Comparison of the Strain on the Alveolar Ridge According to the Occlusal Scheme of Complete Dentures

Won-Jun Choi, D.D.S.,M.S.D., Young-Jun Lim, D.D.S.,M.S.D.,PhD.,
Chang-Whe Kim,D.D.S.,M.S.D.,PhD., Myung-Joo Kim, D.D.S.,M.S.,PhD.

Department of Prosthodontics, Graduate School, Seoul National University

The purpose of this study was to compare the strain on the alveolar ridge in the centric, eccentric and protrusive position according to the occlusal scheme (bilateral balanced occlusion with 33 degree anatomical teeth, group B; monoplane occlusion with non-anatomical teeth, group M; lingualized occlusion with 33 degree anatomical teeth and non-anatomical teeth, group L; of complete dentures.

Experimental dentures were set bilateral balanced occlusion, lingualized occlusion and monoplane occlusion. They are analysed through T-Scan II(Tekscan, Boston, U.S.A) and 1.5mm thick layer was removed from the denture-supporting surface of resin model and then replaced with silicone to simulate resilient edentulous ridge mucosa. A 4x6 linear strain gauge is attached to the 1st premolar and 1st molar area. The strain values are recorded according to the occlusal scheme in the centric, eccentric and protrusive position after uniformly applying 50 N and 150 N force through a Universal Testing Machine(instron® 5567, Bluehill 2.0 software ,U.S.A.) with the models mounted in the articulator. When performing centric and protrusive occlusion, the three groups of occlusal scheme were compared in the anterior region and in the posterior region. The strains of each group were also compared in the working side and in the non-working side during eccentric excursion.

It was observed that the strain in the bilateral balanced occlusion showed a higher value than the lingualized occlusion and monoplane occlusion in every position except the non-working side. However, during the eccentric movement the strain value in the non-working side showed the lowest value in the bilaterally balanced occlusion.

The strain change amount from the working side or centric occlusion to non-working side and also the strain variation rate within the non-working side showed the highest value in bilateral balanced occlusion.

Key words: bilateral balanced occlusion, lingualized occlusion, monoplane occlusion, strain, T-Scan II

(**Journal of Dental Rehabilitation and Applied Science** 2010:26(1):1~12)

Corresponding author : Pf. Myung-Joo Kim
Department of Prosthodontics, School of Dentistry, Seoul National University,
62-1 changyunggungro Jongrogu Seoul, Korea
Fax: 02-2072-3860,e-mail: silk1@snu.ac.kr
Received: November 10, 2009, Last Revision: November 30, 2009, Accepted: March 25, 2010

INTRODUCTION

In the fabrication of complete dentures, the clinician must consider denture stability and restoration of physiologic function, including mastication and speech. Many posterior artificial tooth forms and arrangements involved in occlusal schemes are important factors for denture stability and function. Many types of occlusal forms and posterior tooth arrangements have been used in complete dentures.[1-4] Many investigators[5-9] have also evaluated the effectiveness of the various type of posterior occlusal form. Their research examined three factors:(1)masticatory efficiency, (2)comfort and esthetic requirement, (3)forces directed to the ridges

Thompson[10] examined four sets of different occlusal forms for masticatory efficiency of denture wearers: 33 degree anatomic teeth were 65% efficient, 20 degree modified anatomic teeth were 57% efficient, Hall's inverted cusp teeth were 58% efficient, and Sears's channel-type posterior teeth were 29% efficient. Clough et al[8] tested lingualized occlusion and monoplane occlusion. They found that lingualized occlusion was preferred by 67% of the denture wearers because of improved masticatory ability, comfort, and esthetics. Michael et al[9] estimated the biting force and chewing force of denture wearers using anatomic teeth and non-anatomic teeth. They concluded that the occlusal form of the posterior teeth had no significant influence on masticatory force. However, there was difference in the stress transmitted to the mandibular alveolar ridge with different occlusal schemes. Lopuck et al[11] used a photoelastic method to compare the distribution of stresses on the mandibular alveolar ridge according to the posterior denture occlusion. He concluded that the flat occlusal scheme transmitted slightly less force to the ridge than the cuspal forms did.

Complete denture causes stress on the residual alveolar ridge which contributes to the degeneration of the supporting bone[12-14] and this phenomenon seems more visible in the mandible.[15] In long-term longitudinal studies of denture patients, Atwood[16] and Tallgren[17] substantiated the fact that under complete denture function approximately four times more bone reduction occurs in the mandible than in the maxillae.

