APPENDIX A

Data of stress values in miniscrew implants with different loading force

Table A.1 Stress values in different sizes of miniscrew implants with 100 g loading force

Diameter (mm)	Length (mm)	Maximum von Mises stress (MPa)	Maximum first principal stress (MPa)	
			Cortical bone	Cancellous bone
1.0	4.0	24.24	5.30	0.36
	6.0	30.31	4.35	0.37
	8.0	23.66	4.94	0.27
	10.0	23.77	5.38	0.32
	12.0	23.01	5.71	0.35
1.2	4.0	18.75	3.09	0.42
	6.0	20.30	2.97	0.29
	8.0	19.36	3.02	0.23
	10.0	22.04	3.86	0.50
	12.0	22.20	3.49	0.93
1.4	4.0	10.33	2.05	0.90
	6.0	12.77	1.95	0.17
	8.0	12.80	1.83	0.14
	10.0	13.18	4.20	0.38
	12.0	13.02	1.88	0.16
1.6	4.0	8.62	1.48	0.81
	6.0	9.04	1.07	0.19
	8.0	8.38	1.34	0.20
	10.0	8.79	1.77	0.17
	12.0	8.51	1.32	0.12
1.8	4.0	5.98	1.27	0.67
	6.0	6.68	1.03	0.25
	8.0	6.68	0.97	0.11
	10.0	6.76	1.21	0.12
	12.0	6.45	1.26	0.09

Table A.2 Stress values in different sizes of miniscrew implants with 150 g loading force

Diameter (mm)	Length (mm)	Maximum von Mises stress (MPa)	Maximum first principal stress (MPa)	
			Cortical bone	Cancellous bone
1.0	4.0	36.36	7.95	0.55
	6.0	45.47	6.53	0.56
	8.0	35.48	7.42	0.40
	10.0	35.65	8.08	0.48
	12.0	34.51	8.56	0.53
1.2	4.0	28.12	4.64	0.63
	6.0	30.55	4.45	0.37
	8.0	29.04	4.53	0.35
	10.0	33.06	5.79	0.75
	12.0	33.31	5.24	1.39
1.4	4.0	15.49	3.08	1.35
	6.0	19.15	2.96	0.26
	8.0	19.20	2.74	0.21
	10.0	19.77	6.30	0.57
	12.0	19.53	2.81	0.24
1.6	4.0	12.93	2.22	1.22
	6.0	13.56	2.55	0.28
	8.0	12.57	2.01	0.17
	10.0	13.19	2.67	0.25
	12.0	12.77	1.98	0.18
1.8	4.0	8.98	1.87	1.00
	6.0	10.22	1.55	0.38
	8.0	10.01	1.46	0.17
	10.0	10.13	1.82	0.19
	12.0	9.65	1.93	0.13

Table A.3 Stress values in different sizes of miniscrew implants with 200 g loading force

Diameter (mm)	Length (mm)	Maximum von Mises stress (MPa)	Maximum first principal stress (MPa)	
			Cortical bone	Cancellous bone
1.0	4.0	48.48	10.60	0.73
	6.0	60.62	8.70	0.75
	8.0	47.31	9.89	0.54
	10.0	47.54	10.77	0.63
	12.0	46.02	11.41	0.71
1.2	4.0	37.50	6.19	0.85
	6.0	40.47	5.93	0.50
	8.0	38.72	6.04	0.47
	10.0	44.08	7.72	0.99
	12.0	44.41	6.98	1.86
1.4	4.0	20.66	4.11	1.80
	6.0	25.54	3.95	0.35
	8.0	25.60	3.66	0.28
	10.0	26.36	8.40	0.75
	12.0	26.04	3.75	0.32
1.6	4.0	17.24	2.96	1.63
	6.0	18.09	3.40	0.38
	8.0	16.76	2.68	0.23
	10.0	17.59	3.55	0.33
	12.0	17.03	2.64	0.23
1.8	4.0	11.97	2.53	1.33
	6.0	13.36	2.06	0.51
	8.0	13.35	1.95	0.23
	10.0	13.51	2.43	0.25
	12.0	12.87	2.57	0.17

Table A.4 Stress values in different sizes of miniscrew implants with 250 g loading force

