A Prospective Randomized Clinical Study Comparing Implant-Supported Fixed Prostheses and Overdentures in the Edentulous Mandible: Prosthodontic Production Time and Costs

Sigvard Palmqvist, LDS, Odont Dr/PhD[a]/Bengt Öwall, LDS, Odont Dr/PhD, Dr Med H C[b]/Sören Schou, LDS, PhD[c]

Purpose: This work compared implant-supported fixed prostheses and overdentures in the edentulous mandible in a randomized prospective study of treatment results, clinical working hours, laboratory working hours, and laboratory costs including materials.
Materials and Methods: Seventeen subjects agreed to participate. Three standard Brånemark implants were placed between the mental foramina in each patient. After the connection of standard abutments, subjects were randomly assigned to the fixed prosthesis group (n = 11) or overdenture group (n = 6). Subjects in the fixed group were provided with prostheses according to the All-in-One concept. Subjects in the overdenture group received a conventional denture retained by a Dolder bar system.
Results: One implant was lost in the fixed prosthesis group after 1 year. A new implant was placed, and the prosthesis was refitted. Mean clinical working hours were 3.1 in the fixed prosthesis group and 4.1 in the overdenture group. Mean laboratory working hours were 12.5 in the fixed prosthesis group and 7.7 in the overdenture group. Total laboratory costs, including materials, were on average about US$1,700 for the fixed prosthesis and US$1,350 for the overdenture. ***Conclusion:*** A fixed implant-supported prosthesis in the edentulous mandible could be provided at about the same cost as an overdenture using the method described. Provided that the early survival results prove to be long lasting, the choice between a fixed and a removable prosthesis need not be a matter of economy. *Int J Prosthodont 2004;17:231–235.*

Treatment strategies differ between countries and areas regarding the choice of a fixed prosthesis or an overdenture when restoring the edentulous mandible by means of oral implants.[1–3] The original Brånemark protocol focused on the fixed prosthesis. This type of prosthesis is still used for the great majority of edentulous patients treated with implants in Sweden.[3,4] In Central Europe, the overdenture concept has predominated.[2,5]

Many factors are involved in prosthodontic treatment decision making.[6] The choice between a fixed prosthesis and an overdenture supported by implants in the edentulous mandible is influenced by treatment traditions, treatment results, treatment costs, patient economy, insurance systems, national regulations, etc. Unlike the maxilla, there is in the mandible no significant difference in survival rate for implants supporting either a fixed prosthesis or an overdenture.[7–9] Some long-term denture wearers even seem to prefer the overdenture solution.[10] Only with a fixed implant-supported prosthesis, however, has it been shown that patients psychologically experience the prosthesis as part of their own body.[11]

Financial considerations are probably the most common reason for choosing the overdenture option. In many countries, the fees for fixed restorations compared to removable ones seem to be higher than they need to be if based strictly on clinical and laboratory working hours and material costs. This makes fixed restorations comparably more expensive and limits the choice of an alternative to the overdenture. In Sweden, on the other hand, the general dental insurance system has had the opposite effect because of its so-called

[a]*Professor Emeritus, Department of Prosthetic Dentistry, School of Dentistry, University of Copenhagen.*
[b]*Professor and Chair, Department of Prosthetic Dentistry, School of Dentistry, University of Copenhagen.*
[c]*Departments of Oral and Maxillofacial Surgery, University of Copenhagen and Aalborg University Hospital.*

Correspondence to: *Dr Bengt Öwall, Department of Prosthetic Dentistry, Faculty of Health Sciences, University of Copenhagen, 20 Nørre Allé, Dk 2200 Copenhagen N, Denmark. Fax: + 45 35 32 69 39. e-mail: Bum@odont.ku .dk*

"high cost protection."[12] The influence of different dental insurance systems in countries with a similar standard of living has been shown to be significant for both dental treatment and dental status.[13]

In the past, the higher cost for a fixed prosthesis compared to an overdenture also resulted from the use of six implants to support a fixed prosthesis in the mandible instead of two to three implants for an overdenture. However, within the last decade, convincing long-term results indicate that four implants are sufficient to support a fixed prosthesis, at least in the mandible.[14,15] There are also promising short-term results with only three implants supporting a fixed prosthesis.[16,17] A reduced number of implants, together with less-expensive and simpler superstructure techniques,[18–21] lowers the cost of a fixed prosthesis considerably, thereby making the choice between a fixed and removable prosthesis less dependent on economy.

