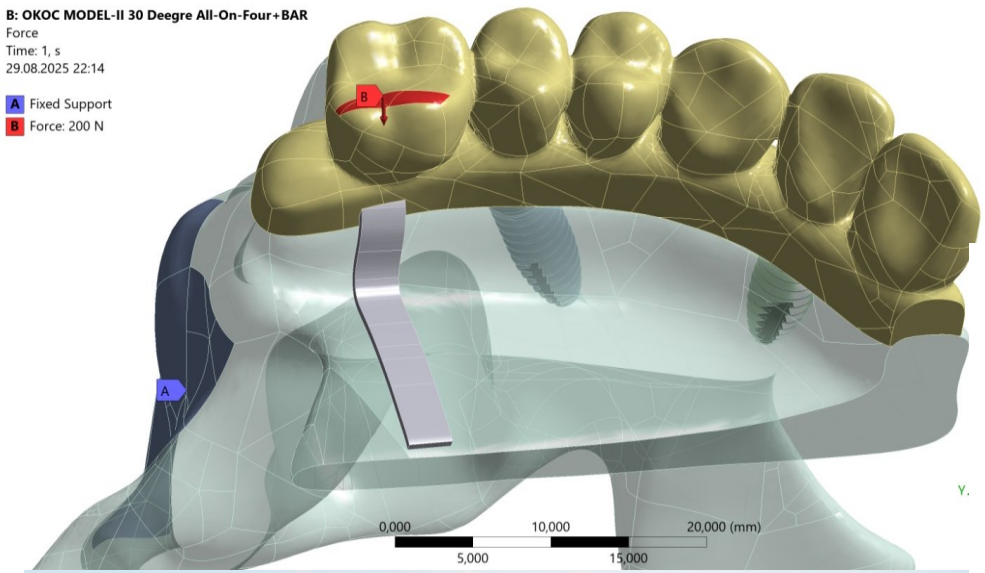
	AVERAGE SKEWNESS VALUE	NODES	ELEMENT	MESH SIZE (mm)	MESH ELEMENT TYPE
Maxilla	0.46	284881	97565	1.2	Hexahedral
Prosthesis	0.25	66213	41479	0.9	Tetrahedral
Bar	0.22	62950	40424	0.9	Tetrahedral
Straight Implant	0.5	61748	19767	0.2	Hexagonal
Multiunit Abutment	0.22	7158	1494	0.4	Hexahedral
Sloped Implant	0.5	84457	26766	0.2	Hexagonal
Sloped Abutment	0.22	12407	2652	0.4	Hexahedral

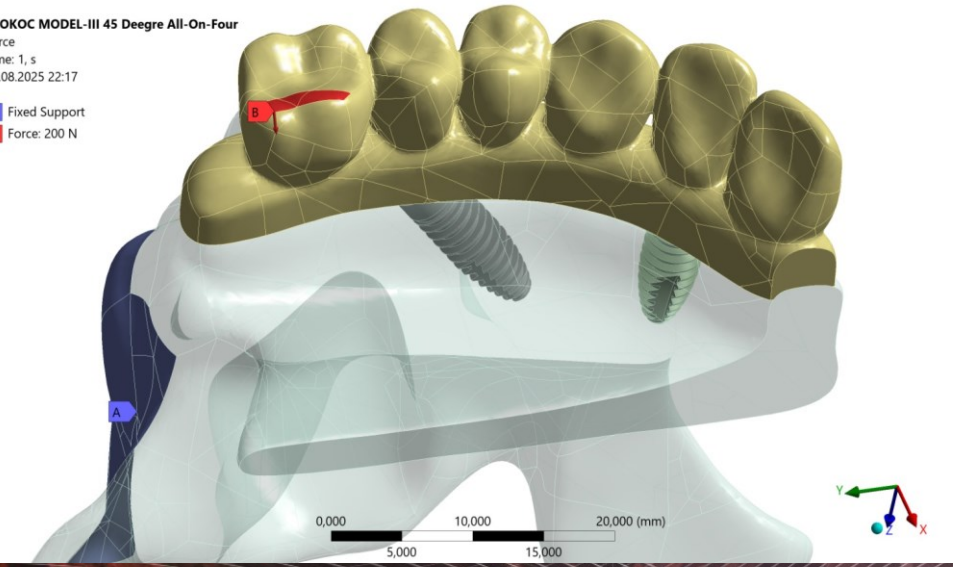


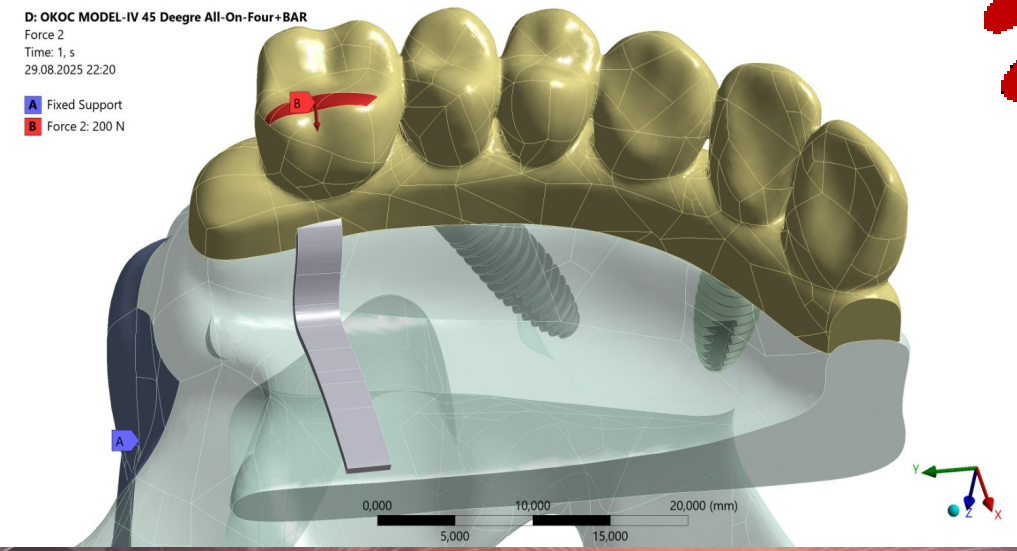
Mesh metrics spectrum created by ANSYS Software

Excellent	Very good	Good	Acceptable	Bad	Unacceptable
0-0.25	0.25-0.50	0.50-0.80	0.80-0.94	0.95-0.97	0.98-1.00


A: OKOC MODEL-I 30 Deegre All-On-Four
Force
Time: 1, s
29.08.2025 22:05
A Fixed Support
B Force: 200 N
0,000
10,000
20,000 (mm)
5,000
15,000


B: OKOC MODEL-II 30 Deegre All-On-Four+BAR
Force
Time: 1, s
29.08.2025 22:14
A Fixed Support
B Force: 200 N
0,000
10,000
20,000 (mm)
5,000
15,000

