The Effect of Tooth Loss on Body Balance Control Among Community-Dwelling Elderly Persons

Mitsuyoshi Yoshida, DDS, PhD[a]/Takeshi Kikutani, DDS, PhD[b]/Gentaro Okada, DDS[c]/
Takahisa Kawamura, DDS[c]/Misaka Kimura, PhD[d]/Yasumasa Akagawa, DDS, PhD[e]

Purpose: Since tooth loss may be considered to affect postural control, the aim of this study was to compare body balance control among samples of edentulous and dentate community-dwelling elderly subjects. ***Materials and Methods:*** A case control study was conducted using test and control groups matched by age, gender, body fat, and muscle composition. The test group included all participants of the 2006 Kyoto Health Seminar who wore a full denture in either or both arches. The control group was blindly selected from the same population, but only included individuals who retained all of their dentition with either natural teeth or crown prostheses. The results of physical fitness examinations and stabilometer tests were compared between these two groups. ***Results:*** The test and control groups both included 12 male and 23 female subjects. Body balance ability, measured by time spent standing on one leg with eyes open ($P = .013$) and functional reach ($P = .037$), was significantly less in the test group when compared to the control, as shown by analysis done using the Mann-Whitney *U* test. The stabilometer examination also indicated that sway area (an accurate indicator of postural balance) and body sway (evidence of energy consumption for postural control) while standing with eyes closed were both significantly higher in the test group ($P = .035$ and .048, respectively; Wilcoxon signed ranks test) than the control. ***Conclusion***: It is suggested that tooth loss is a risk factor for postural instability. This further suggests that proprioceptive sensation from the periodontal ligament receptor may play a role in body balance control. *Int J Prosthodont 2009;22:136–139*

More than one third of persons 65 years of age or older fall each year and, for half of these individuals, such falls are recurrent.[1,2] Approximately 1 in 10 falls results in serious injury, such as hip fracture.[3] Fracturing a hip increases morbidity and mortality in this population, with death occurring within 1 year of the fracture in over 30% of elderly individuals.[4] Also, falling and a fear of falling are risk factors for disuse syndrome, the major cause of becoming bedridden according to the Annual Report of the Aging Society published by the Cabinet Office in 2002.[5] The prevention of falls in this rapidly increasing segment of the population is a primary concern for maintaining an adequate quality of life (QOL).

Studies have shown that demented elderly persons are twice as likely to fall as cognitively normal persons of the same age group[1,6] and a relationship between dental occlusion and falls among the elderly with dementia has been demonstrated.[7,8] This finding suggests that elderly individuals who lack dental occlusion are at a higher risk of falling than those whose dental occlusion has been maintained. Other investigators have suggested that occlusion and head position affect sway at the center of gravity, resulting in an increased risk suffering of a fall.[9,10] Gangloff and Perrin[11] showed

[a]*Chief, Dental Department, Hiroshima City General Rehabilitation Center, Hiroshima, Japan.*
[b]*Associate Professor, Nippon Dental University Hospital at Tokyo, Clinic of Rehabilitation for Speech and Swallowing Disorders, Tokyo, Japan.*
[c]*Postgraduate Student, Department of Advanced Prosthodontics, Hiroshima University Graduate School of Biomedical Science, Hiroshima, Japan.*
[d]*Professor, School of Nursing, Kyoto Prefectural University of Medicine, Kyoto, Japan.*
[e]*Professor and Chairman, Department of Advanced Prosthodontics, Hiroshima University Graduate School of Biomedical Sciences, Hiroshima, Japan.*

Correspondence to: *Dr Mitsuyoshi Yoshida, Hiroshima City General Rehabilitation Center, Tomo-minami 1-39-1, Asaminami-ku, Hiroshima 731-3168, Japan. Fax: +81-82-849-8003. Email: mitsu@hiroshima-u.ac.jp*

Table 1 Characteristics of Test and Control Goups

	Test group	Control group	*P* value
Sex (male/female)	12/23	12/23	1.000
Mean age	75.6 ± 4.3	75.9 ± 3.9	.645
Body mass index (kg/m^2)	21.9 ± 2.9	21.8 ± 2.5	.949
Arm muscle circumference (cm)	20.8 ± 1.9	21.1 ± 2.0	.747
Hand grip (kg)	25.2 ± 6.9	25.9 ± 8.4	.941
Leg extensor power (kg)	21.0 ± 9.1	19.8 ± 9.7	.307
One-leg standing time with eyes open (s)	28.4 ± 32.6	47.6 ± 44.5	.013*
Functional reach (cm)	29.1 ± 9.8	33.7 ± 8.0	.037*

*$P < .05$ (Mann-Whitney *U* test).

that proprioception of the mandibular system has a great effect on postural control. They reported that postural control significantly deteriorated in young volunteers after undergoing unilateral conduction anesthesia of the mandibular nerve. These results suggest that tooth loss may affect postural control. The aim of this study was to compare body balance control between edentulous and dentate community-dwelling elderly subjects.

