Implant Prosthodontic Management of Anterior Partial Edentulism: Long-Term Follow-Up of a Prospective Study

(Traitement par prothèse sur implant de l'édentement antérieur partiel : suivi à long terme d'une étude prospective)

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Sommaire

Objectif : *Cet article rend compte des résultats à long terme obtenus chez des patients souffrant d'édentement partiel de classe IV de Kennedy, traités à l'Unité de dentisterie prothétique (UDP) à l'Université de Toronto (Ontario).*

Méthodes : *L'information nécessaire à cet article a été recueillie à partir des dossiers des 30 premiers patients consécutifs partiellement édentés traités à l'UDP. Tous ces patients souffraient d'édentement de classe IV et faisaient partie des premières études cliniques prospectives entamées en 1983. Les antécédents dentaires des patients suggéraient des expériences inadaptées avec des prothèses amovibles traditionnelles ou une hésitation à ce que des dents intactes ou presque soient préparées pour servir de rétenteur pour les prothèses fixes. Quinze hommes et 15 femmes, traités avec 94 implants dentaires Brånemark, supportant 34 prothèses, ont été suivis jusqu'au mois de juin 2000 (25 patients) ou jusqu'à ce qu'on ne puisse plus les trouver pour faire un suivi (5 patients). Les multiples dents manquantes se trouvaient dans 19 maxillaires et 15 mandibules.*

Résultats : *Les premiers traitements de dentisterie prothétique devaient réussir dans 33 prothèses fixes partielles et dans 1 prothèse hybride. Au moment de ce rapport, 25 patients avec 86 implants supportant 31 prothèses fixes et 3 prothèses hybrides avaient été suivis pendant une moyenne de 12 ans (les périodes de suivis allaient de 7 à 16 ans). La survie globale des implants était de 92 %. La différence entre les hommes (94 %) et les femmes (89 %) n'avait pas d'importance d'un point de vue statistique.*

Conclusions : *Ce rapport est une mise à jour provisoire sur une étude prospective à long terme en cours. Jusqu'à maintenant, les résultats ont démontré un taux de survie élevée pour les implants Brånemark supportant les prothèses ostéo-intégrées pour le traitement de l'édentement antérieur partiel.*

Mots clés MeSH : *dental implants; denture, partial, fixed; jaw, edentulous, partially/surgery*

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Loss of anterior teeth is a compelling reason for prosthodontic treatment. Kennedy Class IV partial edentulism is a frequent result of traumatic incidents, certain congenital anomalies and dental disease. It poses a unique challenge for the dental profession and has been managed with short-span adhesive prostheses, as well as fixed or removable partial dentures. All of these methods, when suitably selected and prescribed, have yielded good results. However, their inherent invasiveness has been documented to compromise oral ecology, with unpredictable consequences, including the need for frequent dental interventions.

Osseointegrated implant-supported prostheses were originally prescribed for edentulous patients and introduced to North American clinical educators in 1982.[1] This biotechnological breakthrough ushered in 3 important developments in prosthodontic treatment:

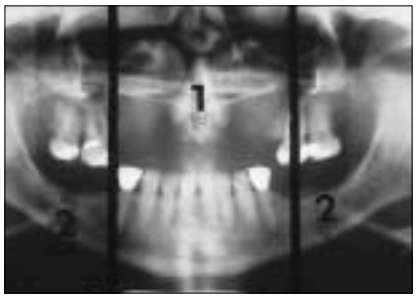

Figure 1: *Panoramic view of a partially edentulous patient illustrates the demarcation between anterior and posterior zones, with their implicit bone quality/quantity considerations and anatomic landmarks. The proposed demarcation between the anterior and posterior zones (zones 1 and 2, respectively) is a vertical line through the mental foramina.[7] This particular image shows Class IV maxillary and Class I mandibular partial edentulism.*

Figure 2a: ***Figs. 2a, 2b*** *and* ***2c*** *are 3 examples of maxillary partial edentulism demonstrating the various extents of hard- and soft-tissue deficits. The greater the deficit, the greater the residual ridge reduction and the likely need for a labial flange replacement to ensure an optimal esthetic result. Surgical augmentation of such sites is controversial, and evidence for its long-term outcome is lacking.*

Figure 2b: *A potential challenge in managing this case is the limited vertical space due to the overerupted mandibular incisors.*

Figure 2c: *Extensive residual ridge resorption in the mandible necessitates the use of a labial flange.*

- potential for stable and electively fixed prostheses
- retardation in resorption of the residual ridge
- minimal risk of preprosthetic surgical morbidity.