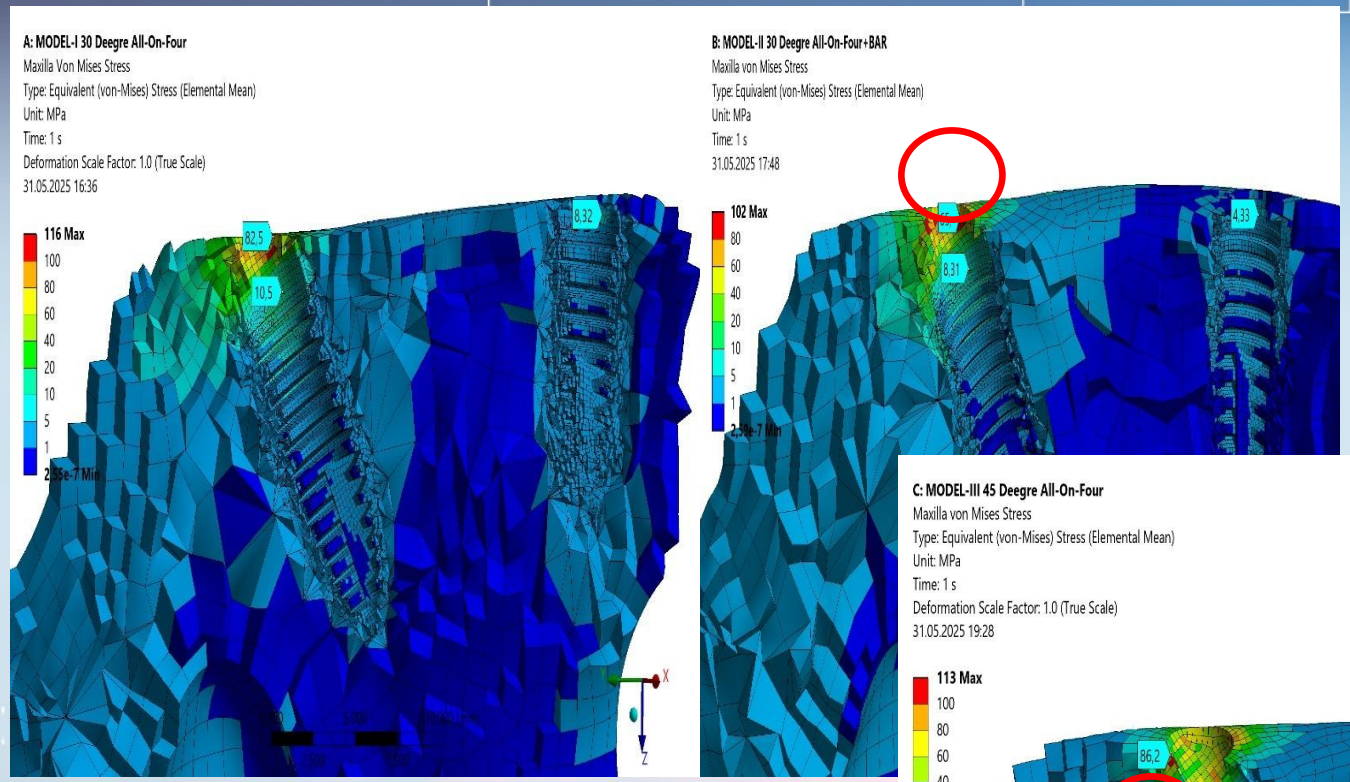

C: OKOC MODEL-III 45 Deegre All-On-Four
Force
Time: 1, s
29.08.2025 22:17
A Fixed Support
B Force: 200 N
0,000
10,000
20,000 (mm)
5,000
15,000


D: OKOC MODEL-IV 45 Deegre All-On-Four+BAR
Force 2
Time: 1, s
29.08.2025 22:20
A Fixed Support
B Force 2: 200 N
0,000
10,000
20,000 (mm)
5,000
15,000