The edentulous mandible is not structurally capable of bearing forces once the dentoalveolar attachment apparatus has dissipated.[18,19]Many investigators have been aware of this problem and have developed numerous philosophies about tooth form and placement of teeth.[20,21]

The purpose of this study is to compare the amount of strain applied to the mandibular residual ridge according to the occlusal scheme of the complete dentures. In order to do so, complete dentures in bilaterally balanced, lingualized and monoplane occlusion were fabricated over a ready-made acrylic resin edentulous model.

T-Scan II was used to record the occlusal pattern of dentures with three different occlusal positions : centric, eccentric and protrusive position and the strain values are recorded according to the occlusal scheme with strain gauge distinctively from other previous studies.

MATERIALS AND METHODS

1. Complete dentures fabrication

An edentulous maxillary and mandibular acrylic resin model(G1-402,Nissin dental products INC, Kyoto, Japan)were used in this study. Three sets of identical maxillary and mandibular stone cast were duplicated. One set of casts was mounted on a semiadjustable articulator(Hanau H2, Teledyne, Buffalo, New York)with a standard occlusal rim by the split-cast mounting technique.[22] The imaginary occlusal plane of the occlusal rim corresponded to the midplane of the articulator and the opposing ridges were arranged in Angles Class Ⅰ relationship. The articulator was set with the saggital and lateral path inclinations at 30 and 15 degrees, respectively, and with the sagittal and lateral inclination of the incisal guide table at 10 and 0 degrees, respectively.

Maxillary and mandibular anterior teeth(SR Vivodent PE, Ivoclarvivadent AG, Liechtenstein) were arranged before arranging the three groups of posterior teeth. The overjet was set to 1.5mm and the overbite was set to 1mm. In order to reproduce the three sets of test dentures in the same spatial position that the master dentures occupied on the articulator, special jig was made with the master denture mounted on the articulator as a guide. Jig contained pattern resin(Duralay, Reliance Dental MFG Co, U.S.A)was fixed with dental stone on mounting plates of the articulator to guide the mounting positions of maxillary and mandibular casts. Mold was silicone(KE-1402, ShinEtsu, Tokyo, Japan) index of the occlusal rim of the maxillary and mandibular master dentures that were arranged anterior teeth. It reproduced the same denture base contours and positions of anterior teeth. This silicone mold had a sprue hole and a vent hole. A special jig was used to mount the maxillary master cast through slip-cast mounting technique. Following that, the three occlusal rims with identical anterior teeth arrangement were positioned in the already mounted maxillary master cast and consecutively the mandibular master cast was mounted. Three complete dentures were fabricated for three groups characterized by the different occlusal scheme. In other words, the posterior teeth were arranged with 33 degree anatomical teeth(SR Postaris DCL, Ivoclarvivadent AG, Liechtenstein) in the bilateral balanced occlusion group and in the monoplane group the maxillary and mandibular teeth were arranged with non-anatomical teeth(Orthoplane DCL, Ivoclarvivadent AG, Liechtenstein). In the lingualized occlusion group, 33 degree anatomical teeth were used to arrange the maxillary teeth(SR Postaris DCL, Ivoclarvivadent AG, Liechtenstein) while the mandibular teeth(Orthoplane DCL, Ivoclarvivadent AG, Liechtenstein) were arranged with non-anatomical teeth in the conventional manner. Experimental dentures were set according to three different schemes: bilateral balanced occlusion(Group B) , lingualized occlusion(Group L) and monoplane occlusion(Group M) with bilateral contact from the centric relation to all eccentric and protrusive positions(Fig. 1).

(a)group B (b)group L (c)group M

Fig. 1. Experimental dentures set according to three different schemes.
(a) Bilateral balanced occlusion with 33 degree anatomical teeth, group B
(b) Lingualized occlusion with 33 degree anatomical teeth and non-anatomical teeth, group L
(c) Monoplane occlusion with non-anatomical teeth, group M

