

The Journal of Indian Prosthodontic Society is indexed/listed with DOAJ, Health and Wellness Research Center, Health Reference Center Academic, InfoTrac One File, Expanded Academic ASAP, ProQuest Databases, Genamics JournalSeek, and Ulrich's International Periodical Directory.

The journal is official publication of the **Indian Prosthodontic Society**, and issues are published quarterly in the last week of March, June, September and December.

All the rights are reserved. Apart from any fair dealing for the purposes of research or private study, or criticism or review, no part of the publication can be reproduced, stored, or transmitted, in any form or by any means, without the prior permission of the Editor.

The Journal and/or its publisher cannot be held responsible for errors or for any consequences arising from the use of the information contained in this journal.

The appearance of advertising or product information in the various sections in the journal does not constitute an endorsement or approval by the journal and/or its publisher of the quality or value of the said product or of claims made for it by its manufacturer.

The journal is published and distributed by Medknow Publications. Copies are sent to subscribers directly from the publisher's address. It is illegal to acquire copies from any other source. If a copy is received for personal use as a member of the association/society, one can not resale or give-away the copy for commercial or library use.

The Journal is printed on acid free paper.

#### Editorial Office

Dr. (Mrs) S. J. Nagda  
Prof. & Head,  
Dept. of Prosthodontics,  
Nair Hospital Dental College,  
Mumbai - 400 008, India.  
E-mail: [jipseditor@yahoo.co.in](mailto:jipseditor@yahoo.co.in)

#### Published by

Medknow Publications,  
A-109, Kanara Business Centre,  
Off Link Road, Ghatkopar (E),  
Mumbai - 400075, India.  
Tel: 91-22-6649 1818/1816,  
E-mail: [publishing@medknow.com](mailto:publishing@medknow.com)  
Website: [www.medknow.com](http://www.medknow.com)

#### Websites

[www.jprosthodont.com](http://www.jprosthodont.com)  
[www.journalonweb.com/jips](http://www.journalonweb.com/jips)

# The Journal of Indian Prosthodontic Society

Official Publication of Indian Prosthodontic Society

ISSN 0972-4052

## Editor

Dr. (Mrs.) S. J. Nagda

## Editorial Board

Dr. (Mrs) A. P. Wadkar

Dr. M. A. Gandhewar

Dr. (Mrs) Vrushali Abhyankar

Dr. Ravi Savadi

Dr. Shailendra Sahu

## Advisory Board

Dr. Chandrasekhar Nair

Dr. E. G. R. Solomon

Dr. Hariprakash

Dr. Muniratnam Naidu

Dr. Mahesh Verma

Dr. Sridhar Shetty

Dr. Sreelal

Dr. Satish Babu

## Indian Prosthodontic Society

(Registered under Public Trust Act No. 537/78, Public Trust F/551 5, Mumbai)

### President

Dr. T. V. Padmanabhan

### Immediate Past President

Lt. Gen. Paramjit Singh

### Hon. General Secretary

Dr. V. Rangarajan

### Editor

Dr. (Mrs.) Suhasini J. Nagda

### Executive Council Members

Dr. F. D. Mirza

Dr. E. G. R. Solomon

Air Cmde S. Murali Mohan

Dr. U. V. Gandhi

Dr. Ravi C. Savadi

Dr. M. Shiva Shankar

Dr. Soorya Poduval

Dr. Himanshu Aeran

Dr. Saranjit Singh Bhasin

Dr. K. Mahendranadh Reddy

Dr. Supriya Nerli

Brig. Vimal Arora

Dr. Shilpa Shetty

Dr. S. K. Khindria

Dr. K. R. Nagaraj

Dr. V. Anand Kumar

### IPS Office

Dr. V. Rangarajan

Hon. Gen. Secretary cum Treasurer, 230, Avvai Shanmugham Salai,  
Royapettah, Chennai - 600014, India. E-mail: [drvrange@gmail.com](mailto:drvrange@gmail.com)