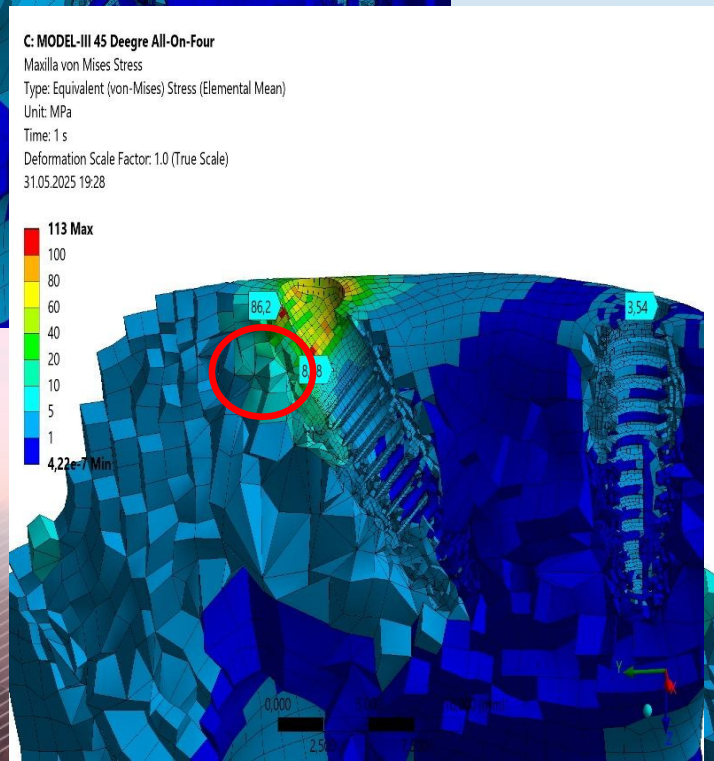
RESULTS

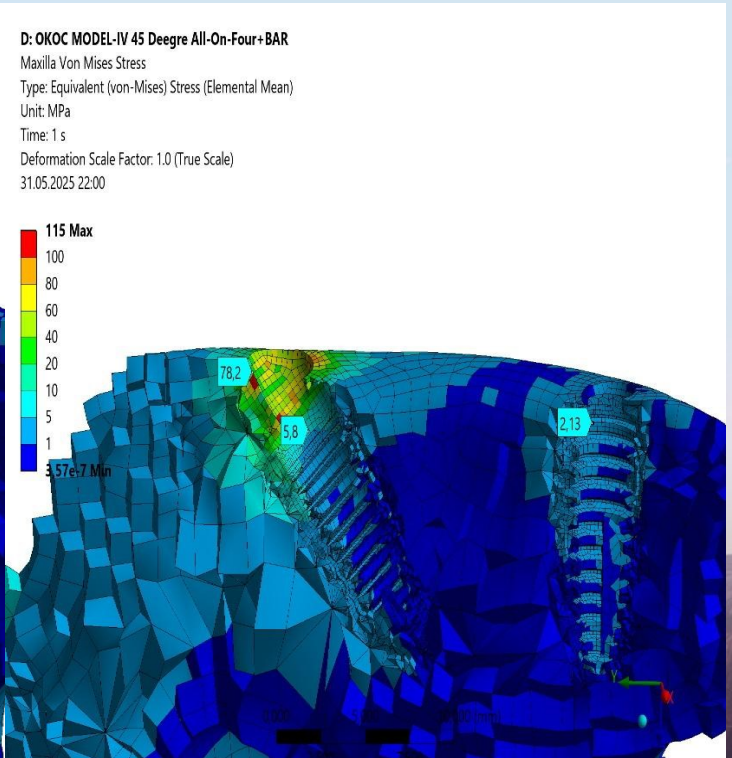
von Mises Stress Distributions

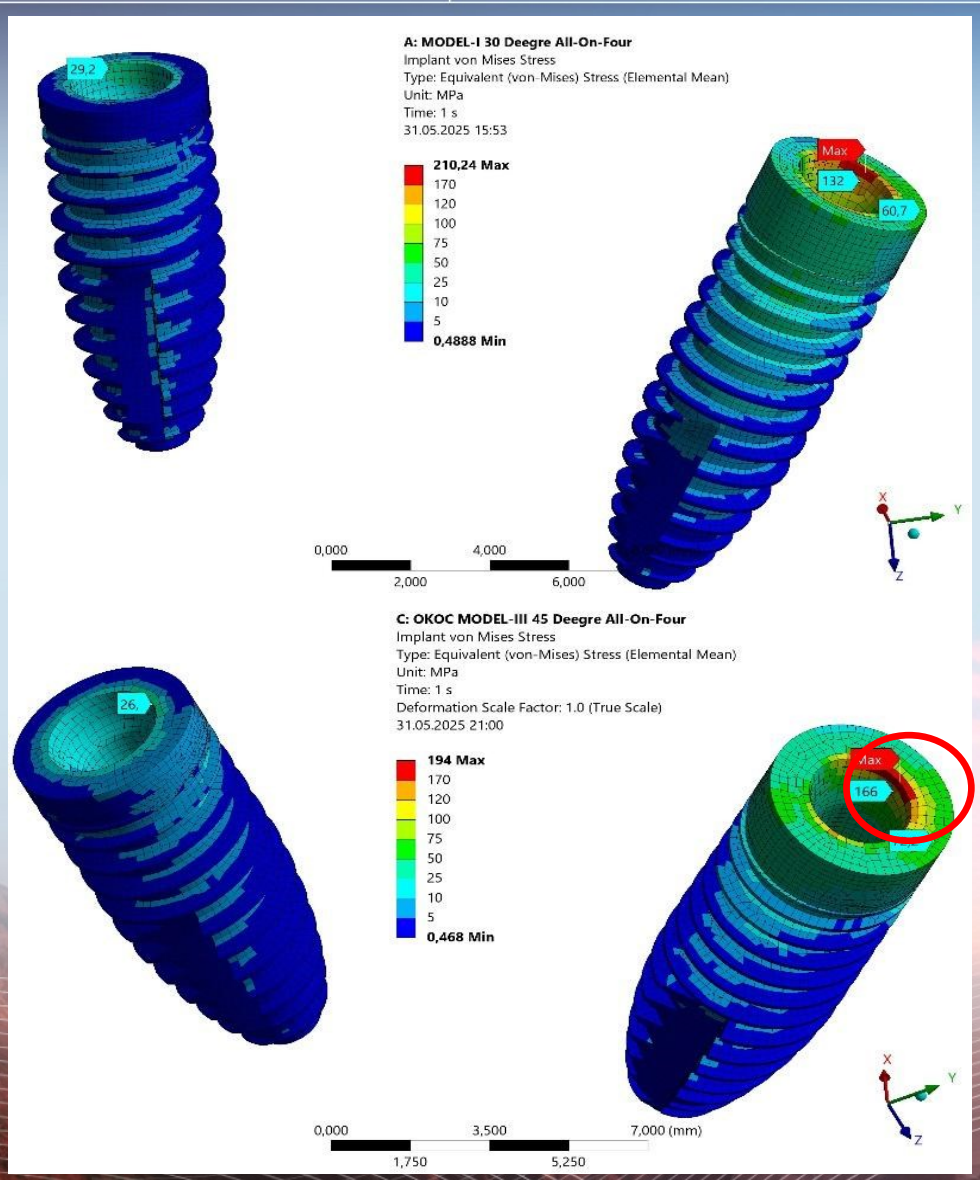
	Model-I	Model-II	Model-III	Model-IV
Anatomic structure	Von Mises Stress (MPa)	Von Mises Stress (MPa)	Von Mises Stress (MPa)	Von Mises Stress (MPa)
Distal implant maxilla bone site	82.5	65	86.2	78.2
Straight Implant	29.2	19.2	26	25.7
Straight Multiunit Abutment	60.2	53.2	63.3	57.7
Distal Implant	132	105	166	149
Distal Multiunit Abutment	234	185	265	244
Bar	186	128	143	155
Prosthesis	21.9	17.2	17.8	17.5

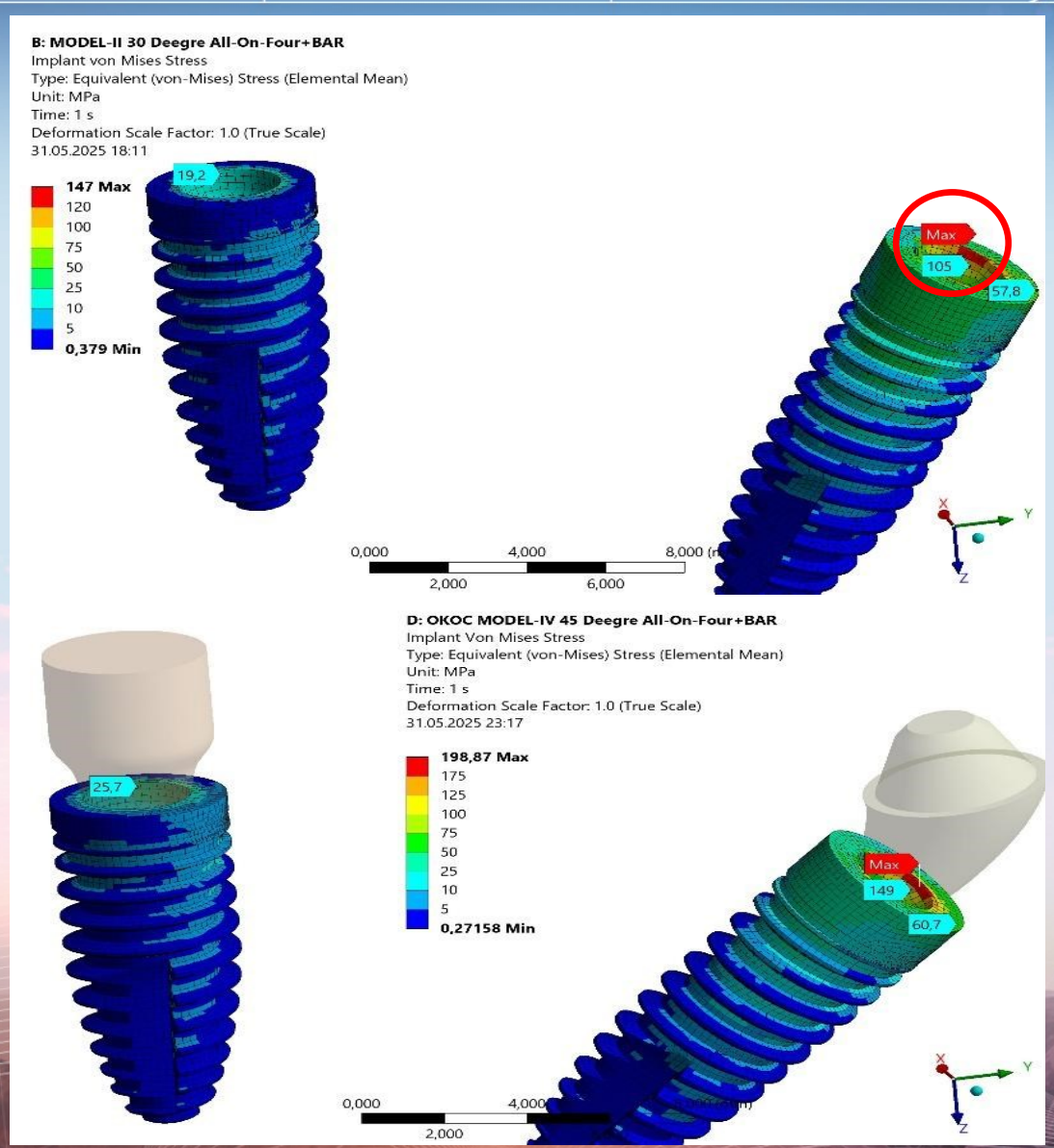

A: MODEL-I 30 Deegre All-On-Four
Maxilla Von Mises Stress
Type: Equivalent (von-Mises) Stress (Elemental Mean)
Unit: MPa
Time: 1 s
Deformation Scale Factor: 1.0 (True Scale)
31.05.2025 16:36
116 Max
100
80
60
40
20
10
5
1
2,35e-7 Min
82,5
10,5
8,32