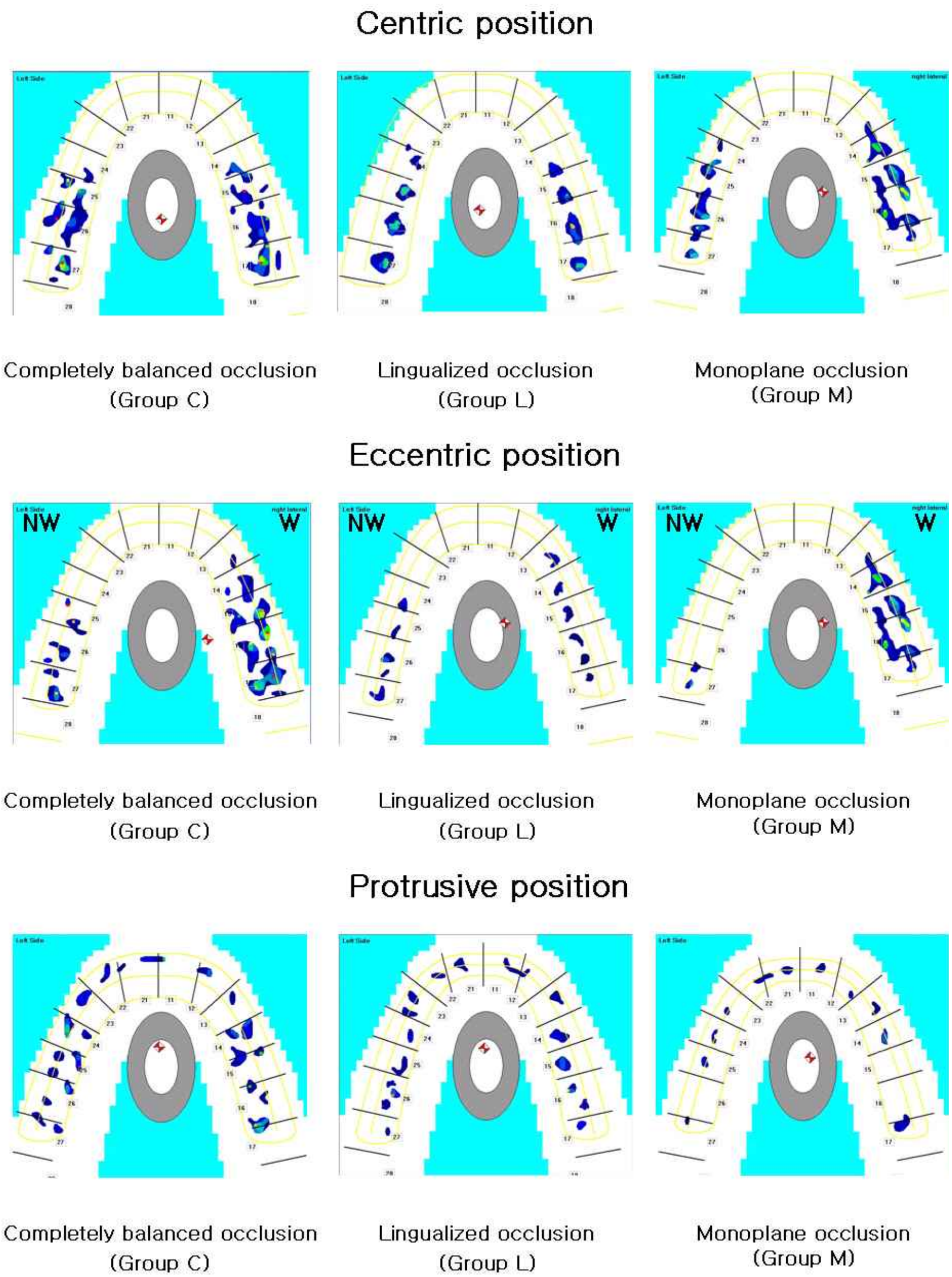

Fig. 2. Occlusal patterns of dentures with three different occlusal schemes in three different position recorded through T-Scan II.
(Bilateral balanced occlusion= Completely balanced occlusion, Group B=Group C
NW:Non-working side ; W:Working side)

2. Occlusal equilibration and record

Occlusal equilibration was performed in the conventional way using articulating paper(AccuFilm[R] II, PARKELL, U.S.A.). T-Scan II(Tekscan, Boston, U.S.A)[23,24] was used to record the occlusal pattern of dentures with three different occlusal positions : centric, eccentric and protrusive position(Fig. 2). The center of T-ScanII's force[25,26,27] was applied to equally distribute the occlusal forces on the right and left side at the time of occlusal equilibration in the centric position.

3. Preparation of the experimental mandibular model

An edentulous mandibular acrylic resin model(G1-402,Nissin dental products INC, Kyoto, Japan) was fabricated. Uchida et al reported that according to an in vivo measurement, the thickness of the masticatory mucosa ranges from 1.45 to 1.58 mm at the mandibular edentulous ridge.[28] Therefore 1.5 mm thick layer was removed from the denture-supporting surface of resin model and then replaced with silicone(Protesil, Austenal Medizintechnik, Germany) to simulate resilient edentulous ridge mucosa. A 5x7 mm silicone mucosa was removed from the first premolar area and another one from the first molar area in order to attach the linear strain gauge at the lingual side. The strain gauge was used to measure the distribution of forces.