Regardless of the initial costs, the supplementary costs for maintenance must also be considered. In some patient materials, the maintenance costs for an overdenture seem to be higher than for a fixed prosthesis.[2,22–24] For the maxilla, the question of whether there is an economic indication for choosing an overdenture arose several years ago, taking into account not only the initial cost but also the maintenance cost.[25]

Against this background, it seemed reasonable to compare the two implant treatment options, fixed prosthesis or overdenture, in a randomized prospective study of subjects with edentulous mandibles. The aim of the present article was to present early results from the study, including working hours and laboratory costs.

Materials and Methods

Healthy subjects up to 70 years of age and edentulous in the mandible were invited to participate in a prospective randomized study, where they randomly received either a fixed prosthesis or an overdenture supported by three implants. The dental status in the maxilla was either a complete denture or a removable partial denture anchored to a few remaining teeth. In the mandible, sufficient bone quantity was required to permit placing three 13-mm or longer implants between the mental foramina. Subjects who were included in the study had to sign an agreement in which they agreed to be provided with either a fixed prosthesis or an overdenture by lot.

All surgery was performed by one of the authors. Three standard Brånemark implants (Nobel Biocare) were placed in the edentulous mandible, two distally as close to the mental foramina as possible and one mesially in either first incisor region. The implants were allowed to heal covered by soft tissue for 3 months. During this period, the patient wore a complete mandibular denture relined with a soft material. After the healing period, standard Brånemark abutments were connected to the implants.

After abutment connection, patients were randomly assigned to either the fixed prosthesis group (n = 11) or overdenture group (n = 6). Patients in the fixed group were treated according to the All-in-One concept (Nobel Biocare), using a computer-numeric controlled (CNC)–milled titanium framework and acrylic resin denture teeth.[20,21] The extension of the fixed prosthesis was from first molar to first molar. Patients in the overdenture group received a conventional mandibular denture retained by four clips to Dolder-type bars uniting the implants and with bilateral extensions. All prosthodontic treatment was performed by one of the authors, who had about 25 years of experience in implant treatment. The laboratory procedures were performed by experienced dental technicians at the same dental laboratory throughout the study.

The clinical time used to complete the prosthetic treatment, including any postinsertion corrections, was recorded for each patient. The time used for laboratory procedures was also recorded for each patient, together with material costs. The bills from the laboratory were based strictly on working hours and material costs. The costs included bills from the special laboratory that made the CNC-milled frameworks but not the working time for the technicians involved in the milling procedure.

After completion of the prosthodontic treatment, radiographs were made to record the initial marginal bone height after treatment. Follow-up examinations were, according to the test protocol, to be performed yearly. Patients will receive hygienic support at least twice a year from a dental hygienist. Control radiographs are scheduled to be made at the 1-, 3-, and 5-year examinations. The time for supplementary prosthodontic treatment in the mandible will be recorded, as well as any additional laboratory time and material costs used when such procedures become necessary. Treatment time and laboratory expenses were recorded for the mandible only.

All but one of the eleven patients in the fixed prosthesis group have passed the 1-year examination; four of them have also reached the 2-year examination. Two of the six patients in the overdenture group have passed the 2-year examination; the other four subjects have not yet passed the 1-year examination.

Results

The mean number of clinical working hours was higher in the overdenture group compared to the fixed prosthesis group. On the other hand, more laboratory

working hours were used in the fixed prosthesis group compared to the overdenture group.

The mean sum of money billed by the laboratory, based on the number of working hours and material costs, was about 25% higher in the fixed prosthesis group compared to the overdenture group (Table 1).

Of 51 implants placed, one was lost. At the 1-year examination, the radiographs showed a near complete loss of supporting bone around this distal implant. This implant was removed, and after 2 months a new implant was placed in the same region. This new implant was allowed to heal unloaded for 4 months. After the healing period, a new abutment was connected. The titanium framework was cut into two pieces and welded together after a new impression had been made. The denture teeth were then reattached to the framework to complete the repair. Subsequently, the same patient experienced marginal bone loss at the distal implant on the other side, necessitating surgical debridement of the defect. This loss of marginal bone support developed during the healing period after placement of the new implant, when the patient wore a removable denture adjusted to the other two implants. No noticeable reduction of marginal bone was diagnosed in the other patients at the radiographic follow-ups.