It also offered scope to expand the management of edentulism to encompass partial edentulism as well as complete edentulism. The Implant Prosthodontic Unit (IPU) at the University of Toronto, Toronto, Ontario, was the first North American teaching and research institution to undertake such an initiative. This paper reports on the long-term outcome of the first group of consecutively treated patients with Class IV partial edentulism treated at the IPU.

Materials and Methods

Data were gathered from the charts of the first 30 consecutive partially edentulous patients treated at the IPU. These patients with Class IV edentulism formed part of the original prospective clinical studies initiated in 1983. The inclusion criteria for patient selection were as follows: demonstrated maladaptive experience or unwillingness to have abutment teeth prepared for crowns, ability to undergo a minor oral surgical procedure, bony dimensions capable of accommodating a Brånemark implant of at least 3.75 x 10 mm, no history of substance abuse and realistic expectations regarding esthetic results.[2,3] All of the subjects for this study presented with teeth missing from zone 1 and with natural tooth support in zone 2, that is, bilateral posterior centric stops were present (Figs. 1 and 2a, 2b and 2c).

The dental history of these patients suggested maladaptive experiences with traditional removable prostheses or a reluctance to have intact or quasi-intact teeth prepared as retainers for fixed prostheses. The first patients underwent preprosthetic surgery in the fall of 1984. All patients had adequate vertical space to accommodate the required implant prosthodontic components, and the occlusal scheme could be designed such that anticipated functional and parafunctional loading would be supported by both implants and natural teeth. The most common cause of edentulism was trauma, which resulted in both loss of teeth and deficits in the supporting tissues. Other causes of tooth loss in this patient group were caries, periodontal disease and congenital malformation. Four patients had teeth missing in both arches.

The edentulous spans were imaged with periapical, panoramic, anterior occlusal and cephalometric radiography. A 2-stage surgical protocol was prescribed for all patients.[4] The abutment connection was placed after a healing period of 4 months for mandibular implants or 6 months or longer for maxillary implants, depending on bone quality. The prostheses were designed with or without labial acrylic resin flanges, depending on esthetic requirements. Initially, the surgical and prosthodontic procedures were carried out by IPU staff, but later, graduate residents performed the procedures under staff supervision. Annual recalls were prescribed but were not always followed by each patient. The protocol during recall appointments included removing the

Table 1 Criteria for optimal treatment outcomes for dental implants[6]

Resultant implant support does not preclude the placement of a planned functional and esthetic prosthesis that is satisfactory to both patient and dentist
No pain, discomfort, altered sensation or infection attributable to the implant
Immobility of individual unattached implants on clinical testing
Mean vertical bone loss less than 0.2 mm annually after the first year of function

Table 2 **Characteristics of 30 patients undergoing implant placement**

	Men	Women
No. of patients	15	15
Age at stage I surgery		
Mean	40.8	40.8
Range	18.9–56.4	19.0–61.6
Implant placement		
Maxilla	9	10
Mandible	9	6

Table 3 **Impact of implant failure on prosthodontic outcomes for the 30 initial patients (total of 94 implants)**

"Sleepers"	Implants lost	Original prosthesis design	Final prostheses design still in function
1	Early 4	33 fixed	31 fixed
	Late 3	1 overdenture	3 overdentures

prosthesis, checking for component integrity and tightness, periapical imaging of individual implants with a specially designed film holder, and maintaining and reinforcing hygiene measures. Throughout the IPU clinical studies, the criteria for treatment outcome were those originally proposed by Albrektsson and others.[5] These criteria subsequently evolved into the ones currently in use[6] (see Table 1).

Thirty patients treated with 94 Brånemark dental implants (Nobel Biocare AB, Gothenburg, Sweden), supporting 34 prostheses, were followed after prosthetic insertion and loading until June 2000. The multiple missing teeth occurred in 19 maxillae and 15 mandibles. Table 2 presents the general patient characteristics and locations of the prostheses. The mean period of edentulism before preprosthetic surgery was 9.3 years (range 1–30 years). Of the 30 patients, follow-up was incomplete for 5 patients, 3 of whom died and 2 of whom moved. The implants were of the regular platform variety (3.75 mm) but differed in length as dictated by quantity of bone at the host site.