4. Loading machine

Static load was applied throuh Universal Testing Machine(instron® 5567, Bluehill 2.0 software., U.S.A.). 50N and 150N loading was applied to the center of the articulator. This load was based on the chewing force and maximum force of the edentulous patient with complete denture.[9] Ten measurements at each load were made under the same conditions, allowing at least 5minutes for recovery. Each experiment was repeated on three sets of three different type complete dentures.

5. Measurement of the strain

Stress on the mandibular alveolar ridge was measured using a strain gauge technique. Four linear strain guages (KFR-2-350-C1-11, Kyowa, Japan)were bonded on the lingual region of first premolar (CH 1, 2) and first molar (CH 3, 4) on the resin model(Fig. 3). The strain guages were bonded with a special cyanoacrylate (M-Bond 200, Vishay Micromeasurement, Raleigh, NC, U.S.A). The lead foils of the gauges were connected to bridge boxes(CTB-100, Curiosity Technology, Seoul, Korea) via terminals. The electric signals from the four strain gauges were amplified and converted into digital signals via 16 byte resolution converter (DAQCard-AL-16XE-50, National Instruments, Austin, U.S.A.), processed by custom software

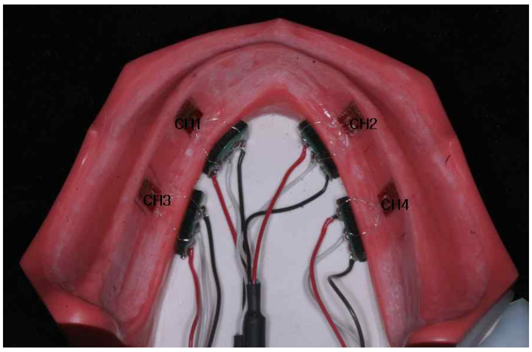

Fig. 3. The linear strain gauges bonded on the lingual region of first premolar (CH 1, 2) and first molar (CH 3, 4) on the resin model.

(CTA-1200, Curiosity Technology, Seoul, Korea).

Channel signals were originally measured in millivolt(mV) and then converted to microstrain units(㎛/m). Measurement capability was 1㎛/m. Stress on the mandibular alveolar ridge was measured: (1) with teeth in centric occlusion (2) with teeth in the eccentric position when the incisal guide pin of the articulator was 2.5 mm left lateral to centric occlusion. (3) with teeth in protrusive position when the incisal guide pin of the articulator was 1.5 mm anterior to centric occlusion.

6. Statistical analysis

The statistical analysis was performed using SPSS 12.0 for Window software(SPSS, Chicago, IL). A one-way analysis of variance(ANOVA) was used to assess the differences between groups. Duncan test was used as post hoc comparisons. The statistical significance level was set to 0.05.

RESULTS

Analyzing the 3 types of occlusal scheme through T-Scan II, the bilateral occlusion showed more contact areas than lingualized occlusion in the centric, eccentric and protrusive position. Differently from the similarities between the occlusal pattern of the before mentioned occlusions due to Wilson curve. the monoplane occlusion showed an asymmetrical occlusion in the working and non working side in the eccentric and prostrusive position due to the difficulty of attributing the Wilson curve This result shows well the characteristics of the monoplane occlusion.

Strain values were measured when applying 50N and 150N at centric, eccentric, protrusive occlusion. When performing centric and protrusive occlusion, the three groups of occlusal scheme were compared in the anterior region - 1st premolar area (mean value of CH1+2) and in the posterior region - 1st molar area (mean value of CH3+4). When performing eccentric occlusion, the 3 groups of occlusal scheme were compared in the working side (CH2+4) and in the non-working side (CH1+3).