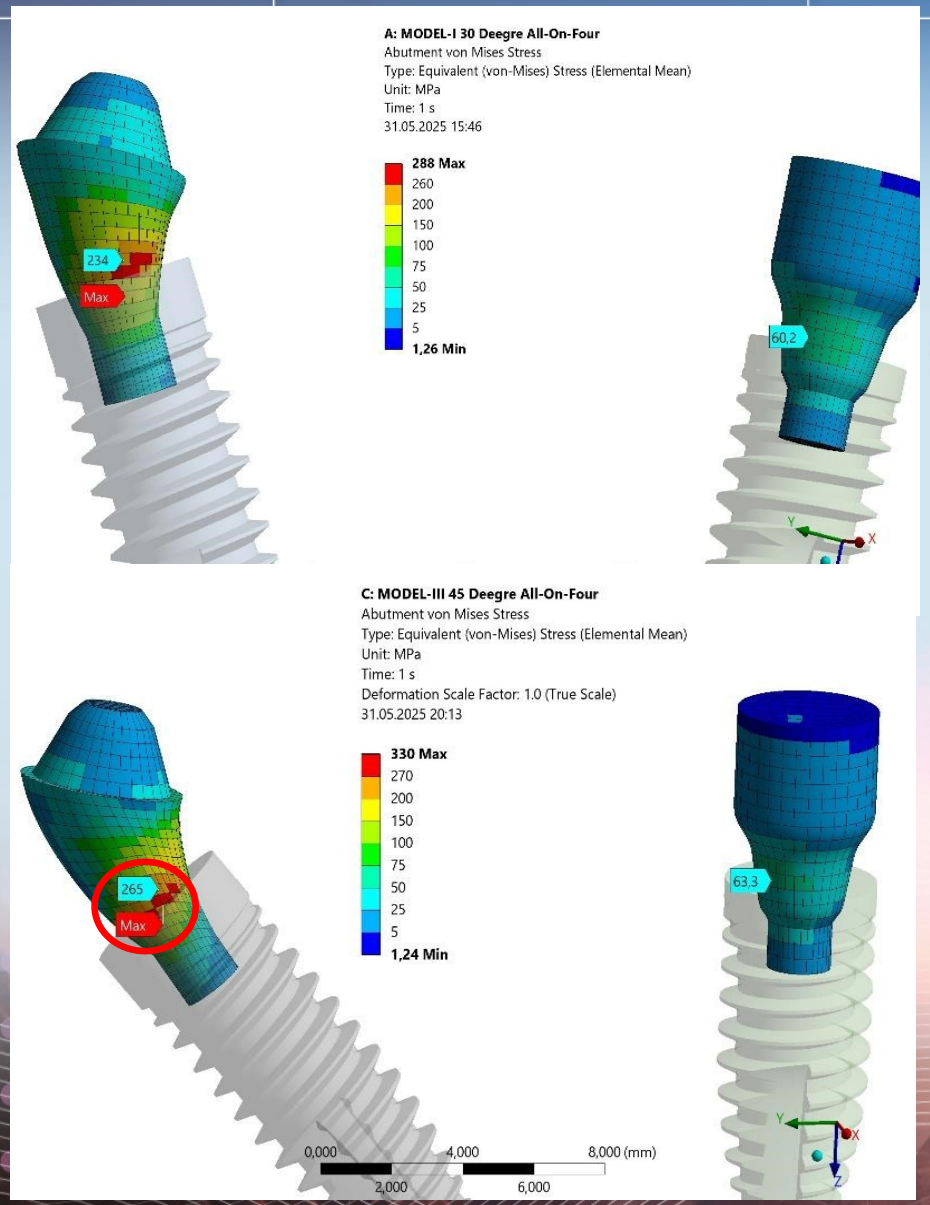
B: MODEL-II 30 Deegre All-On-Four+BAR
Maxilla von Mises Stress
Type: Equivalent (von-Mises) Stress (Elemental Mean)
Unit: MPa
Time: 1 s
31.05.2025 17:48
102 Max
80
60
40
20
10
5
1
2,59e-7 Min
8,31
4,33

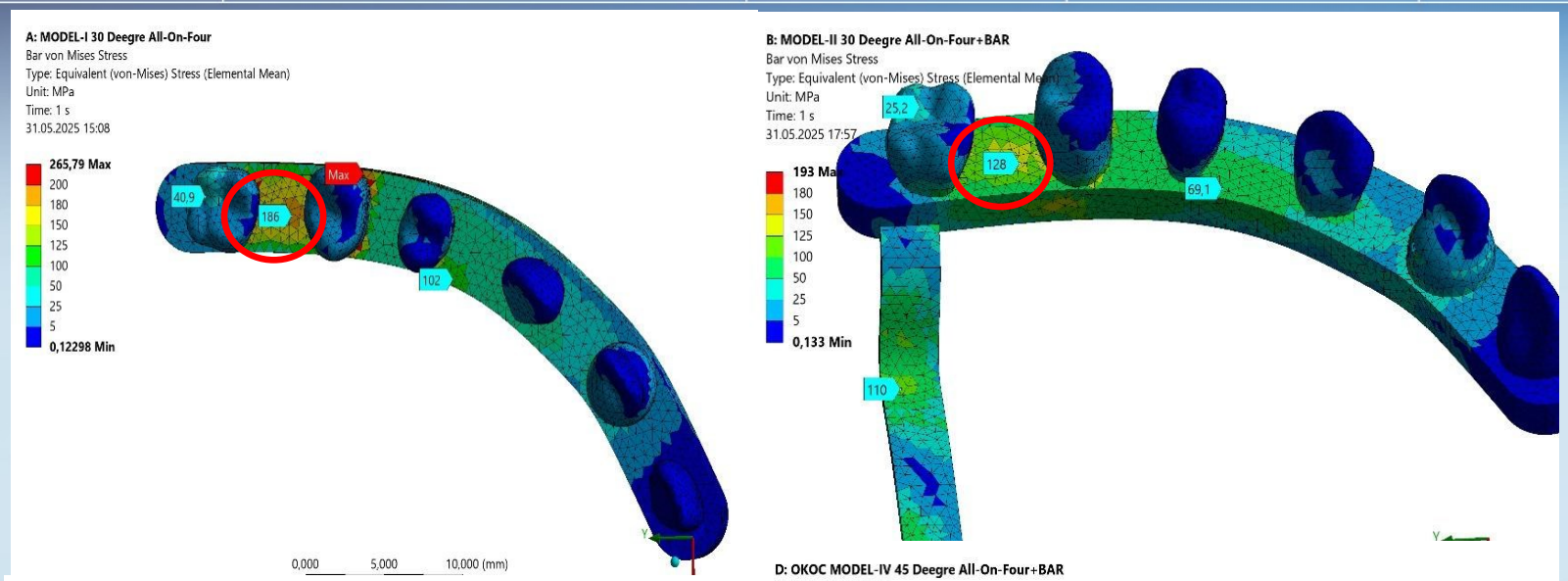

C: MODEL-III 45 Deegre All-On-Four
Maxilla von Mises Stress
Type: Equivalent (von-Mises) Stress (Elemental Mean)
Unit: MPa
Time: 1 s
Deformation Scale Factor: 1.0 (True Scale)
31.05.2025 19:28
113 Max
100
80
60
40
20
10
5
1
4,22e-7 Min
86,2
3,54