# The Journal of Indian Prosthodontic Society

July-September 2007 - Vol 7 - Issue 3

## CONTENTS

### Editorial

The three magic L's

*S. J. Nagda* ..... 117

### Original Articles

The curvature of the retentive arm in a circumferential clasp and its effect on the retention: 3D analysis using finite element method

*Allahyar Geramy, Masoud Ejlali* ..... 118

Biometric relationship between intercanthal dimension and the widths of maxillary anterior teeth

*Ulhas E. Tandale, Shankar P. Dange, Arun N. Khalikar* ..... 123

Role of prosthodontist with regard to impacted esophageal dentures from an ENT perspective

*Abhishek Jaswal, Avik K. Jana, Atish Haldar, Biswajit Sikder, Utpal Jana, Tapan K. Nandi* ..... 126

Evaluation of marginal microleakage of three zinc-oxide-based non-eugenol temporary luting agents: An in vitro study

*Subhash Bandgar, S. J. Nagda* ..... 132

### Review Articles

Clinical tips in full veneer tooth preparation

*Neelam Sharma, Vidya Chitre* ..... 137

Rotational path removable partial denture: A literature review

*Marzieh Alikhasi, Abbas Monzavi, Farideh Gramipanah, Maryam Eghlima, Hakimeh Siadat* ..... 143

Nutrition in maxillofacial prosthetic patients: The unexplored frontier

*Ravi Madan, Saumyendra V. Singh, Arvind Tripathi* ..... 147

### Case Reports

Reconstruction of a cranial defect with an alloplastic implant

*Sandeep Kumar, Seema Gupta, Nayana Prabhu* ..... 150

The removable occlusal overlay splint in the management of tooth wear

*Bilquis J. Ghadiali, S. A. Gangadhar, Kamal Shigli* ..... 153

Customized cast post-and-core abutment for single tooth implants: An easy approach

*S. K. Bhandari, T. Ravindranath, Shabina Sachdeva, Shraddha Gurlhosur, S. S. Bhasin* ..... 158

### Guest Article

Marching ahead to the future

*K. Chandrasekharan Nair* ..... 162

### News and Views

..... 166

### Book Review

..... 167

### 35<sup>th</sup> IPS Conference

..... 168

# The curvature of the retentive arm in a circumferential clasp and its effect on the retention: 3D analysis using finite element method

Allahyar Geramy, Masoud Ejlali\*

Department of Orthodontics, Tehran University of Medical Sciences (TUMS), Dental Research Center, Tehran University of Medical Sciences (DRC-TUMS), \*Department of Prosthodontics, Shahid Beheshti University of Medical Sciences, Tehran, Iran

## For Correspondence

Dr. Allahyar Geramy, Department of Orthodontics, Ghods Ave, Enghelab St., School of Dental Medicine, Tehran University of Medical Sciences, Tehran, Iran. E-mail: [gueramy@yahoo.com](mailto:gueramy@yahoo.com)

**INTRODUCTION:** Missed teeth are replaced to provide the patients with occlusal stability. Partial removable prosthodontics are still in use among the various applications in this field. Adequate retention is essential for its function. Circumferential clasps are used and the main goal of this study is to assess the importance of the geometry of the retentive arm and its effects on the quality of retention produced. **MATERIALS AND METHODS:** Three-dimensional finite element method of analysis was selected to find answer to the questions. Three models were designed with the retentive arms of same lengths and different angular coverages ( $\alpha$  is explained in text). 0.01" to 0.03" of displacements were applied and the forces derived. **RESULTS:** Different amounts of retentive forces were produced, which were assessed in two directions. **CONCLUSION:** The greater the curve of a retentive arm, the greater the retention force produced, assuming that the length of retentive arm remains constant.