Table I. shows that at 50 N of load, in centric occlusion, the anterior and posterior regions showed compressive strain values . In both regions, the

Table Ⅰ. Microstrain value according to different occlusal schemes under 50 N loading

	Group	bilateral balanced occlusion (Group B)	Monoplane occlusion (Group M)	Lingualized occlusion (Group L)	P value
Loading	Channel	Mean SD	Mean SD	Mean SD	
CR 50N	Mean value of CH1+2	13.82 ± 0.76[a]	12.10 ± 0.65[b]	11.78 ± 0.54[b]	p<0.05
	Mean value of CH3+4	23.63 ± 0.59[a]	21.01 ± 0.79[b]	20.72 ± 0.99[b]	p<0.05
ER 50N	Mean value of CH1+3	2.65 ± 0.76[a]	6.15 ± 0.95[b]	6.57 ± 0.82[b]	p<0.05
	Mean value of CH2+4	28.82 ± 1.43[a]	21.13 ± 0.88[b]	20.76 ± 0.88[b]	p<0.05
PR 50N	Mean value of CH1+2	12.25 ± 0.84[a]	10.54 ± 0.68[b]	10.31 ± 0.74[b]	p<0.05
	Mean value of CH3+4	22.42 ± 1.06[a]	20.59 ± 0.62[b]	20.40 ± 0.63[b]	p<0.05

strain values of group B showed statistically significant higher value than group M and L. ($p<0.05$).

During eccentric occlusion, group B showed the lowest compressive strain value in the non-working side while it showed the highest compressive strain value in the working side. In both sides, group B showed significant difference from groups M and L($p<0.05$).

In protrusive occlusion, the anterior and posterior regions showed compressive strain values. In both regions, group B showed statistically significant higher values of strain than groups M and L($p<0.05$).

It was observed that significant differences between groups M and L were not shown ($p>0.05$) in all centric and eccentric positions. In other words, the bilateral balanced occlusion showed the highest compressive strain value in the working side during eccentric occlusion.

Table Ⅱ. shows that at 150 N of load, when performing centric occlusion, the anterior and posterior regions showed compressive strain values.

It was also possible to see that at 50 N and 150 N centric position, eccentric position and protrusive position showed similar patterns. It also observed higher strain in all situations as expected when the load increased from 50 N to 150 N.

The mean change in non-working side according to the load increase from 50N to 150N showed interesting and instructive result (Fig. 4). It was 421 % in the bilateral balanced occlusion. On the other hand, the mean change of lingualized and monoplane occlusion was approximately 230%.

Table Ⅱ. Microstrain value according to different occlusal schemes under 150 N loading

	Group	bilateral balanced occlusion (Group B)	Monoplane occlusion (Group M)	Lingualized occlusion (Group L)	P value
Loading	Channel	Mean SD	Mean SD	Mean SD	
CR 150N	Mean value of CH1+2	28.34 ± 1.40[a]	24.17 ± 1.47[b]	24.08 ± 1.21[b]	p<0.05
	Mean value of CH3+4	54.49 ± 2.43[a]	48.09 ± 1.94[b]	47.98 ± 1.95[b]	p<0.05
ER 150N	Mean value of CH1+3	13.80 ± 2.09[a]	20.49 ± 2.59[b]	22.10 ± 2.39[b]	p<0.05
	Mean value of CH2+4	63.26 ± 2.25[a]	54.03 ± 2.15[b]	53.2 ± 2.03 [b]	p<0.05
PR 150N	Mean value of CH1+2	22.97 ± 1.18[a]	19.18 ± 0.95[b]	19.07 ± 0.95[b]	p<0.05
	Mean value of CH3+4	50.11 ± 1.30[a]	47.42 ± 1.13[b]	47.10 ± 1.25 [b]	p<0.05

•CR: Centric position, ER: Eccentric position, PR: Protrusive position
•CH1+2: first premolar-anterior region channel
•CH3+4: first molar-posterior region channel
•CH1+3: non-working channel
•CH2+4: working channel
•A one-way analysis of variance(ANOVA) was used to assess the differences between groups. Duncan test was used as post hoc comparisons. The different letters were represented a statistically difference. ($p<0.05$)

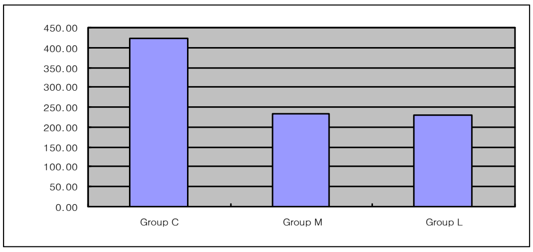

Fig. 4. The mean of change according to the load increase in the non-working side (Group B=Group C)

$\delta = \frac{b-a}{a} \times 100(\%)$, a: strain value at 50N, b: strain value at 150N

The difference from centric or working side to the non-working side and the strain variation rate within the non-working side when load increased from 50N to 150N showed the highest value in bilateral balanced occlusion.