D: OKOC MODEL-IV 45 Deegre All-On-Four+BAR
Maxilla Von Mises Stress
Type: Equivalent (von-Mises) Stress (Elemental Mean)
Unit: MPa
Time: 1 s
Deformation Scale Factor: 1.0 (True Scale)
31.05.2025 22:00
115 Max
100
80
60
40
20
10
5
1
3,57e-7 Min
78,2
5,8
2,13

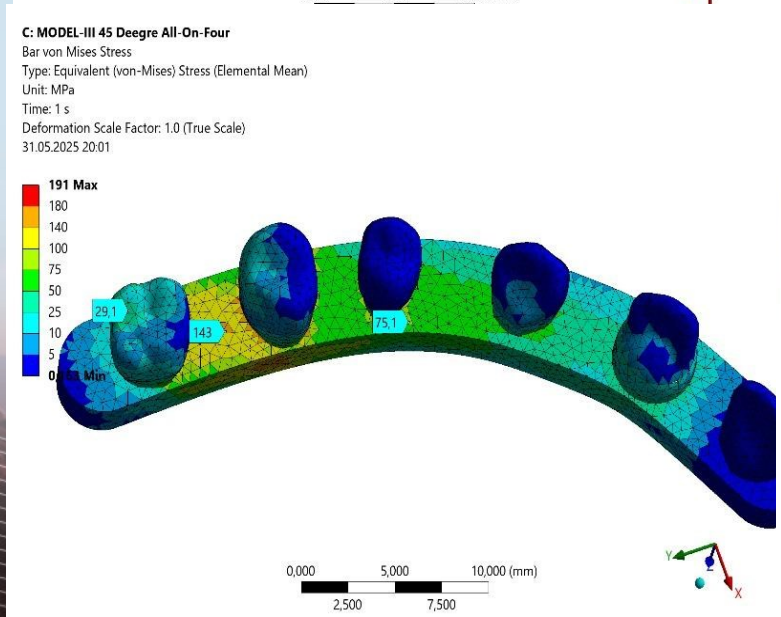

A: MODEL-I 30 Deegre All-On-Four
Implant von Mises Stress
Type: Equivalent (von-Mises) Stress (Elemental Mean)
Unit: MPa
Time: 1 s
31.05.2025 15:53
210,24 Max
170
120
100
75
50
25
10
5
0,4888 Min
29,2
Max
132
60,7
0,000
4,000
2,000
6,000
C: OKOC MODEL-III 45 Deegre All-On-Four
Implant von Mises Stress
Type: Equivalent (von-Mises) Stress (Elemental Mean)
Unit: MPa
Time: 1 s
Deformation Scale Factor: 1.0 (True Scale)
31.05.2025 21:00
194 Max
170
120
100
75
50
25
10
5
0,468 Min
26,
Max
166
0,000
3,500
7,000 (mm)
1,750
5,250

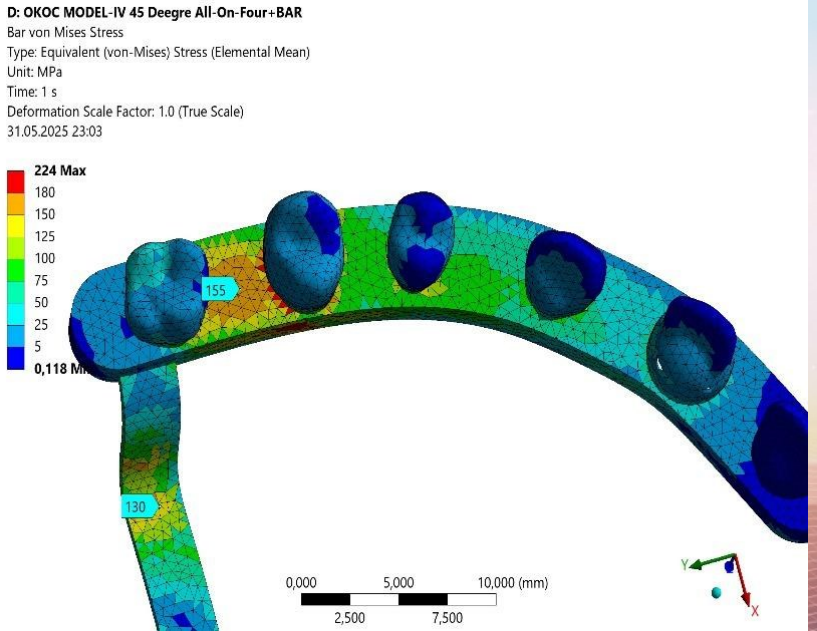

B: MODEL-II 30 Deegre All-On-Four+BAR
Implant von Mises Stress
Type: Equivalent (von-Mises) Stress (Elemental Mean)
Unit: MPa
Time: 1 s
Deformation Scale Factor: 1.0 (True Scale)
31.05.2025 18:11
147 Max
120
100
75
50
25
10
5
0,379 Min
19,2
Max
105
57,8
0,000
4,000
2,000
6,000
D: OKOC MODEL-IV 45 Deegre All-On-Four+BAR
Implant Von Mises Stress
Type: Equivalent (von-Mises) Stress (Elemental Mean)
Unit: MPa
Time: 1 s
Deformation Scale Factor: 1.0 (True Scale)
31.05.2025 23:17
198,87 Max
175
125
100
75
50
25
10
5
0,27158 Min
25,7
Max
149
60,7
0,000
4,000
2,000


A: MODEL-I 30 Deegre All-On-Four
Abutment von Mises Stress
Type: Equivalent (von-Mises) Stress (Elemental Mean)
Unit: MPa
Time: 1 s
31.05.2025 15:46
288 Max
260
200
150
100
75
50
25
5
1,26 Min
234
Max
60,2
B: MODEL-II 30 Deegre All-On-Four+BAR
Abutment von Mises Stress
Type: Equivalent (von-Mises) Stress (Elemental Mean)
Unit: MPa
Time: 1 s
Deformation Scale Factor: 1.0 (True Scale)
31.05.2025 18:04
210 Max
190
150
100
75
50
25
5
0,591 Min
185
Max
53,2
C: MODEL-III 45 Deegre All-On-Four
Abutment von Mises Stress
Type: Equivalent (von-Mises) Stress (Elemental Mean)
Unit: MPa
Time: 1 s
Deformation Scale Factor: 1.0 (True Scale)
31.05.2025 20:13
330 Max
270
200
150
100
75
50
25
5
1,24 Min
265
Max
63,3
0,000
4,000
8,000 (mm)
2,000
6,000
D: OKOC MODEL-IV 45 Deegre All-On-Four+BAR
Abutment Von Mises Stress
Type: Equivalent (von-Mises) Stress (Elemental Mean)
Unit: MPa
Time: 1 s
Deformation Scale Factor: 1.0 (True Scale)
31.05.2025 22:56
329 Max
260
200
150
100
75
50
25
5
1,35 Min
244
Max
57,7
0,000
4,000
8,000 (mm)
2,000
6,000