Diameter (mm)	Length (mm)	Maximum von Mises stress (MPa)	Maximum first principal stress (MPa)	
			Cortical bone	Cancellous bone
1.0	4.0	60.60	13.25	0.91
	6.0	75.78	10.88	0.93
	8.0	59.14	12.36	0.67
	10.0	59.42	13.46	0.79
	12.0	59.52	14.26	0.88
1.2	4.0	46.87	7.74	1.06
	6.0	50.92	7.42	0.62
	8.0	48.40	7.55	0.58
	10.0	55.10	9.65	1.23
	12.0	55.51	8.73	2.32
1.4	4.0	25.82	5.13	2.25
	6.0	32.35	4.96	0.43
	8.0	32.00	4.58	0.35
	10.0	32.96	10.49	0.94
	12.0	33.49	4.91	0.34
1.6	4.0	21.56	3.70	2.03
	6.0	22.61	4.25	0.47
	8.0	22.67	3.09	0.36
	10.0	22.03	4.70	0.42
	12.0	21.28	3.30	0.29
1.8	4.0	14.96	3.16	1.67
	6.0	16.70	2.58	0.64
	8.0	16.69	2.43	0.28
	10.0	16.89	3.04	0.32
	12.0	16.09	3.21	0.21

Table A.5 Stress values in different sizes of miniscrew implants with 300 g loading force

Diameter (mm)	Length (mm)	Maximum von Mises stress (MPa)	Maximum first principal stress (MPa)	
			Cortical bone	Cancellous bone
1.0	4.0	72.72	15.89	1.09
	6.0	90.93	13.05	1.12
	8.0	70.97	14.83	0.80
	10.0	71.31	16.15	0.95
	12.0	69.03	17.12	1.06
1.2	4.0	56.25	9.28	1.27
	6.0	61.11	8.90	0.75
	8.0	58.08	9.06	0.70
	10.0	66.12	11.58	1.49
	12.0	66.61	10.48	2.78
1.4	4.0	30.99	6.16	2.70
	6.0	38.30	5.92	0.52
	8.0	38.40	5.50	0.42
	10.0	39.55	12.59	1.13
	12.0	39.06	5.62	0.48
1.6	4.0	25.87	4.44	2.44
	6.0	27.13	5.10	0.57
	8.0	25.14	4.03	0.34
	10.0	26.38	5.33	0.50
	12.0	25.54	3.96	0.35
1.8	4.0	17.95	3.79	2.01
	6.0	20.04	3.10	0.76
	8.0	20.03	2.92	0.33
	10.0	20.27	3.64	0.38
	12.0	19.31	3.85	0.26

Table A.6 Stress values in different sizes of miniscrew implants with 350 g loading force

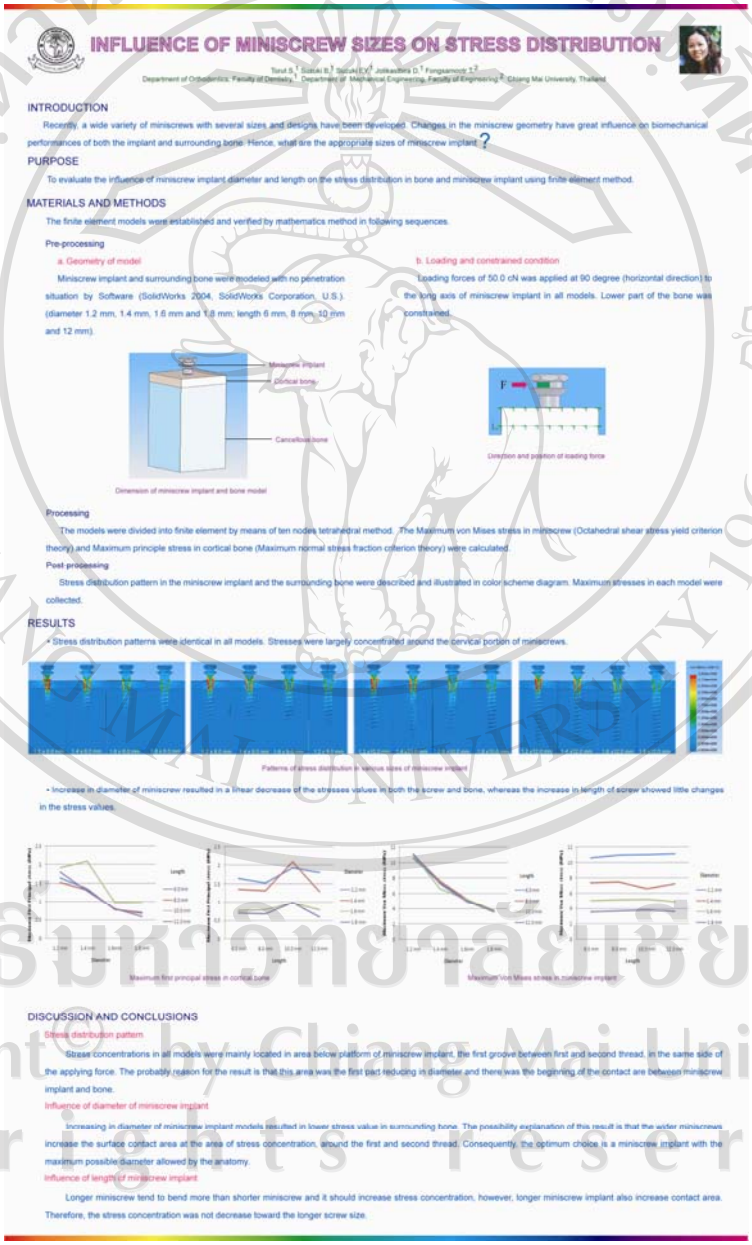
Diameter (mm)	Length (mm)	Maximum von Mises stress (MPa)	Maximum first principal stress (MPa)	
			Cortical bone	Cancellous bone
1.0	4.0	84.84	18.54	1.28
	6.0	106.10	15.23	1.31
	8.0	82.80	17.30	0.94
	10.0	83.19	18.84	1.11
	12.0	80.53	19.97	1.23
1.2	4.0	65.62	10.83	1.48
	6.0	71.29	10.38	0.87
	8.0	67.76	10.58	0.81
	10.0	77.14	13.51	1.74
	12.0	77.72	12.22	3.25
1.4	4.0	36.15	7.19	3.15
	6.0	44.69	6.91	0.61
	8.0	44.80	6.41	0.49
	10.0	46.14	14.69	1.32
	12.0	45.57	6.56	0.56
1.6	4.0	30.18	5.18	2.84
	6.0	31.65	5.95	0.66
	8.0	29.33	4.70	0.40
	10.0	30.78	6.22	0.58
	12.0	29.80	4.62	0.41
1.8	4.0	20.94	4.43	2.34
	6.0	23.39	3.61	0.89
	8.0	23.37	3.41	0.40
	10.0	23.65	4.25	0.45
	12.0	22.52	4.49	0.30