DISCUSSION

The scheme of occlusion and the position of posterior denture teeth are considered to be important factors affecting denture stability and chewing efficiency.[1-4] In this study the strain values on the mandibular alveolar ridge under a complete denture were evaluated with three different occlusal schemes. The strain values were measured to examine the influence of occlusal scheme on the strain distribution.

It is well known that the mandible was very sensitive to this strain and was likely to cause degenerative change because its supporting areas were quite much reduced compared with that of the maxilla, and the mandible in the edentulous status could not stand load better than maxilla in terms of its shape and structure. Although the cause of alveolar resorption of the edentulous ridge is not known, many people believe that lateral forces exerted against these tissue by artificial dentures contribute to bone resorption. A large proportion of these forces is exerted through the occlusal form of the tooth. The different lateral forces originated by different occlusal schemes cause several patterns of deformation of the denture[29-32] and they are followed by varying values of strain on the residual ridge.[11,34] Investigators have tested the specific effects of different occlusal schemes on physical changes in the denture during function. Swoope and Kydd[29,30] showed that the amount and type of deformation were related to the type of tooth in function, with considerably less compression and extension occurring in the denture with the flat posterior occlusal scheme than in the one with 33 degree posterior teeth. Stromberg[32] observed higher stresses in bases with anatomic rather than flat teeth and higher stress on the balancing than the functional side. Johnson[33] found more lateral deformation in the maxillary denture with cusp teeth than with flat teeth. In summary, bilateral balanced occlusion with cusp teeth showed more deformation than occlusal scheme with cuspless teeth. In addition, Lopuck et al[11] evaluated the distribution of stress on the mandibular alveolar ridge with diverse posterior denture occlusion through a photoelastic method. He observed that the cuspal forms transmitted slightly more force to the ridge than the flat occlusal scheme. In this study, bilateral balanced occlusion showed statistically higher strain values than lingualized and monoplane occlusion in centric, eccentric and protrusive occlusions. The results of Lopuck's study were congruent with those of the present study.

These results could be obtained because the cusp teeth of the bilateral balanced occlusion had numerous contacts on inclined plane and apparently generated erratic torquing forces within denture.

Especially, the mean change for strain values according to the occlusal scheme on the non-working side showed the highest value when increasing the load from 50 N to 150 N. This results were observed because the lateral vector value increased, consequence of the numerous contacts on inclined plane between the lingual incline of the mandibular buccal cusps and buccal incline of the maxillary palatal cusps on the non-working side.

Moreover, The difference from centric or working side to the non-working side when load increased from 50N to 150N showed the highest value in bilateral balanced occlusion. Therefore, the bilaterally balanced occlusion showed greater differences than M or L in the strain value applied to the residual ridge according to the change of strain. In a long-term evaluation, it can be said that it will cause instability of the denture and consequently more bone resorption, therefore requiring a more prudent and periodic recall check.

However, in the present study, the masticatory efficiency and esthetic requirements were not taken into consideration. Many studies have compared the chewing efficiency of various forms of posterior teeth in complete dentures.[5-8,10] Some studies have demonstrated a significant difference in chewing efficiency between different occlusal forms and the masticatory efficiency was proven to be superior in the occlusal scheme with cusp teeth.

Moreover, a higher load was demanded in the food crushing process with monoplane occlusion than with bilateral balanced and lingualized occlusion.[35,36] As a result, it was possible to observe a higher strain value being exerted on the mandibular alveolar ridge when performing food crushing.

Regarding the esthetic requirements, bilateral balanced and lingualized occlusion showed more satisfying results.[6,8,37]

Considering all of the above, it can be said that lingualized occlusion is comparatively more advantageous regarding the masticatory efficiency, comfort, esthetics and forces directed to the ridges.

There were some limitations in this study for it is an in vitro study. Factors other than the scheme of occlusion such as the morphology of residual ridge, properties of the saliva and chewing efficiency of the subject were not take into consideration. Future studies considering those factors are needed.

However in the present study, the three occlusal schemes were compared and analyzed in centric, eccentric and protrusive movements under the same conditions and the results were digitalized through T-Scan II. This digitalization process which was not seen in previous studies allowed to obtain the distribution of the load and to minimize the occlusal scheme change in case of conducting further studies. Moreover, compared to the photoelastic stress analysis, finite element stress analysis and the mathematical analysis used with the strain gauge analysis, the possibility of applying it in a further in vivo study highlights the importance of this study.

CONCLUSION

Complete dentures were fabricated with three different occlusal scheme : bilateral balanced, lingualized, and monoplane occlusion. The strain values on the simulated mandibular alveolar ridge under a complete denture was recorded on the centric, eccentric and protrusive position.