A: MODEL-I 30 Deegre All-On-Four
Bar von Mises Stress
Type: Equivalent (von-Mises) Stress (Elemental Mean)
Unit: MPa
Time: 1 s
31.05.2025 15:08
265,79 Max
200
180
150
125
100
50
25
5
0,12298 Min
Max
40,9
186
102
0,000
5,000
10,000 (mm)

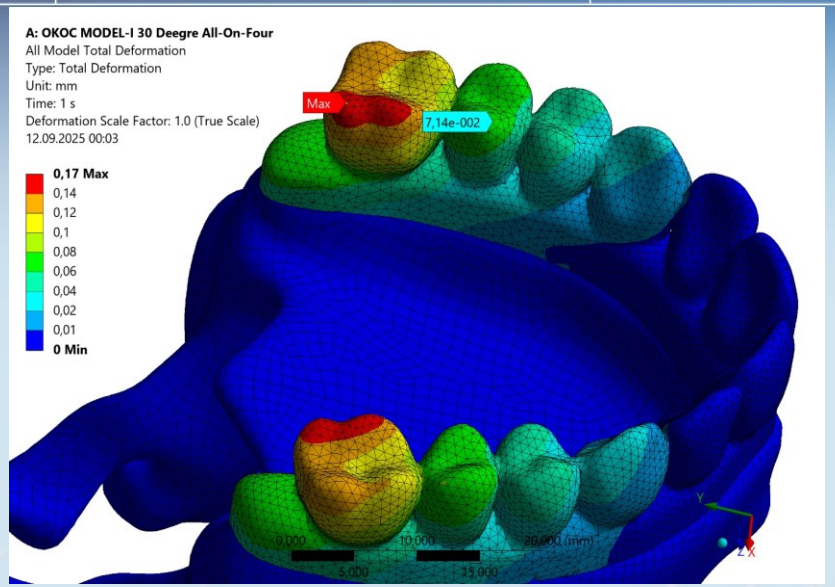
B: MODEL-II 30 Deegre All-On-Four+BAR
Bar von Mises Stress
Type: Equivalent (von-Mises) Stress (Elemental Mean)
Unit: MPa
Time: 1 s
31.05.2025 17:57
193 Max
180
150
125
100
50
25
5
0,133 Min
25,2
128
69,1
110

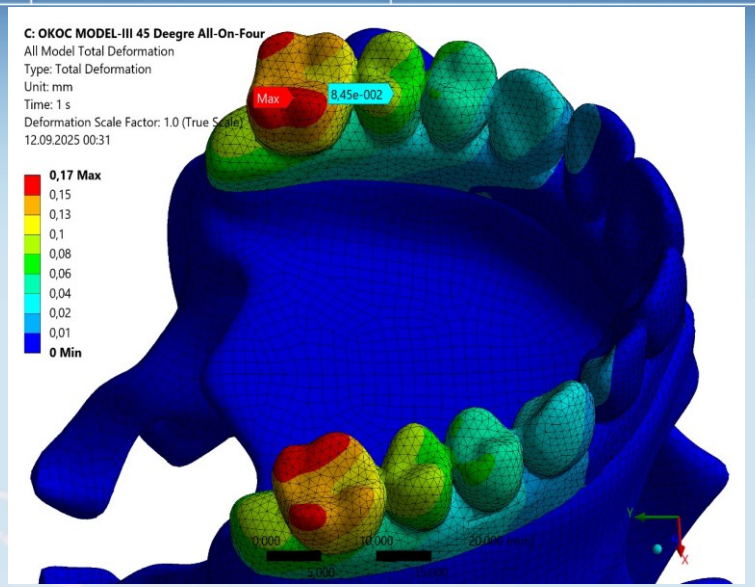

C: MODEL-III 45 Deegre All-On-Four
Bar von Mises Stress
Type: Equivalent (von-Mises) Stress (Elemental Mean)
Unit: MPa
Time: 1 s
Deformation Scale Factor: 1.0 (True Scale)
31.05.2025 20:01
191 Max
180
140
100
75
50
25
10
5
29,1
143
75,1
0,000
5,000
10,000 (mm)
2,500
7,500

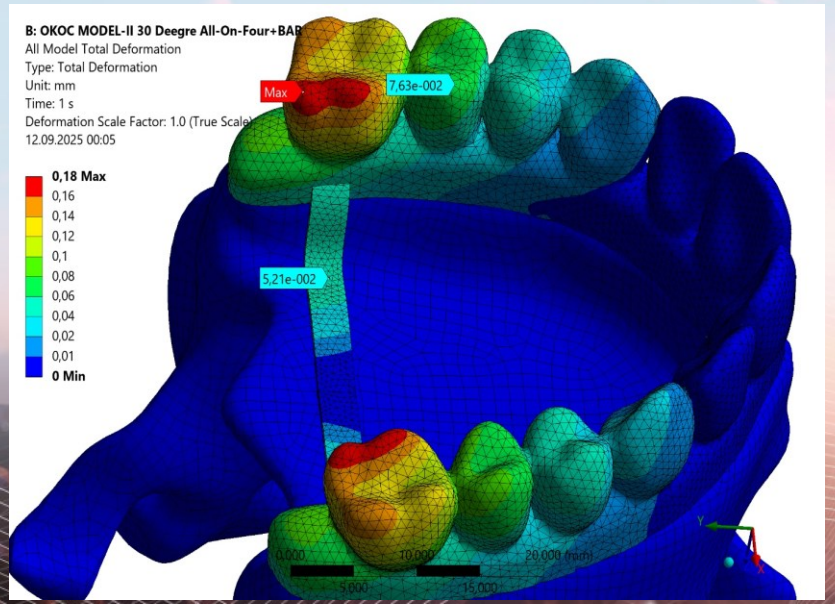

D: OKOC MODEL-IV 45 Deegre All-On-Four+BAR
Bar von Mises Stress
Type: Equivalent (von-Mises) Stress (Elemental Mean)
Unit: MPa
Time: 1 s
Deformation Scale Factor: 1.0 (True Scale)
31.05.2025 23:03
224 Max
180
150
125
100
75
50
25
5
155
130
0,000
5,000
10,000 (mm)
2,500
7,500

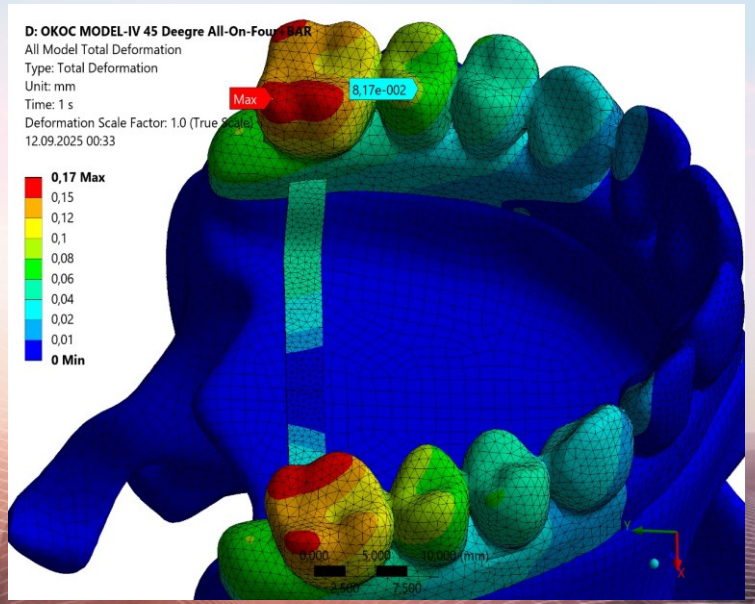
Total Displacement

Total displacement (mm)				
Anatomic	Model I	Model II	Model III	Model IV
Molar Tooth Lingual Site	0.17	0.18	0.17	0.17
Maksilla Implant Area	0.02	0.017	0.017	0.017
Framework Bar	0.10	0.07	0.07	0.10
Angled Implant	0.013	0.010	0.010	0.010
Angled Abutment	0.046	0.033	0.036	0.036