**Key words:** Circumferential clasp, finite element method, removable partial denture, retention, retentive arm

Prostheses are designed to provide esthetics, functions, phonetics and stability of the dental system by replacing the missed teeth. In spite of the progresses in fixed prosthodontics, partial removable ones are still in use. One of the most important considerations in partial removable prosthetic designs is retention. Direct retainers provide retention, which is the resistance of prosthesis against the moving away from the ridge. Circumferential clasps are the most widely used choices. These clasps provide retention by the resistance to deformation found in the retentive arms placed gingival to the height of contour.

In 1971, Clayton and Jaslow,<sup>[1]</sup> attempted to measure the forces produced by clasp arms on the abutment teeth by making use of resistance strain gauges and also compared the cast and wrought wire clasps on the basis of the forces produced. The application of a continuous force from all the clasp designs while in rest was found. Moris *et al.*,<sup>[2]</sup> measured different clasp patterns available in the market and their tapered forms. They found various width-to-thickness ratios ranging from 1.1 to 2.5. The largest deflection of a 10-mm-long clasp was reported to be between 0.175 to 0.250 mm. The importance of the geometric form in the retention produced by a clasp arm was not

mentioned.<sup>[2]</sup> Snyder and Duncanson studied the effect of clasp thickness on its deformation after 1500 cycles of 0.01-in displacements. According to their findings, the permanent deformation of clasps is independent of their forms or their width-thickness ratios.<sup>[3]</sup>

In 1995, Sato *et al.*,<sup>[4]</sup> investigated the preferred design for a circumferential clasp by using 2D FEM models. They concluded that the use of the preformed clasp patterns with a taper of 0.8 is preferable for reducing fatigue and/or permanent deformation of the clasp arm. Two years later, Sato *et al.*,<sup>[5]</sup> discussed the importance of the friction coefficient on the circumferential clasp retention. They concluded that the retentive force increased linearly with the increasing friction coefficient between abutment material and clasp material and suggested that clasp designs should be changed based on the abutment materials.

Marei<sup>[6]</sup> compared the average measurements of forces required to dislodge circumferential clasps with round and half-round retentive arms in different amounts of undercut. The findings indicated the possible use of cast round clasps, where the advantages of clinical fit and reduction of transmitted forces to the abutments can be gained.

Sato and Hosokawa<sup>[7]</sup> attempted to discuss the

importance of the guiding planes and proximal plates for conventional tooth-supported removable partial dentures with circumferential clasps. They geometrically analyzed the retention force of the clasps and concluded that short or oblique guiding planes resulted in reduced retention.

One of the latest studies on circumferential clasps considered the material used to fabricate it. In this study, Rodrigues *et al.*,<sup>[8]</sup> concluded that although titanium clasps produced less retention in comparison with Co-Cr ones, they preserve it in a 5-year period better than the other materials.

Finite element method (FEM) is a numeric means to find accurate answers to the clinical or basic questions with regard to the changing parameters; this method proven its efficiency in solving different problems in some 60 years of its introduction to the science. FEM has been used to easily demonstrate the principles for educational applications<sup>[9-11]</sup> to normal situations with respect to the nature of tooth movements under the orthodontic loads<sup>[12]</sup> and special situations such as alveolar bone resorption<sup>[13-16]</sup> and also from extraoral forces<sup>[17]</sup> to the optimization of treatment methods.<sup>[18, 19]</sup> It can also be applied to simply find an answer to a clinical question.<sup>[20]</sup>

According to McCracken,<sup>[21]</sup> flexibility of a clasp arm is affected by (1) the length of the clasp arm, (2) width of the clasp arm, (3) cross section of the clasp arm, (4) width-thickness ratio of the clasp arm and (5) the alloy used.