Materials and Methods

This study was approved by the Ethics Committee of Kyoto Prefectural University of Medicine. All subjects were living independently in Kyoto and participated in the 2006 Kyoto Health Seminar, which is held by the Kyoto Prefectural University of Medicine each May. Individuals suffering from cerebrovascular diseases, motor neuron diseases, or otologic symptoms or those who were obese (Body Mass Index [BMI] > 30) were excluded from the study. In addition, the Geriatric Depression Scale[12] was performed and any subject considered to be depressed was excluded. Dental examinations were performed by the authors using a dental mirror and small light. A case control study was planned as follows: the test group included all seminar participants who wore a full denture in either or both arches. The control group was selected from the 149 subjects who retained all dentition with either natural teeth or crown prostheses. A blinded practitioner matched the control group to the test group by age, gender, body fat (BMI), and muscle composition, measured by arm muscle circumference (AMC).

Physical fitness examinations were performed as a part of this seminar. Hand grip and leg extensor power reflected muscle strength. Time spent standing on one leg with the eyes open and functional reach (the difference between arm length and maximal forward reach) reflected balance ability.

Body balance ability was also evaluated using a stabilometer (Stabilometer S510-U, Sakamoto). The stabilometer test is a valid and reliable examination used to evaluate whirling and staggering body movements.[13] Each subject was asked to remain as stable and relaxed as possible while standing barefoot on a vertical force platform focusing on a mark 2 m away. The parameters of the examination were sway area, serving as an accurate indicator of postural balance, and body sway, which reflected the energy consumption needed to remain steady. Measurements were recorded for 20 seconds with each subject standing with both eyes open and closed and the pressure placed at the center of the foot was displayed on a personal computer. In the test group, the same measurements were taken using the stabilometer with and without dentures.

Comparisons between test and control groups were made using the Mann-Whitney *U* test with the aid of SPSS 15.0 J for Windows (SPSS). The Wilcoxon signed ranks test was used to compare performances in the test group with and without dentures.

Results

The test and control groups each included 12 male and 23 female subjects. Mean age, BMI, and AMC for each group are shown in Table 1. Physical function, as measured by the hand grip and leg extensor tests, was not significantly different when comparing the two groups (Table 1). However, body balance ability, measured by time spent standing on one leg with the eyes open and functional reach, was significantly reduced among members of the test group ($P < .05$) (Table 1).

The results of the stabilometer test showed that sway area was significantly greater in the test group when standing with the eyes closed ($P < .05$) (Table 2). Also, body sway reflected a significantly increased energy consumption in the same group under the same condition ($P < .05$) (Table 2). In the test group, denture wearing was not shown to have any correlation to postural stabilization (Table 3). A power analysis used to analyze the beta bias of the sample demonstrated that the power of these results was 60% to 70%.

Table 2 Results of Stabilometer Test for Test and Control Groups

	Test group	Control group	*P* value
Sway area (mm^2)			
Eyes open	8.0 ± 5.4	9.1 ± 14.7	.716
Eyes closed	11.0 ± 7.0	7.6 ± 5.3	.035*
Body sway (cm)			
Eyes open	40.8 ± 12.9	39.5 ± 13.8	.518
Eyes closed	57.5 ± 21.5	46.9 ± 15.0	.048*

*$P < .05$ (Mann-Whitney *U* test).