A: OKOC MODEL-I 30 Deegre All-On-Four
All Model Total Deformation
Type: Total Deformation
Unit: mm
Time: 1 s
Deformation Scale Factor: 1.0 (True Scale)
12.09.2025 00:03
0,17 Max
0,14
0,12
0,1
0,08
0,06
0,04
0,02
0,01
0 Min
Max
7,14e-002


C: OKOC MODEL-III 45 Deegre All-On-Four
All Model Total Deformation
Type: Total Deformation
Unit: mm
Time: 1 s
Deformation Scale Factor: 1.0 (True Scale)
12.09.2025 00:31
0,17 Max
0,15
0,13
0,1
0,08
0,06
0,04
0,02
0,01
0 Min
Max
8,45e-002


B: OKOC MODEL-II 30 Deegre All-On-Four+BAR
All Model Total Deformation
Type: Total Deformation
Unit: mm
Time: 1 s
Deformation Scale Factor: 1.0 (True Scale)
12.09.2025 00:05
0,18 Max
0,16
0,14
0,12
0,1
0,08
0,06
0,04
0,02
0,01
0 Min
Max
7,63e-002
5,21e-002


D: OKOC MODEL-IV 45 Deegre All-On-Four+BAR
All Model Total Deformation
Type: Total Deformation
Unit: mm
Time: 1 s
Deformation Scale Factor: 1.0 (True Scale)
12.09.2025 00:33
0,17 Max
0,15
0,12
0,1
0,08
0,06
0,04
0,02
0,01
0 Min
Max
8,17e-002

DISCUSSION

In the All-on-Four technique, numerous studies have been conducted to evaluate the 'implant length and diameter'.

J Prosthodont. 2009 Jul;18(5):393-402. doi: 10.1111/j.1532-849X.2009.00453.x. Epub 2009 Apr 3.

Implant-bone interface stress distribution in immediately loaded implants of different diameters: a three-dimensional finite element analysis

Xi Ding [1], Xing-Hao Zhu, Sheng-Hui Liao, Xiu-Hua Zhang, Hong Chen

Affiliations + expand

PMID: 19374710 DOI: 10.1111/j.1532-849X.2009.00453.x

J Oral Implantol. 2015 Apr;41(2):163-71. doi: 10.1563/AAID-JOI-D-12-00312. Epub 2013 Apr 5.

All-on-4 concept: a 3-dimensional finite element analysis

Gianpaolo Sannino [1]

Affiliations + expand

DOI: 10.1563/AAID-JOI-D-12-00312

Braz Dent J. 2018 Jan-Feb;29(1):36-42. doi: 10.1590/0103-6440201801746.

Three-Dimensional Finite Element Analysis of Varying Diameter and Connection Type in Implants with High Crown-Implant Ratio

Sandra Lúcia Dantas de Moraes [1], Fellippo Ramos Verri [2], Joel Ferreira Santiago Júnior [3], Daniel Augusto de Faria Almeida [4], Cleidiel Aparecido Araujo Lemos [2], Jéssica Marcela de Luna Gomes [2], Eduardo Piza Pellizzer [2]

Affiliations + expand

PMID: 29267522 DOI: 10.1590/0103-6440201801746

J Healthc Eng. 2018 Sep 3:2018:3163096. doi: 10.1155/2018/3163096. eCollection 2018.

Splinted and Nonsplinted Crowns with Different Implant Lengths in the Posterior Maxilla by Three-Dimensional Finite Element Analysis

Cleidiel Aparecido Araujo Lemos [1], Fellippo Ramos Verri [1], Joel Ferreira Santiago Junior [2], Victor Eduardo de Souza Batista [3], Daniel Takanori Kemmoku [4], Pedro Yoshito Noritomi [4], Eduardo Piza Pellizzer [1]

Affiliations + expand

PMID: 30254726 PMCID: PMC6140271 DOI: 10.1155/2018/3163096

‘evaluating masticatory forces’

› Clin Implant Dent Relat Res. 2014 Aug;16(4):501-10. doi: 10.1111/cid.12024. Epub 2012 Dec 6.

Evaluation of "all-on-four" concept and alternative designs with 3D finite element analysis method

Derya Özdemir Doğan [1], Nilufer Tulin Polat, Serkan Polat, Emre Şeker, Esma Başak Gül

Affiliations + expand

PMID: 23217013 DOI: 10.1111/cid.1202

› Comput Biol Med. 2017 Jul 1:86:47-54. doi: 10.1016/j.compbiomed.2017.04.015. Epub 2017 May 4.

Biomechanical evaluation of implant-supported prosthesis with various tilting implant angles and bone types in atrophic maxilla: A finite element study

Zeynep Gümrükçü [1], Yavuz Tolga Korkmaz [2], Fatih Mehmet Korkmaz [3]

Affiliations + expand

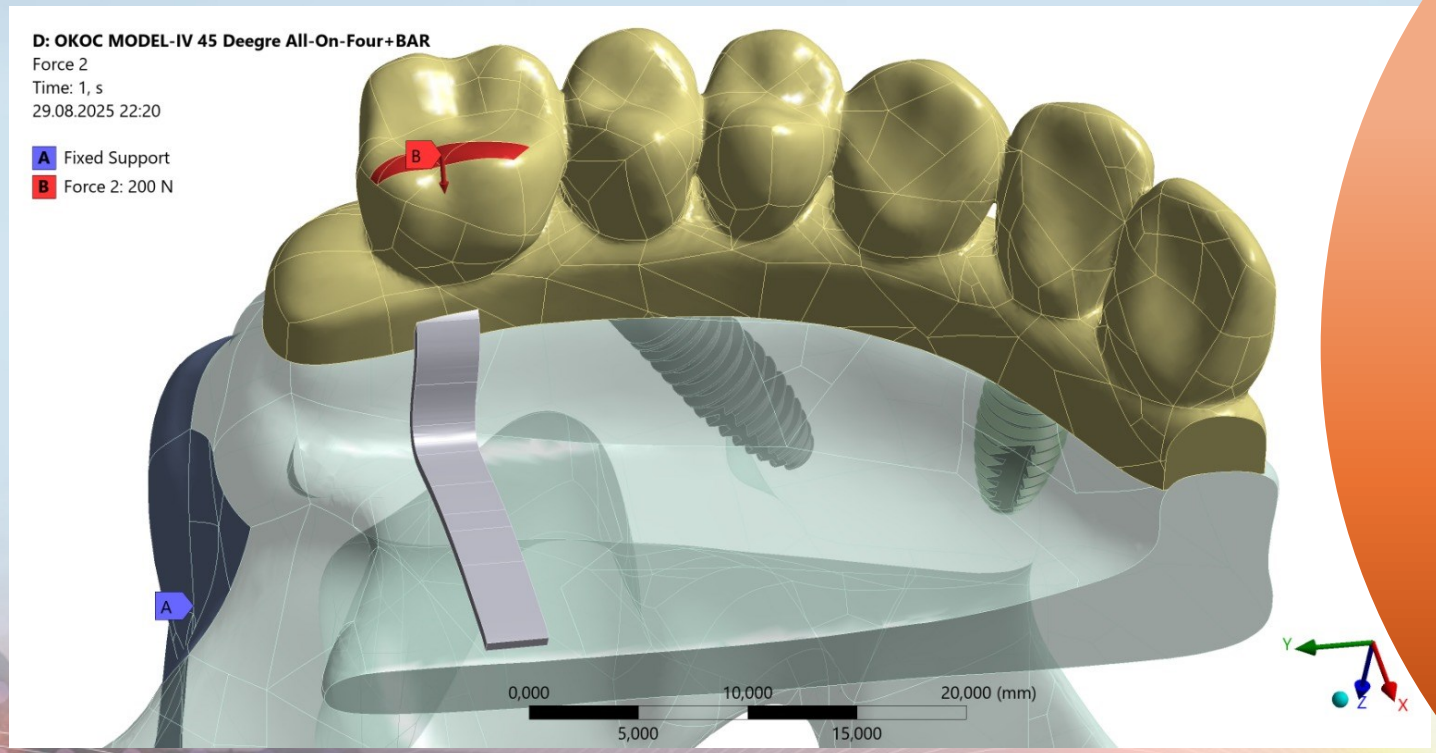
PMID: 28500959 DOI: 10.1016/j.compbiomed.2017.04.015