A Microsoft Excel template was designed for the purpose of this review. The collected data were then transferred to a Statistical Package for the Social Sciences worksheet (SPSS Inc., Chicago, IL) for statistical analysis. A wide range of variables related to both the patient and the implant (bone quality and quantity, opposing dentition, period of edentulism, implant length, smoking history and existing medical condition[7]) were examined. Life-table analysis was generated for determining overall implant survival. Statistical significance was defined as $p = 0.5$.

Results

The original prosthodontic prescriptions were for 33 fixed partial prostheses and one overdenture. The unfavourable placement of one mandibular implant precluded its use as an abutment, and this implant was classified as a "sleeper." In 2 patients, 4 implants failed to osseointegrate before abutment connection and were described as early losses. Three implants (in 2 patients) met the success criteria at stage 2 surgery but were lost within the first year after completion of the prostheses and occlusal loading; these were characterized as late losses. Late implant loss made it necessary to give the patients partial overdentures (Table 3). For the 5 patients lost to follow-up, outcome had been recorded as successful at the most recent recall visit, and the patients had worn the prostheses for periods ranging from 3 to 8 years. At the time of writing, the remaining 25 patients had been followed for an average of 12 years (range 7–16 years).

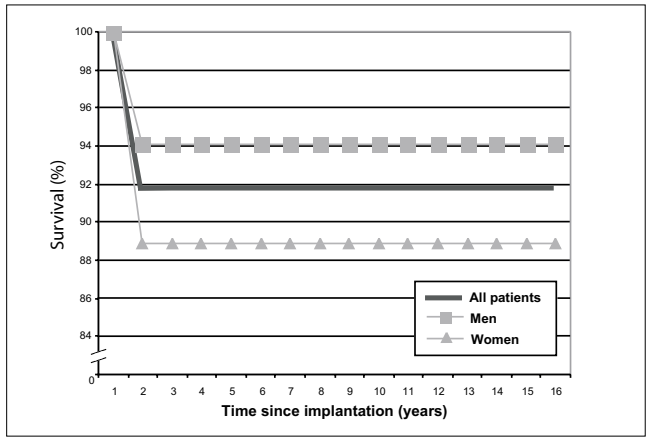

Figure 3: *Overall survival of dental implants in 30 consecutive patients with anterior partial edentulism treated in the Implant Prosthodontic Unit at the University of Toronto. Time zero is the time of stage 1 surgery. There was no difference between men and women (Wilcoxon test,* p = *0.399).*

Figure 3 represents a life-table analysis of implant survival. The overall survival of implants placed in zone 1 was 92%. The difference in implant survival between men (94%) and women (89%) was not significantly different ($p = 0.399$).

Discussion

This paper is an update on the outcome of the first 30 consecutively treated Class IV partially edentulous patients treated at the IPU at the University of Toronto. The decision to begin treating anterior maxillary and mandibular partially edentulous zones was the logical "next stage" in the development and testing of the osseointegration technique (Figs. 4a and 4b). The traditional learning curve had plateaued since the inception of the IPU's studies of edentulous patients in 1978. Consequently, optimized selection judgement and surgical skill were expected to yield predictably favourable results. This expectation was reinforced by the shared occlusal loading implicit in Class IV restorations, given the presence of bilateral centric stops in the natural or restored posterior segments in this patient population. Beyron's objectives of occlusion were satisfied[8] (i.e., bilateral centric occlusal contacts on natural teeth were almost always present), which reduced the risk of occlusal overload on the tissue-integrated prostheses.

Figure 4a: *Experience with traditional implant placement in anterior edentulous zones provided an evolving surgical and prosthodontic modus operandi for managing "smaller" interventions of the Class IV variety.* ***Figs. 4a*** *and* ***4b*** *illustrate some of the clinical stages in a patient with large edentulous spans and limited bilateral molar support.*

Figure 4b: *These pictures highlight some of the laboratory and clinical stages involved in implant prosthodontic Class IV edentulism.*

Figure 5a: *Mandibular Class IV partial edentulism, with obvious deficits in tooth and bone support.*