Table 3 Results of Stabilometer Test for Test Group With and Without Dentures

	With dentures	Without dentures	*P* value
Sway area (mm^2)			
Eyes open	8.0 ± 5.4	7.7 ± 5.5	.984
Eyes closed	11.0 ± 7.0	10.5 ± 7.4	.071
Body sway (cm)			
Eyes open	40.8 ± 12.9	41.2 ± 12.5	.829
Eyes closed	57.5 ± 21.5	53.6 ± 14.9	.072

Discussion

The results of this study demonstrate that tooth loss is a risk factor for postural instability among the elderly. Yamaga et al[14] showed that the condition of dental occlusion is associated with reduced lower extremity dynamic strength in elderly individuals and a reduction in the amount of time they are able to stand on one leg with their eyes open. The present study agreed with this finding that tooth loss decreases body balance ability by examining the results of a series of physical examinations.

Normally, when in an upright position, frequent small oscillations are generated to maintain balance. Sensorial afferents are provided from proprioceptive, tactile, vestibular, and visual receptors. Proprioception of the mandibular system arises from the masticatory muscular system and dentoalveolar ligaments.[15] It has been suggested that a more symmetric maxillomandibular position results in a more symmetric sternocleidomastoid muscle contraction pattern and less body sway.[16] Therefore, it follows that poor or nonexistent dental occlusion may decrease proprioception in this area, interfering with the stability of head posture. The removal of visual input leads to an increased difficulty in postural control and may emphasize the role of mandibular system proprioceptive sensation in body balance control. The results of the stabilometer test in this study confirmed this since the body balance ability of the test group was significantly decreased when their eyes were closed.

Proprioceptive sensation from the periodontal ligament receptor plays an important role in body balance control, shown by the fact that the results of the stabilometer test did not differ between the test groups when they were or were not wearing dentures. A study by Usumez et al[17] found no significant changes in head position 30 days after new complete dentures were inserted. On the other hand, another Japanese study reported that totally edentulous patients without dentures showed a significantly higher degree of postural swaying when compared to patients with dentures.[18] In that study, 19 of 35 subjects had lost all of their teeth and another 16 subjects had some teeth in one arch or the other (mean = 5.8 teeth). The difference in the results of these two studies may be because about half of the subjects in the test group had some teeth and functional periodontal ligaments, which would influence body balance.

Furthermore, dynamic body balance–associated functions, such as quickness or recovery action of the body, appeared to have deteriorated in the absence of dental occlusion.[19,20] In such conditions, muscle strength factors can be more important to balancing ability than static body balance, as examined in this study. An earlier report suggested that voluntary teeth clenching, in which the ankle extensors and flexors co-contract to fix the ankle joint, may contribute to the stabilization of postural stance.[21] However, these results were obtained from young, healthy volunteers. Further research will be needed to conclude similar results for an elderly population.

Conclusion

Within the limited conditions of this study, it can be concluded that natural occlusion, which involves the presence of periodontal ligaments, may play a role in generating an adequate postural reflex through mandibular stability. A longitudinal study with a large sample will be needed to confirm that complete occlusion is linked to a reduction in the number of falls. In any case, a dental examination is recommended for inclusion in the standard health examination for elderly persons.

Acknowledgment

This study was supported by a grant-in-aid from the Ministry of Health, Labour, and Welfare (H16-kenko-021).