Table 1 Mean Clinical Working Hours for Prosthetic Treatment, Mean Laboratory Hours to Produce Prostheses, and Mean Amount Billed by Laboratory

	Fixed prosthesis group (n = 11)	Overdenture group (n = 6)
Clinical hours used by prosthodontist	3.1	4.1
Hours used by dental technicians	12.5	7.7
Sum billed by dental laboratory*	1,700	1,350

*Approximately converted to US$.

Discussion

Originally, it was planned to include 15 patients in each treatment group. However, there were great difficulties in recruiting patients to this randomized clinical trial, in spite of the fact that the treatment fees were heavily subsidized. In principle, the patients had to pay only the laboratory costs. One common reason for subjects' unwillingness to participate was that they could not decide in advance on the type of prosthodontic treatment they would receive. Several candidates could not accept the removable alternative.

The early results were promising, even though one implant was lost in the fixed prosthesis group. The reason for this loss cannot be established, but it is interesting to note the marginal bone loss around another implant in the same patient that developed during the second healing period, when a fixed prosthesis was not worn. No general conclusion about the prognosis for implants supporting a fixed or a removable prosthesis can be drawn from this single patient.

Regarding clinical as well as laboratory working hours, there were no major differences between the groups. On average, patients in the overdenture group needed 1 clinical hour more than patients in the fixed prosthesis group. On the other hand, nearly 5 more hours were used by dental technicians per patient in the fixed prosthesis group. According to the dental laboratory, this difference was mostly due to the fact that the milled titanium frameworks needed about 3 hours of individual aftergrinding to obtain an esthetically acceptable result. The CNC-milling technique is now said to be more precise, thus lowering the number of working hours used for fixed prostheses according to the All-in-One technique. If so, the difference in laboratory costs for a fixed prosthesis and an overdenture will be minimal.

Similar laboratory expenses, together with the fact that the fixed prosthesis required less clinical treatment time than did the overdentures, make the total cost of the two alternatives about equal. This will allow a choice of prosthodontic alternative that is dependent on professional judgment and patient preference. If earlier results indicating high maintenance costs for overdentures[23–25] are also taken into consideration, the fixed prosthesis may be a less-expensive alternative in the long run.

The result of the present study is certainly not in agreement with the conclusions of another recent study that advocates the overdenture as the most cost-effective solution in the edentulous mandible.[26] However, that study was retrospective on nonrandomized patients. The clinical working hours used in the calculations were not recorded individually. The number of implants used for the fixed prostheses were much higher than for the overdentures (only two). Like in an earlier study,[27] the frequency of screw and framework fractures was unreasonably high in the fixed prosthesis group. Furthermore, and most important, no comparison was made between the laboratory hours used for the fixed prostheses and the overdentures. Instead, the ordinary fees billed by the laboratories were used in the comparison between the treatment alternatives. The authors of the present article hold the view that in many countries the laboratory fees are relatively too high for fixed prostheses compared to those for removable prostheses and are not based on time studies. In the present study, the differences in laboratory hours

were fairly small between the fixed prosthesis and overdenture groups.

It is too early to draw any conclusions about the long-term results with fixed prostheses on only three implants in the edentulous mandible. This is true for the results of both the present study and others.[15–17,21] However, there seem to be reasonable grounds to believe that no major difference exists between the fixed and removable alternatives in relation to biologic risks. The conclusion from a recent consensus meeting on overdenture treatment,[28] that an overdenture should be the first choice for implant treatment in the edentulous mandible, is not in accordance with the results of the present study or of other studies.[15–17,21]

When comparing the treatment costs for a fixed prosthesis and an overdenture, as in the present study, it can be argued that the overdenture could be made cheaper by using only two implants. This will, however, make only a small difference in prosthodontic costs. Regarding treatment results, there are reports that overdentures on two implants in the mandible, contrary to fixed prostheses, will cause continuous bone resorption in the posterior parts of the mandible[29] and also some indications of increased bone resorption in the maxilla, if the patient is wearing a maxillary complete denture.[30,31] A literature review of possible causative factors behind this so-called "combination syndrome" indicates that a fixed prosthesis in the mandible is biologically favorable.[32]

Conclusion

The economic comparison of fixed and removable alternatives in this study relates to the rather simple and inexpensive prosthodontic techniques described: overdentures without a cast framework, fixed prostheses with acrylic resin denture teeth. More expensive solutions, eg, gold and metal ceramics for the fixed prostheses, will of course result in larger differences in costs. The two techniques used in the present study can be considered to be of equivalent standard, and hence the fixed and removable alternatives are compared without introducing confounding economic factors. It is the intention of the authors to follow the patients for 5 years and also report about the patients' experiences of the prosthodontic solutions.