Figure 5b: *The favourable smile line facilitates achievement of an optimal esthetic result, which is dictated exclusively by pontic selection. The presence or absence of a labial flange becomes a consideration for optimal esthetic outcome in this case.*

Figure 5c: *The occlusal intraoral view reveals a 4-unit, 2-implant fixed prosthesis. The pontic arch form is labial to the residual ridge, as evidenced by prosthetic teeth position and screw locations.*

Figure 6: *Four-unit, 3-implant fixed prosthesis in a patient with maxillary Class IV partial edentulism. The loss of some posterior teeth due to periodontal disease resulted in a shortened dental arch.*

If the selected incisal guidance required anterior tooth contact, light contacts were generated and tested with articulating paper and shim stock. Prosthetic changes related to tooth wear were evaluated visually at annual clinical recall appointments. The number of arches treated and the diversity of occlusal conditions encountered did not allow any conclusions about the specific load-bearing potential of the implants. However, it is not unreasonable to suggest that a limited osseointegrated area of abutment support offers much scope for fixed prosthesis design, given the dentist's ability to organize the occlusion to ensure a reduced or optimally distributed implant load.[7]

The major challenge in treating these patients was the need to reconcile morphologic dictates, esthetic objectives and the limited selection of implant hardware available at the time. Angulated and customized abutments had not yet been developed, whereas the minor but relevant esthetic inadequacies that were encountered could be easily resolved today. However, traditional prosthodontic ingenuity addressed these concerns successfully, as indicated by patients' subjective responses to traditional clinical questions about their overall satisfaction (Figs. 5 and 6). At their annual recall appointments, patients were offered the possibility of revising their prostheses to rectify any concerns that had arisen as a result of earlier limitations in the availability of implant prosthodontic hardware or choice of materials. For example, development of and improvements in metal ceramic technology gave the IPU staff excellent design options for particular morphologic situations. However, a gingival analogue or labial flange was necessary in situations of moderate to advanced resorption of the residual ridge. Although some concerns have been expressed regarding the design of flanges and choice of tooth materials,[7] the observations reported here suggest that these considerations did not have a significant bearing on osseointegration outcome. The cumulative survival rate of the initial 94 Brånemark implants was 92% after 16 years, which compares favourably with the results reported by Lekholm and others[9] (92.6% after 10 years). The 4 implants that failed before stage 2 surgery suggest that the healing response was compromised in these patients. It might also have been affected by the quality and quantity of host bone and the patients' health status, use of medications and smoking history. Current and future publications continue to seek to correlate

implant failure with the previously mentioned and other variables. However, it was impossible to determine the cause of the 3 late failures. Many reports on Brånemark implants have strongly suggested that the infrequently encountered failures result from compromised healing response that cannot be detected at the time of stage 2 surgery but that become evident after loading.[9] This hypothesis places occlusal loading in the "straw that breaks the camel's back" category, albeit inadequate interfacial osteogenesis is required for the failure to occur.

The prosthetic designs available frequently made it difficult to maintain oral hygiene. Nonetheless, treatment outcome at all measurable levels did not support a correlation between bone integrity and patients' oral hygiene.[10] Marginal bone changes around the implants have not been reported in this survey. However, unpublished results reveal almost identical amounts of marginal bone resorption as recorded for completely edentulous patients whose implants were placed in similar host bone sites. It appears that the pathogenesis of implant failure is not identical with that occurring in periodontal disease, although a contributory microbiological role is probably inevitable. All prostheses met the success criteria established at the Toronto consensus conference in 1998,[6] including patient satisfaction.

In a recently published meta-analysis, Lindh and others[11] reported that the cumulative survival rate for implants in partially edentulous jaws, supporting fixed partial dentures (including restorations of single teeth), was over 90%. The meta-analysis reflected pooled results from 19 studies for which follow-up ranged from 1 to 8 years, with all but 2 studies reaching the 3- to 4-year interval. The authors concede that the small sample size used and the descriptive nature of the design employed demand caution in interpreting the results, although importance must be given to the length of follow-up of this study. These results appear to endorse and support the merits of implant-supported prostheses for anterior partial edentulism.

Conclusion

This report is an interim update on the long-term prospective study of implant prosthodontic management of Kennedy Class IV edentulism. It demonstrates that Brånemark implants have high survival rates. It appears that tissue-integrated prostheses continue to be an appropriate treatment option for the management of anterior partial edentulism. ◆

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