› J Prosthet Dent. 1986 Aug;56(2):226-9. doi: 10.1016/0022-3913(86)90480-4.

Limits of human bite strength

C H Gibbs, P E Mahan, A Mauderli, H C Lundeen, E K Walsh

PMID: 3463748 DOI: 10.1016/0022-3913(86)90480-4



200 N oblique force was applied to all models at the palatal cusp of the first molar.

RPD

J Prosthet Dent. 1973 Jul;30(1):102-5. doi: 10.1016/0022-3913(73)90088-7.

Selection of a major connector for the extension-base removable partial denture

A M LaVere, A J Krol

PMID: 4575203 DOI: 10.1016/0022-3913(73)90088-7

Comparative Study J Prosthet Dent. 1999 May;81(5):526-32.
doi: 10.1016/s0022-3913(99)70206-4.

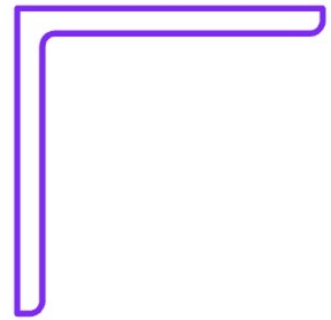
Stiffness of different designs and cross-sections of maxillary and mandibular major connectors of removable partial dentures

Z Ben-Ur [1], E Mijiritsky, C Gorfil, T Brosh

Affiliations + expand

PMID: 10220656 DOI: 10.1016/s0022-3913(99)70206-4

L beam effect



Steel Beam
L-Section (L-Angle)

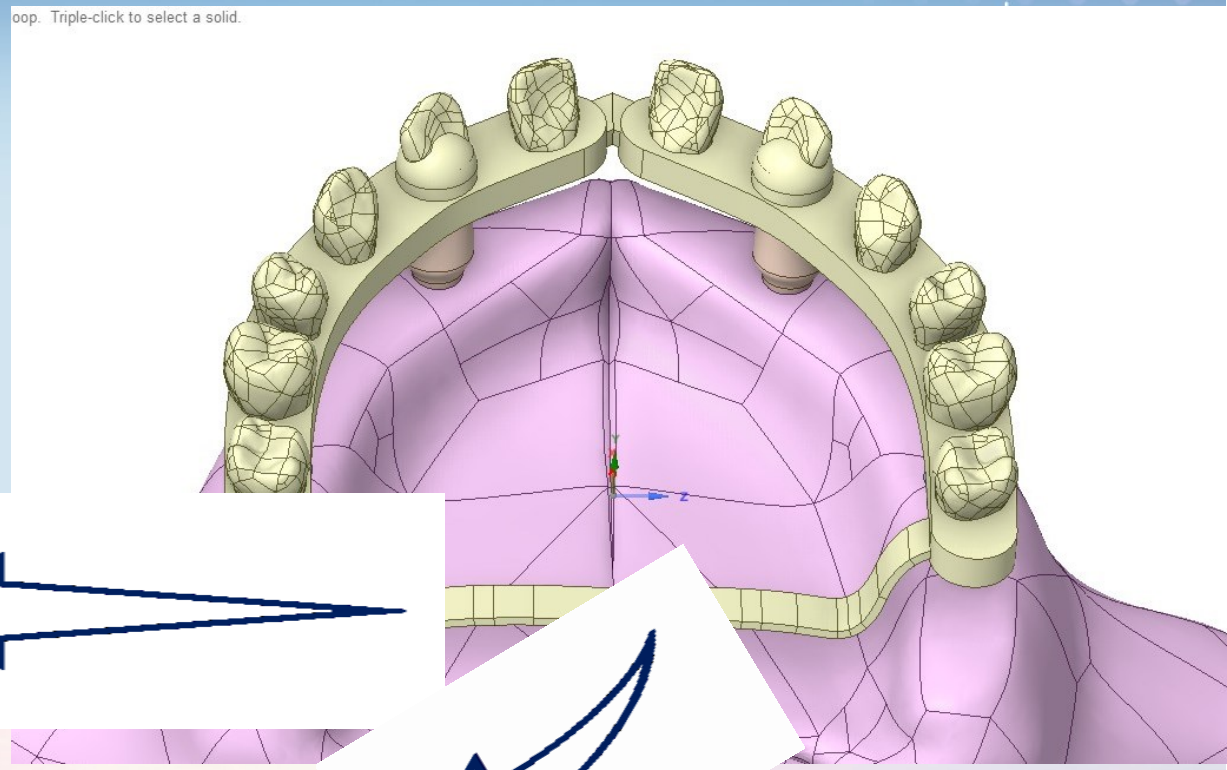
Comparative Study > J Prosthet Dent. 2003 Apr;89(4):400-7. doi: 10.1067/mpr.2003.76.

The effect of design modifications on the torsional and compressive rigidity of U-shaped palatal major connectors

Lawrence K Green [1], Steven O Hondrum

Affiliations + expand

PMID: 12690354 DOI: 10.1067/mpr.2003.76



Width
3mm

Thickne
0,5mm

In the All-on-Four technique, numerous studies have been conducted to evaluate the **'angulation of distal implants'** •

› Int J Oral Maxillofac Implants. 2009 Jul-Aug;24(4):663-71.

Stress patterns around distal angled implants in the all-on-four concept configuration

Tasneem Begg [1], Greta A V M Geerts, Jasson Gryzagoridis

Affiliations + expand

PMID: 19885406

› J Oral Implantol. 2015 Apr;41(2):163-71. doi: 10.1563/AAID-JOI-D-12-00312. Epub 2013 Apr 5.

All-on-4 concept: a 3-dimensional finite element analysis

Gianpaolo Sannino [1]

Affiliations + expand

PMID: 23560570 DOI: 10.1563/AAID-JOI-D-12-00312

CONCLUSION

Model-I → Exhibited the highest displacement and framework bar stresses.

Model-III → Showed the highest stress values in the angled abutment and implant region.

Model-II → Generally demonstrated the lowest stress and displacement values.

THANKS FOR YOUR LISTENING