There is no rational reason why a fixed implant-supported prosthesis in the edentulous mandible per se should be much more expensive to the patient than an overdenture. The good initial results with only three implants supporting a fixed prosthesis in the edentulous mandible, together with the simplified laboratory techniques, may eliminate cost as a reason for not choosing a fixed or removable implant-supported prosthesis in the edentulous mandible.

Acknowledgments

The implant components were provided free of charge by Nobel Biocare, Denmark. Special thanks are due to Chief Dental Technician John Bak and his staff at the PTL Laboratory, Silkeborg, Denmark.

References

1. Schepers E, Naert I, Theuniers G. Overdentures on Oral Implants. Leuven, Belgium: Leuven University, 1989.
2. Mericske-Stern R. Treatment concepts of the edentulous jaw. In: Lang NP, Karring T, Lindhe J (eds). Proceedings of the Third European Workshop on Periodontology. Implant Dentistry. Berlin: Quintessence, 1999.
3. Kronström M, Carlsson GE. Use of implant overdentures in edentulous mandibles. A survey of treatment policy in prosthodontic specialist clinics in Sweden. Swed Dent J 2003;27:59–66.
4. Brånemark P-I, Hansson B-O, Adell R, et al. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. Scand J Plast Reconstr Surg Suppl 1977;16:1–132.
5. Mericske-Stern R. Treatment outcomes with implant-supported overdentures: Clinical considerations. J Prosthet Dent 1998;79:66–73.
6. Kronström M. Prosthodontics and the General Dentist. A Study of Practice Profiles and Prosthodontic Decision Making in Sweden [thesis]. Swed Dent J Suppl 1999;137:1–62.
7. Engquist B, Bergendal T, Kallus T, Lindén U. A retrospective multicenter evaluation of osseointegrated implants supporting overdentures. Int J Oral Maxillofac Implants 1988;3:129–134.
8. Jemt T, Chai J, Hernett J, et al. A 5-year prospective multicenter follow-up report on overdentures supported by osseointegrated implants. Int J Oral Maxillofac Implants 1996;11:291–298.
9. Bergendal T, Engquist B. Implant-supported overdentures: A longitudinal prospective study. Int J Oral Maxillofac Implants 1998;13: 253–262.
10. Feine JS, de Grandmont P, Boudries P, et al. Within subject comparisons of implant-supported mandibular prostheses: Choice of prosthesis. J Dent Res 1994;73:1105–1111.
11. Blomberg S, Lindquist LW. Psychological reactions to edentulousness and treatment with jawbone-anchored bridges. Acta Psychiatr Scand 1983;68:251–262.
12. The Dental Service Review Committee. Dental Care Until 2010. Report to the Swedish Government. SOU 2002:53 [English summary]. Stockholm: Fritzes, 2002.
13. Palmqvist S, Söderfeldt B, Vigild M. Influence of dental care systems on dental status. A comparison between two countries with different systems but similar living standards. Community Dent Health 2001;18:16–19.
14. Brånemark P-I, Svensson B, van Steenberghe D. Ten-year survival rates of fixed prostheses on four or six implants ad modum Brånemark in full edentulism. Clin Oral Implants Res 1995;6:227–231.
15. Eliasson A, Palmqvist S, Svensson B, Sondell K. Five-year results with fixed complete-arch mandibular prostheses supported by 4 implants. Int J Oral Maxillofac Implants 2000;15:505–510.
16. Brånemark P-I, Engstrand P, Öhrnell L-O, et al. Brånemark Novum: A new treatment concept for rehabilitation of the edentulous mandible. Preliminary results from a prospective clinical follow-up study. Clin Implant Dent Relat Res 1999;1:2–16.
17. De Bruyn H, Kisch J, Collaert B, Lindén U, Dvärsäter L. Fixed mandibular restorations on three early-loaded regular platform Brånemark implants. Clin Implant Dent Relat Res 2001;3:176–184.