The following results may be drawn within the limitations of this study:

1. It was possible to observe through the use of T-Scan II that there were differences in the

contact pattern according to different occlusal schemes in the centric, lateral and protrusive position.
2. Strain values increased and were compressive stress as the applied load increased from 50N to 150N.
3. The bilateral balanced occlusion showed higher strain values than lingualized and monoplane occlusion except on the non-working side ($p<0.05$).
4. The bilateral balanced occlusion showed the lowest strain value in the non-working side during eccentric position ($p<0.05$) regardless of the magnitude of the load.
5. The bilateral balanced occlusion showed the largest difference of strain values between working side and non-working side during lateral excursion.
6. There was no significant differences between the lingualized and monoplane occlusion ($p>0.05$) in all circumstances.

REFERENCES

1. Ortman HR. Complete denture occlusion. In: Winkler S(ed). Essentials of Complete Denture Prosthodontics, ed 2. Philadelphia: WB Saunders, 1994:2 17-90
2. Renner RP. Practical complete denture occlusion. In: Renner RP(ed). Complete Dentures. A Guide for Patient Treatment. New York: Masson, 1981:120-51
3. Heartwell CM Jr, Rahn AO. Tooth Arrangement. Syllabus of Complete Dentures, ed 4. Philadelphia: Lea & Febiger,1986:327-42
4. Boucher CO. Arrangement of posterior teeth for functional harmony. In: Boucher CO, Hickey JC, Zarb GA(eds). Prosdontic Treatment for Edentulous Patient,ed7. St Louis: Mosby,1975: 413-46.
5. Schultz AW. Comfort and chewing efficiency in dentures. J Procthet Dent 1951;1:38-48
6. Payne SH. A comparative study of posterior occlusion. J Prosthet Dent 1952;2:661-65
7. Trapozzano VR, Lazzari JB. An experimental study of the testing of occlusal patterns on the same denture base. J Prosthet Dent 1952;2:440-57
8. Clough HE, et. al. A comparison of lingualized occlusion and monoplane occlusion in complete denture. J Prosthet Dent 1983;50:176-79
9. Michael CG, et. al. Biting strength and chewing forces in complete denture wearers. J Prosthet Dent 1990;63:549-53
10. Thompson MJ. Efficiency as related to cusp form in denture prosthesis. J Am Dent Assoc 1937;24:207-19
11. Stephen LO, et. al. Photoelastic comparison of posterior denture occlusions. J Prosthet Dent 1978;40: 18-22
12. Kelsey CC. Alveolar bone resorption under complete dentures. J Prosthet Dent 1971;25(3):152-161
13. Campbell RL A comparartive study of the resorption of the alveolar ridges in denture-wearers and nondenture wearers. J Am Dent Assoc 1960;60:143-53
14. Jozefowicz W. The influence of wearing dentures on residual ridges-A comparative study. J Prosthet Dent 1970;24(2):137-44
15. Tallgren A. Alveolar bone loss in denture wearers as related to facial morphology. Acta Odontol Scand 1970;28(2):251-70
16. Atwood, DA. Clinical. cephalometric, and densitometric study of the reduction of residual ridges. J Prosthet Dent 1971;26(3):280-95
17. Tallgren A. The continuing reduction of the residual alveolar ridges in complete denture wearers : A mixed longitudinal study covering 25 years. J Prosthet Dent 1972;27(2):120-32
18. Neufeld, JO. Changes in the trabecular pattern of the mandible following the loss of teeth. J Prosthet Dent 1958;8:685
19. Ortman H. The role of occlusion in preservation and prevention in complete prosthodontics. J Prosthet Den 1971;25(3):121-38
20. Wright C. Evaluation of the factors necessary to develop stsbility in mandibular dentures. J Prosthet