References

1. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. N Engl J Med 1988;319:1701–1707.
2. Nevitt MC, Cummings SR, Kidd S, Black D. Risk factors for recurrent nonsyncopal falls. A prospective study. JAMA 1989;261:2663–2668.
3. Marks R, Allegrante JP, Ronald MacKenzine C, Lane JM. Hip fractures among the elderly: Causes, consequences and control. Aging Res Rev 2003;2:57–63.
4. Gillespie LD, Gillespie WJ, Robertson MC, Lamb SE, Cumming RG, Rowe BH. Interventions for preventing falls in elderly people. Cochrane Database Syst Rev 2001;3:CD000340.
5. Cabinet Office. Annual report on the aging society 2002. http://www8.cao.go.jp/kourei/english/annualreport/2002/02wp-e.html
6. van Dijk PT, Meulenberg OG, van de Sande HJ, Habbema JD. Falls in dementia patients. Gerontologist 1993;33:200–204.
7. Yoshida M, Morikawa H, Kanehisa Y, Taji T, Tsuga K, Akagawa Y. Functional dental occlusion may prevent falls in elderly individuals with dementia. J Am Geriatr Soc 2005;53:1631–1632.
8. Yoshida M, Morikawa H, Kanehisa Y, Yan Z, Taji T, Akagawa Y. Relationship between dental occlusion and falls among the elderly with dementia. Prosthodont Res Pract 2006;5:52–56.
9. Hellsing E, Hagberg C. Changes in maximum bite force related to extension of the head. Eur J Orthod 1990;12:148–153.
10. Makofsky HW, Sexton TR, Diamond DZ, Sexton MT. The effect of head posture on muscle contact position using T-scan system of occlusal analysis. Cranio 1991;9:316–321.
11. Gangloff P, Perrin PP. Unilateral trigeminal anaesthesia modifies postural control in human subjects. Neurosci Lett 2002;330:179–182.
12. Yesavage JA, Brink TL, Rose TL, et al. Development and validation of a geriatric depression screening scale: A preliminary report. J Psychiat Res 1982–1983;17:37–49.
13. Murray MP, Seireg A, Scholz RC. Center of gravity, center of pressure, and supportive forces during human activities. J Appl Physiol 1967;23:831–838.
14. Yamaga T, Yoshihara A, Ando Y, et al. Relationship between dental occlusion and physical fitness in an elderly population. J Gerontol A Biol Sci Med Sci 2002;57:616–620.
15. Gangloff P, Louis JP, Perrin PP. Dental occlusion modifies gaze and posture stabilization in human subjects. Neurosci Lett 2000;293:203–206.
16. Sforza C, Tartaglia GM, Solimene U, Morgun V, Kaspranskiy RR, Ferrario VF. Occlusion, sternocleidomastoid muscle activity, and body sway: A pilot study in male astronauts. Cranio 2006;24:43–49.
17. Usumez A, Usumez S, Orhan M. Effect of complete dentures on dynamic measurement of changing head position: A pilot study. J Prosthet Dent 2003;90:394–400.
18. Maruya M, Shimizu K, Onuma T, Koji T, Morita O. The effect of wearing denture and changes of occlusal position on body sway in edentulous patient [in Japanese]. J Jpn Prosthodont Soc 2000;44:781–785.
19. Ishijima T, Hirai T, Koshino H, Konishi Y, Yokoyama Y. The relationship between occlusal support and physical exercise ability. J Oral Rehabil 1998;25:468–471.
20. Hosoda M, Masuda T, Isozaki K, et al. Effect of occlusion status on the time required for initiation of recovery in response to external disturbances in the standing position. Clin Biomech 2007;22:369–373.
21. Takada Y, Miyahara T, Tanaka T, Ohyama T, Nakamura Y. Modulation of H reflex of pretibial muscles and reciprocal Ia inhibition of soleus muscle during voluntary teeth clenching in humans. J Neurophysiol 2000;83:2063–2070.

Literature Abstract

Retrospective analysis of 56 edentulous dental arches restored with 344 single-stage implants using an immediate loading fixed provisional protocol: Statistical predictors of implant failure

The purpose of this retrospective study was to analyze the factors that are most likely to predict a negative outcome for the use of immediately loaded, provisional full-arch fixed prostheses supported by multiple single-stage implants. Over a period of 8 years, the author has restored 56 consecutive fully edentulous patients with same-day cross-stabilized acrylic resin-fixed provisional restorations supported by multiple single-stage implants. The cases were finally restored with metal ceramic fixed prostheses and monitored for 2 to 10 years after placement and potential risk factors were evaluated. These included smoking, grafted bone, anterior vs. posterior placement, maxilla or mandible, number of implants per arch (4 to 10), length (6, 8, 10, 12, 14, and 16 mm) and diameter of implants (3.3, 4.1, and 4.8 mm), age, gender, implant surface (SLA vs. TPS), and type of tissue retraction techniques (be it tissue punch or full-thickness flap reflection). Patients were deemed to be failures if they had at least one implant failure but no criteria was given to assess failure. Univariate tests were made using Fisher exact tests and the Cochran Armitage test was used to analyze linear trends. Logistic regression modeling was also used to determine predictive factors. The results initially showed that smoking, grafted recipient sites, and maxillary bone were predictors of high failure. However, logistic regression showed that only implant length emerged as statistically significant and short implants (ie, 6 mm), was shown to be a predictor of failure.

Kinsel R, Liss M. *Int J Oral Maxillofac Implants* 2007;22:823-830. **References:** 24. **Reprints:** Dr Richard Kinsel, Department of Restorative Dentistry, University of California, San Francisco, 1291 E Hillsdale Blvd Suite 143, Foster City, CA 94404. Fax: 650 573 8280.—*Y. L. Seetoh, Singapore*