Table A.7 Stress values in different sizes of miniscrew implants with 400 g loading force

Diameter (mm)	Length (mm)	Maximum von Mises stress (MPa)	Maximum first principal stress (MPa)	
			Cortical bone	Cancellous bone
1.0	4.0	96.96	21.19	1.46
	6.0	121.20	17.40	1.49
	8.0	94.63	19.78	1.07
	10.0	100.00	20.50	1.94
	12.0	90.39	23.08	1.41
1.2	4.0	75.00	12.38	1.69
	6.0	81.48	11.87	1.00
	8.0	77.44	12.09	0.93
	10.0	88.16	15.44	1.99
	12.0	87.08	16.56	3.57
1.4	4.0	41.31	8.21	3.60
	6.0	51.07	7.90	0.69
	8.0	51.20	7.33	0.56
	10.0	52.73	16.79	1.51
	12.0	52.08	7.50	0.64
1.6	4.0	34.49	5.91	3.25
	6.0	36.17	6.80	0.76
	8.0	33.52	5.37	0.45
	10.0	35.17	7.11	0.67
	12.0	34.81	5.30	0.47
1.8	4.0	23.93	5.06	2.67
	6.0	26.73	4.13	1.02
	8.0	27.11	3.90	0.45
	10.0	27.02	4.86	0.51
	12.0	25.79	5.06	0.34

APPENDIX B

Poster, abstract and information of 6th Asian Implant Orthodontics Conference (6th AIOC) held in Taiwan



INFLUENCE OF MINISCREW SIZES ON STRESS DISTRIBUTION

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INTRODUCTION

Recently, a wide variety of miniscrews with several sizes and designs have been developed. Changes in the miniscrew geometry have great influence on biomechanical performances of both the implant and surrounding bone. Hence, what are the appropriate sizes of miniscrew implant ?

PURPOSE

To evaluate the influence of miniscrew implant diameter and length on the stress distribution in bone and miniscrew implant using finite element method.

MATERIALS AND METHODS

The finite element models were established and verified by mathematics method in following sequences.

Pre-processing

a. Geometry of model

Miniscrew implant and surrounding bone were modeled with no penetration situation by Software (SolidWorks 2004, SolidWorks Corporation, U.S.). (diameter 1.2 mm, 1.4 mm, 1.6 mm and 1.8 mm; length 6 mm, 8 mm, 10 mm and 12 mm).

Miniscrew Implant
Cortical bone
Cancellous bone

Dimension of miniscrew implant and bone model

b. Loading and constrained condition

Loading forces of 50.0 cN was applied at 90 degree (horizontal direction) to the long axis of miniscrew implant in all models. Lower part of the bone was constrained.