Dent 1966;16(3):414-30

21. Sears V. Thirty years of non-anatomic teeth. J Prosthet Dent 1953;3:596
22. Nogueira SS. Russi S. Compagnoni MA, De. J Prosthet Dent 2004;91:386-8
23. Mizui M, Nabershima F, Tosa J, Tanaka M, Kawazoe T. Quantitative analysis of occlusal balance in intercuspal position using the T-Scan System. Int J Prosthodont 1994;7:62-71
24. Kapur KK, Yurkstas AA. An evaluation of centric relation records obtained by various techniques. J Prosthet Dent 1957;7:770-86
25. Francesco OL. et. al. New method for analyzing complete denture occlusion using the center of force concept:A case report J Prosthet Dent 1998;80: 519-23
26. Jacobson TE, Krol AJ. A contemporary review of the factors involved in complete dentures. Part II : stability. J Prosthet Dent 1983;49:165-72.
27. Boening KW, Walter MH. Computer-aided evaluation of occlusal load in complete dentures. J Prosthet Dent 1992;67:339-44.
28. H. Uchida, et. al. Measurement in vivo of masticatory mucosal thickness with 20 MHz B-mode ultrasonic diagnostic equipment, *J Dent Rec* 1989;68:95 - 100.
29. Kydd W. Complete denture base deformation with varied occlusal tooth forms. J Prosthet Dent 1956; 6:714
30. Swoope CC Jr, Kydd. WL. The effect of cusp form and occlusal area in denture base deformation. J Prosthet Dent 1966;16:34-43
31. Sharry JJ, et. al. Influence of artificial tooth forms on bone deformation beneath complete dentures. J Dent Res 1960; 39: 253-66
32. Stromberg WR. A Method of Measuring Forces of Denture Bases Against Supporting Tissues, J Prosthet Dent 1955;5:268-88
33. Johnson W. A study of stress distribution in complete upper dentures. Dent Pract Dent Rec 1965;15:371
34. Maeda Y, Wood WW. Finite element method stimulation of bone resorption beneath a complete denture. J Dent Res 1989;68:1370-3
35. Inoue S, et. al. An in vitro study of influence of occlusal scheme on pressure distribution of complete denture supporting tissues. Int J Prosthodont 1996;9: 179-87
36. Ohguri T, et. al. Influence of occlusal scheme on the pressure distribution under a complete denture. Int J Prosthodont. 1999;12:353-8.
37. Pound E. Utilizing speech to simplify a personalized denture service. J Prosthet Dent 1970;24:586-600

총의치 교합양식에 따른 응력 분포 양상 비교연구

서울대학교 치의학전문대학원 치과보철학교실

최원준 · 임영준 · 김창회 · 김명주

총의치가 잔존치조제에 가하는 응력은 지지골의 흡수를 야기할 수 있으며, 이는 하악골에서 더 흔히 발생한다. 이러한 응력은 측방력과 관련이 있고, 이는 총의치의 교합력에 따라 차이를 보이게 된다. 그러므로 본 연구의 목적은 총의치의 교합양식(양측성 균형교합-33도 해부학적 치아, C군 ; 무교두교합-0도 비해부학적 치아, M군 ; 설측교두교합,-상악은 33도 해부학적 치아와 하악은 0도 비해부학적 치아, L군)에 따른 하악잔존치조제에 미치는 응력의 크기를 중심위, 측방위, 전방위 상태에서 비교하는 것이다. 기성 아크릴릭 무치악 모델을 이용하여 양측성 균형교합, 무교두교합, 설측교두교합 양식을 갖는 총의치를 제작하여 이를 T-ScanⅡ(Tekscan, Boston, U.S.A)를 이용해 기록했다. 하악 무치악 아크릴 모형을 1.5 mm 일정하게 삭제한 뒤 실리콘으로 점막을 재현하여 제1소구치와 제1대구치 부위에 각각 4x6의 linear strain gauge를 부착했다. 교합기에 모형을 부착한 상태에서 Universal Testing Machine(instron® 5567, Bluehill 2.0 software ,U.S.A.)으로 50 N과 150 N의 힘을 중심위, 측방위, 전방위 상태에서 일정하게 가하여 교합양식에 따른 응력값을 측정했다. 중심위와 전방위 상태에서는 전방과 후방의 응력값을 교합양식에 따라 비교하고, 측방위에서는 작업측과 비작업측에서의 응력값을 비교하였다.

이상과 같은 실험으로 양측성 균형교합에서의 응력값이 비작업측을 제외하고는 모든 위치에 서 설측교두교합과 무교두교합보다 더 컸으며, 비작업측과의 차이값과 비작업측에서의 응력 변화율도 가장 컸다. 그러나, 측방운동시 비작업측의 응력은 양측성 균형교합에서 가장 작은 것으로 나타났다.

주요어: 양측성 균형교합, 설측교두교합, 무교두교합, strain, T-ScanⅡ

교신저자: 김명주
서울대학교 치과대학 치과보철학교실, 서울특별시 종로구 창경궁로 62-1 대한민국,
팩스: 02-2072-3860,이메일: silk1@snu.ac.kr
원고접수일: 2009년 11월 10일, 원고수정일: 2009년 11월 30일, 원고채택일: 2010년 03월 25일