To explain the differences between the 3D models designed in this study, two parameters are defined. If we considered a tooth as a cylinder (in an occluso-gingival view), its radius is “ $R$ ” and the angle between the radius connecting the start point of the retentive arm to the center of the cylinder and the radius connecting its end to the center is considered as “ $\alpha$ .” Three models were considered to rotate around different teeth (different values of  $R$ ) with the same lengths. Apparently, when the value of  $R$  increases, the angle  $\alpha$  decreases [Figure 1].  $R = 5$  mm and  $\alpha = 180$  degrees in model 1,  $R = 7.5$  mm and  $\alpha = 135$  in model 2 and  $R = 10$  mm and  $\alpha = 90$  degrees in model 3.

The main objective of this study was to investigate the importance of the curvature of retentive clasp arm of circumferential clasps in the retention produced with the same amount of undercut. If different clasps are fabricated with the same characteristics and lengths, except for the  $R$  and  $\alpha$ , will the produced retention be affected? In other words, can the retention produced by two clasps with the same characteristics and placed at the same undercut depths be different?

## MATERIALS AND METHODS

Three FEM models were designed for the analyses. A

3D approach was selected and the retentive arm of a circumferential clasp was considered for modeling. All the characteristics such as taper, width-thickness ratio and alloy used were the same. Each model consisted of 26496 nodes and 21375 elements [Figure 2 a-d]. A 3D brick, isoparametric, octahedral element was selected to construct the models. In the first model,  $\alpha = 180$  degree and  $R = 5$  mm. For the second one,  $\alpha$  increased to 135 degree and  $R$  decreased to 7.5 mm and for the last one,  $\alpha = 90$  degrees with  $R = 10$  mm [Figure 3].

The boundary condition was defined so that all the nodes at the base of each model were fixed to simulate its connection to the clasp assembly. The buccal side of each clasp was assumed to be parallel to the tangent drawn at the most prominent part of the clasp under study, as shown in Figure 1. The displacements (0.01, 0.02 and 0.03”) in toward buccal direction were considered and evaluated. The analyses were performed in a Pentium IV personal computer by ANSYS Version 5.71 (ANSYS Inc., Soutpointe, 275 Technology Drive, Cononsburg PA 15317, USA). Output data for the forces produced in two directions (buccolingually and mesiodistally) were evaluated and presented.