F
Direction and position of loading force

Processing

The models were divided into finite element by means of ten nodes tetrahedral method. The Maximum von Mises stress in miniscrew (Octahedral shear stress yield criterion theory) and Maximum principle stress in cortical bone (Maximum normal stress fraction criterion theory) were calculated.

Post-processing

Stress distribution pattern in the miniscrew implant and the surrounding bone were described and illustrated in color scheme diagram. Maximum stresses in each model were collected.

RESULTS

• Stress distribution patterns were identical in all models. Stresses were largely concentrated around the cervical portion of miniscrews.

Patterns of stress distribution in various sizes of miniscrew implant

• Increase in diameter of miniscrew resulted in a linear decrease of the stresses values in both the screw and bone, whereas the increase in length of screw showed little changes in the stress values.

Length
Diameter
Maximum first principal stress in cortical bone
Maximum von Mises stress in miniscrew implant

DISCUSSION AND CONCLUSIONS

Stress distribution pattern

Stress concentrations in all models were mainly located in area below platform of miniscrew implant, the first groove between first and second thread, in the same side of the applying force. The probably reason for the result is that this area was the first part reducing in diameter and there was the beginning of the contact are between miniscrew implant and bone.

Influence of diameter of miniscrew implant

Increasing in diameter of miniscrew implant models resulted in lower stress value in surrounding bone. The possibility explanation of this result is that the wider miniscrews increase the surface contact area at the area of stress concentration, around the first and second thread. Consequently, the optimum choice is a miniscrew implant with the maximum possible diameter allowed by the anatomy.

Influence of length of miniscrew implant

Longer miniscrew tend to bend more than shorter miniscrew and it should increase stress concentration, however, longer miniscrew implant also increase contact area. Therefore, the stress concentration was not decrease toward the longer screw size.

Figure B.1 Poster presented at 6th AIOC in Taiwan

Influence of Miniscrew Sizes on Stress Distribution

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Purpose

The purpose of this study was to evaluate the influence of miniscrew implant diameter and length on the stress distribution in bone and implant using finite element analysis.

Materials and Methods

Sixteen finite element models featuring miniscrew implants of various sizes (1.2, 1.4, 1.6 and 1.8 mm in diameter and 6, 8, 10 and 12 mm in length) and surrounding bone were created and loaded with 50 cN force perpendicular to the long axis of the implant in order to investigate resultant stress distribution.

Results

Patterns of stress distribution were identical in all models. Stresses were concentrated mainly around the cervical portion of the body of miniscrews. The increase in the miniscrew s diameter resulted in a linear decrease of the stresses values in both the screw and bone, whereas the increase in length of miniscrew showed not significant changes in the stress values.

Conclusions

The results of this study suggest that the wider diameter miniscrew implants might ensure a better biomechanical environment for miniscrews. The length of miniscrews did not alter the biomechanical properties of miniscrews inserted in the bone.

Figure B.2 Abstract

Figure B.3 Pictures of 6th AIOC

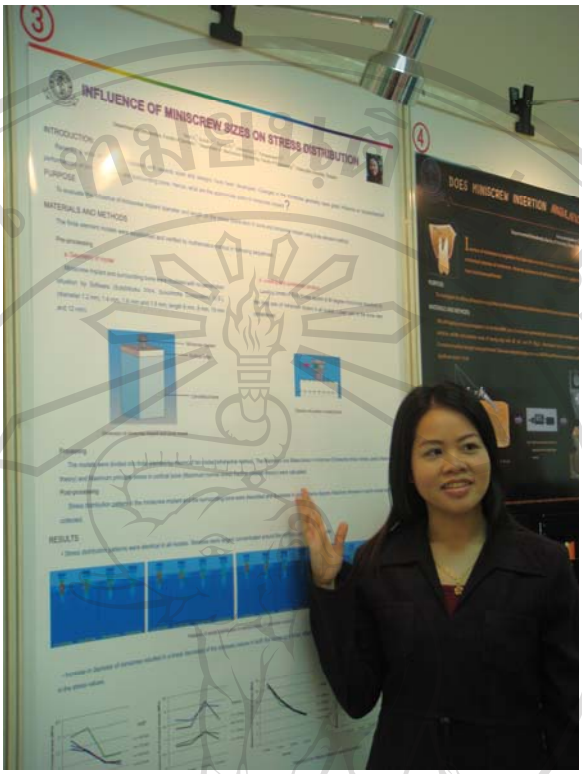

Figure B.3 Pictures of 6th AIOC (Cont.)

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