18. Bergendal B, Palmqvist S. Laser-welded titanium frameworks for fixed prostheses supported by osseointegrated implants: A 2-year multicenter study report. Int J Oral Maxillofac Implants 1995;10: 199–206.
19. Bergendal B, Palmqvist S. Laser-welded titanium frameworks for implant-supported fixed prostheses: A 5-year report. Int J Oral Maxillofac Implants 1999;14:69–71.
20. Jemt T, Bäck T, Petersson A. Precision of CNC-milled titanium frameworks for implant treatment in the edentulous jaw. Int J Prosthodont 1999;12:209–215.
21. Örtorp A, Jemt T. Clinical experience of CNC-milled titanium frameworks supported by implants in the edentulous jaw: A 3-year interim report. Clin Implant Dent Relat Res 2002;4:104–109.
22. Walton JN, MacEntee MI. Problems with prostheses on implants: A retrospective study. J Prosthet Dent 1994;71:283–288.
23. Den Dunnen ACL, Slagter AP, de Baat C, Kalk W. Professional hygiene care, adjustments and complications of mandibular implant-retained overdentures: A three-year retrospective study. J Prosthet Dent 1997;78:387–390.
24. Chaffee NR, Felton DA, Cooper LT, Palmqvist U, Smith R. Prosthetic complications in an implant-retained mandibular overdenture population: Initial analysis of a prospective study. J Prosthet Dent 2002; 87:40–44.
25. Jemt T, Book K, Lindén B, Urde G. Failures and complications in 92 consecutively inserted overdentures supported by Brånemark implants in severely resorbed edentulous maxillae: A study from prosthetic treatment to first annual check-up. Int J Oral Maxillofac Implants 1992;7:162–167.
26. Attard NJ, Wei X, Laporte A, Zarb GA, Ungar WJ. A cost minimization analysis of implant treatment in mandibular edentulous patients. Int J Prosthodont 2003;16:271–276.
27. Zarb GA, Schmitt A. The longitudinal clinical effectiveness of osseointegrated dental implants: The Toronto study. Part III: Problems and complications encountered. J Prosthet Dent 1990;64:185–194.
28. Feine JS, Carlsson GE, Awad MA, et al. The McGill consensus statement on overdentures. Int J Prosthodont 2002;15:413–414.
29. Wright PS, Glantz P-O, Randow K, Watson RM. The effects of fixed and removable implant-stabilised prostheses on posterior mandibular residual ridge resorption. Clin Oral Implants Res 2002;13:169–174.
30. Lechner SK, Mammen A. Combination syndrome in relation to osseointegrated implant-supported overdentures: A survey. Int J Prosthodont 1996;9:58–64.
31. Gupta S, Lechner SK, Duckmanton NA. Maxillary changes under complete dentures opposing mandibular implant-supported fixed prostheses. Int J Prosthodont 1999;12:492–497.
32. Palmqvist S, Carlsson GE, Öwall B. The combination syndrome. A literature review. J Prosthet Dent 2003;90:270–275.

Literature Abstract

Peri-implant bone alterations in relation to inter-unit distance.

This retrospective study evaluated the longitudinal alteration in radiographic bone topography at proximal sites of three-unit implant-supported fixed partial prostheses during the first 3 years after insertion in relation to vertical and horizontal interunit distances. The 28 subjects were partially dentate and had received prostheses supported by three implants in the posterior areas of the jaw; 35 screw-retained prostheses on Brånemark standard implants were included. Intraoral radiographs using a standardized, parallel technique at prosthesis insertion and 1- and 3-year follow-ups were obtained. One examiner assessed the radiographs for implant position, contact point level, bone level at implants and adjacent tooth, and midproximal bone crest level. Data were analyzed with respect to two proximal units: tooth-implant (n = 35) and implant-implant (n = 70). At the tooth-implant units, mean bone loss over the 3 years was 0.5 mm at the implant and 0.4 mm at the tooth. No explanatory factor was identified for the peri-implant/periodontal bone changes at the tooth-implant units. At the implant-implant units, peri-implant bone loss was 0.6 to 0.7 mm and was significantly influenced by the vertical interimplant distance, difference in bone level at baseline between two neighboring implants, and bone level changes at the opposing implant surface. The magnitude of apical displacement of the interimplant bone crest level during the follow-up was negatively associated with horizontal interimplant distance. Both vertical and horizontal differences in implant position might influence bone alterations in the interimplant area during the first 3 years of loading; data failed to show corresponding relationships for bone changes at the proximal area between the implant and neighboring tooth.

Cardaropoli G, Wennström JL, Lekholm U. *Clin Oral Implants Res* 2003;14:430–436. **References:** 22.
Reprints: Dr Giuseppe Cardaropoli, Department of Periodontology, The Sahlgrenska Academy at Göteborg University, Box 450, 40530 Göteborg, Sweden. Fax: (46) 31 7733189. e-mail: Giusseppe.Cardaropoli@odontologi.gu.se—*Tee Khin Neo, Singapore*