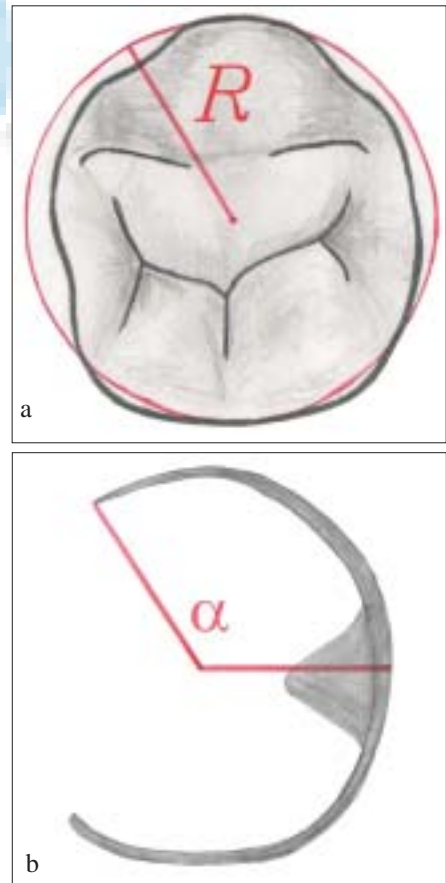
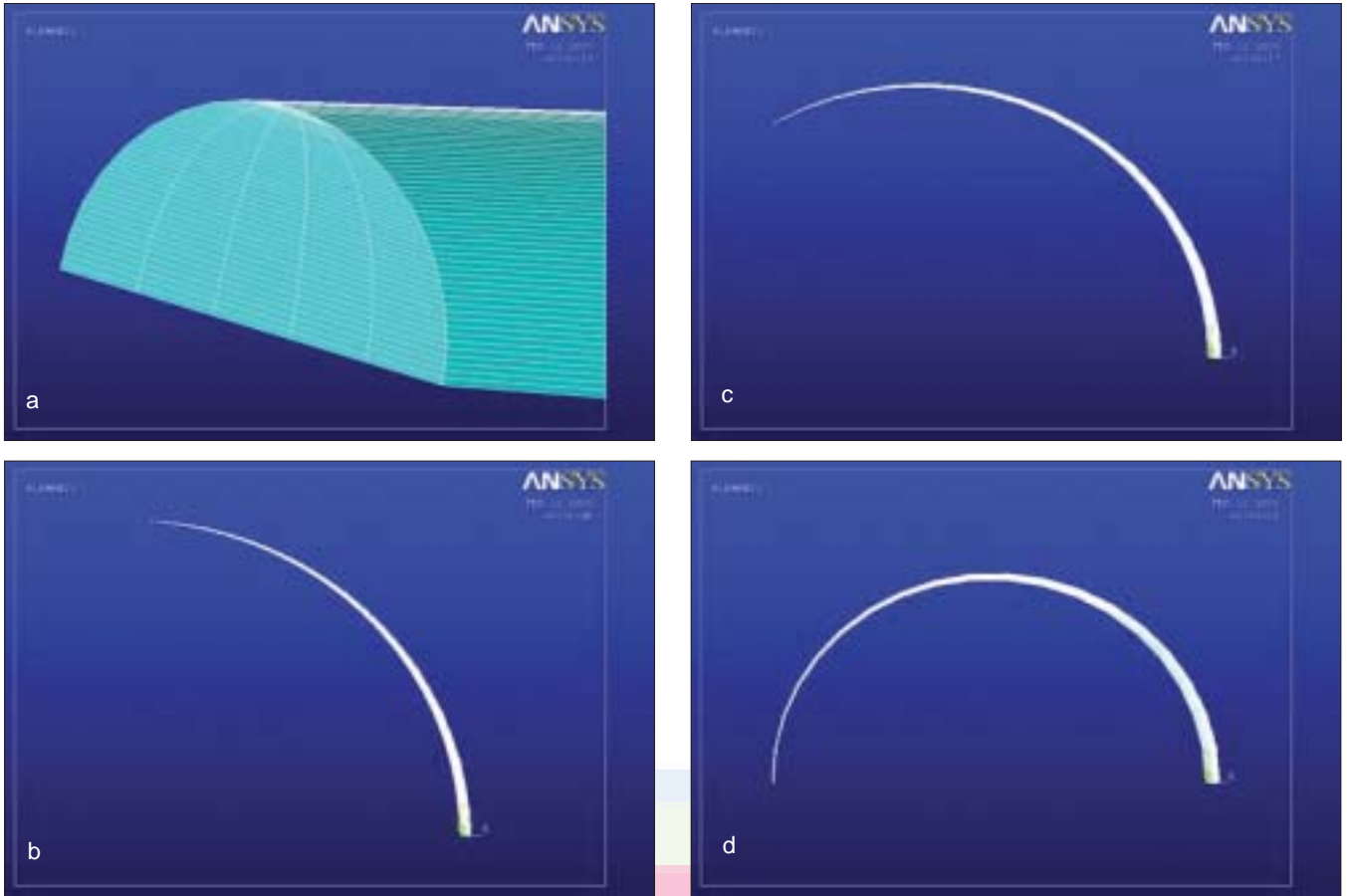


Figure 1: a)  $R$ ; b)  $\alpha$



**Figure 2:** (a) Close-up of the meshed model in which the element size and the cross section of the retentive arm are shown, (b) 3D model of the 90-degree retentive arm, (c) 3D model of the 120-degree retentive arm and (d) 3D model of the 180-degree retentive arm

**RESULTS**

The output data for the forces produced in two directions (mesiodistal and buccolingual) were derived and divided according to  $\alpha$  [Table 1].

$\alpha = 90$  degrees

The mesiodistal force shows an increase between 60.76 gr for a 10-gauge undercut and 161 gr for a 30-gauge undercut.

The buccolingual force ranged between 9.39 and 23.37 gr in the three undercuts considered.

$\alpha = 120$  degrees

Mesiodistal force: Increase of this result from 27.96 gr in a 10-gauge undercut to 77.69 in a 30-gauge undercut is recorded.

Buccolingual force: Although more slowly, these findings show an increase from 11.89 to 34.84 gr.

$\alpha = 180$  degrees

Mesiodistal force: These findings are the lowest among all the mesiodistal findings - from 2.35 gr for a 10-gauge undercut to 6.82 gr for the 30-gauge one.

Buccolingual force: The highest findings among all the forces in this direction belonged to this group, which were between 17.65 and 52.48 gr.

**DISCUSSION**

The effect of  $R$  and  $\alpha$  on the retention produced by three retentive arms were evaluated. Retention is essential for the proper functioning of a removable

**Table 1: Output data of retention forces decomposed to mesiodistal and buccolingual forces**

	10 gauge		20 gauge		30 gauge	
	*MD force	**BL force	MD force	BL force	MD force	BL force
90	60.76	9.39	114.43	16.604	161	23.37
120	27.96	11.89	53.87	23.61	77.69	34.84
180	2.35	17.65	4.56	35.24	6.82	52.48

\*Mesiodistal, \*\*Buccolingual

**Table 2: The ratio of retention modification in comparison to the 90-degree retentive arm at the same undercut**

	10 gauge		20 gauge		30 gauge	
	*MD force	**BL force	MD force	BL force	MD force	BL force
90	1	1	1	1	1	1
120	0.46	1.266	0.47	1.42	0.482	1.49
180	0.038	1.879	0.0398	2.122	0.042	2.245

\*Mesiodistal, \*\*Buccolingual

partial prosthesis.

The basic literature with regard to partial removable prosthodontics state that the retention is affected by (1) length of the clasp arm, (2) width of the clasp arm (3) width-thickness ratio of the clasp arm, (4) cross section and (5) the alloy used. In this manner, the effect of the 3D form of the retentive arm on the retention produced by it is ignored in a circumferential clasp.

There are several articles studying the clasp arms from various viewpoints. To the best of our knowledge, this is the first time the curvature of the retentive arm in a circumferential clasp and its effects on the retention is numerically evaluated. In this manner, a factor that has been ignored in the retention produced

by the retentive arms is explained.

The thorough assessment of the output data and the tables reveal that in considering an undercut to produce retention, extending the retentive arm at any instant increases the retention produced under the same conditions. This increase in retention is directly proportional to the amount of undercut gauge. In this study, the variations in the numeric data suggest that this factor should be taken into consideration because it affects the retention quality produced by an undercut. An increase of 1.879 times for a 10-gauge undercut between  $R = 90$  and 180 to 2.245 times for the same condition in a 30-gauge undercut confirms that, at any instant, we can shift from the big molars towards the smaller premolars without damaging the retention produced [Table 2].

The only factor that must be considered for such a suggestion is the root surface of the premolars.

According to the results presented, the exact shape of the retentive arm in a circumferential clasp can be considered as a determining factor in the quality of its retention, which is apart from other factors considered for the retention produced by a clasp arm.

The retention produced by a retentive arm, keeping all the features the same, may be changed by the amount of curvature ( $\alpha$  and  $R$ ). This has not been considered in partial removable denture texts. It shows that the different teeth in two quadrants can be considered to produce comparable retentions according to their  $R$  and  $\alpha$  values.

[Figure 4a] shows the increase in retention between  $\alpha = 90$  degrees and  $\alpha = 180$  degrees. The comparison of these data with the findings of the decreased mesiodistal retention shows the interrelationship that is present [Figure 4b]. This figure opens a new area of research for the researchers and also to the clinicians to consider the shifting toward lower gauges of undercut and maintaining the same retention. In this manner, the clasp life is increased while the stress produced in the PDL in the path of removal and seating of the prosthesis is maintained at a low level (in the absence of an ideal reciprocation).

Due to the size of the structure, FEM seems to be the sole method with accurate findings and low cost, while this can also be considered as quite conservative.

## CONCLUSION

The given length of the retentive arm placed at the same depth of undercut in different teeth (different mesiodistal dimensions) produces various retention forces based on to the values of  $R$  and  $\alpha$ .

## REFERENCES

1. Clayton JA, Jaslow C. A measurement of clasp forces

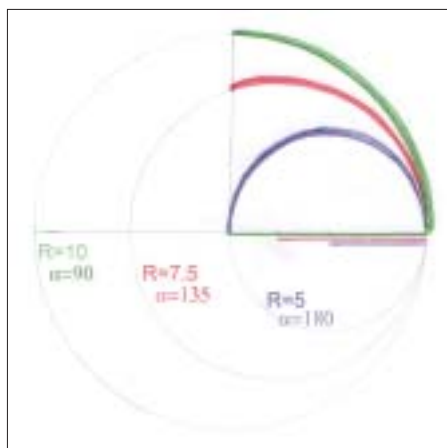


Figure 3: Different values of  $R$  and  $\alpha$  considered in this study

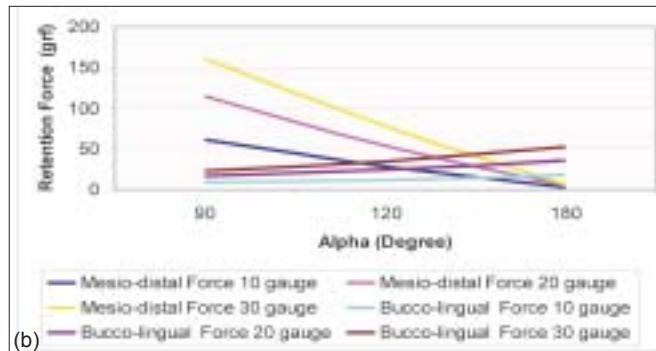
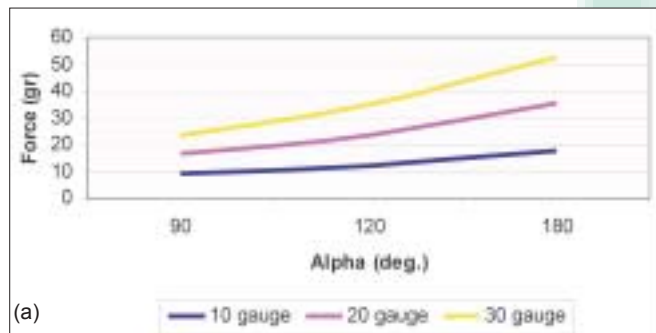


Figure 4: (a) Increase in the buccolingual force with the change in  $\alpha$  and (b) superimposition of the changes in retention force with different values of  $\alpha$

- on teeth. J Prosthet Dent 1971;25:21-43.
2. Morris HF, Asgar K, Brudvik JS, Winkler S, Roberts EP. Stress-relaxation testing. Part IV: Clasp pattern dimensions and their influence on clasp behavior. J Prosthet Dent 1983;50:319-26.
  3. Snyder HA, Duncanson MG. The effect of clasp form on permanent deformation. Int J Prosthodont 1992;5:345-50.
  4. Sato Y, Yuasa Y, Akagawa Y, Ohkawa S. An investigation of the preferable taper and thickness ratios for cast circumferential clasp arm using finite element analysis. Int J Prosthodont 1995;8:392-7.
  5. Sato Y, Abe Y, Yuasa Y, Akagawa Y. Effect of friction coefficient on Akers clasp retention. J Prosthet Dent 1997;78:22-7.
  6. Marei MK. Measurement (*in vitro*) of the amount of force required to dislodge specific clasp from different depths of undercut. J Prosthet Dent 1995;74:258-63.
  7. Sato Y, Hosokawa R. Proximal plate in conventional circumferential cast clasp retention. J Prosthet Dent 2000;83:319-22.
  8. Rodrigues RC, Ribeiro RF, de Mattos Mda G, Bezzon OL. Comparative study of circumferential clasp retention force for titanium and cobalt-chromium removable partial dentures. J Prosthet Dent 2002;88:290-6.
  9. Geramy A. The same amount of the CRes displacement in various orthodontic tooth movements while the applied force is remained constant: 3D analysis using Finite element method. J Dent Shiraz Univ Med Sci 2002;3:59-65.
  10. Geramy A. V-bend force system: 3D analysis using finite element method. Iran J Orthodont 2006;1:12-7.
  11. Geramy A. Bracket base characteristics: 3D analysis using finite element method. Iran J Orthodont.
  12. Geramy A. Moment /force ratio and the center of rotation: Three-dimensional analysis by means of the finite element method. J Dent Shiraz Univ Med Sci 2000;1:26-34.
  13. Geramy A. Alveolar bone resorption and the center of resistant modification (3D analysis by means of the finite element method). Am J Orthod Dentofac Orthop 2000;117:399-405.
  14. Geramy A. Initial stress produced in the periodontal membrane by orthodontic loads in the presence of varying loss of alveolar bone: A three-dimensional finite element analysis. Eur J Orthod 2002;24:21-33.
  15. Geramy A. Stress Tensor Modification in alveolar Bone resorption: 3D analysis using FEM. J Dent Shiraz Univ Med Sci 2002;3:39-49.
  16. Geramy A, Faghihi SH. Secondary trauma from occlusion: 3D analysis using Finite Element method. Quintessence Int 2004;35:835-43.
  17. Geramy A. The cervical headgear force system: Three-dimensional analysis by means of the finite element method. J Dent Shiraz Univ Med Sci 2000;2:21-30.
  18. Geramy A. Optimization of unilateral overjet management: Three-dimensional analysis by the finite element method. Angle Orthod 2002;72:585-92.
  19. Geramy A, Morgano S. Finite element analysis of three designs of an implant-supported molar crown. J Prosthet Dent 2004;92:434-40.
  20. Geramy A, Sharafoddin F. Abfraction: 3D analysis by means of the Finite element method. Quintessence Int 2003;34:526-33.
  21. McGivney GP, Carr AB. McCracken's removable partial prosthodontics, 3<sup>rd</sup> ed. St. Louis: Mosby; 2000. p. 102.

Source of Support: Nil, Conflict of Interest: None declared.

## Author Help: Online Submission of the Manuscripts

Articles can be submitted online from <http://www.journalonweb.com>. For online submission articles should be prepared in two files (first page file and article file). Images should be submitted separately.

### 1) First Page File:

Prepare the title page, covering letter, acknowledgement, etc., using a word processor program. All information which can reveal your identity should be here. Use text/rtf/doc/pdf files. Do not zip the files.

### 2) Article file:

The main text of the article, beginning from Abstract till References (including tables) should be in this file. Do not include any information (such as acknowledgement, your names in page headers, etc.) in this file. Use text/rtf/doc/pdf files. Do not zip the files. Limit the file size to 400 kb. Do not incorporate images in the file. If file size is large, graphs can be submitted as images separately without incorporating them in the article file to reduce the size of the file.

### 3) Images:

Submit good quality colour images. Each image should be less than **400 kb** in size. Size of the image can be reduced by decreasing the actual height and width of the images (keep up to about 4 inches) or by reducing the quality of image. All image formats (jpeg, tiff, gif, bmp, png, eps, etc.) are acceptable; jpeg is most suitable. The image quality should be good enough to judge the scientific value of the image. Always retain a good quality, high resolution image for print purpose. This high resolution image should be sent to the editorial office at the time of sending a revised article.

### 4) Legends:

Legends for the figures/images should be included at the end of the article file.