Economics

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Chapter 3 Costs of implant-retained mandibular overdentures

Summary

The effectiveness of dental implants is studied widely. Most of these studies examine clinical outcomes. However, from the policy makers' point of view other variables than safety and efficacy are vital in decision making, such as the costs and effectiveness of dental implants as compared to other alternatives. This paper compares the costs of different treatment strategies in a randomised clinical trial in patients with resorbed mandibles and persistent problems with their conventional dentures: treatment with a mandibular overdenture on permucosal dental implants, an overdenture on a transmandibular implant, a new set of dentures after preprosthetic surgery and a new set of dentures only

Cost data were gathered on an individual patient level to gain insight in specific cost episodes. Direct costs are identified, subdivided into the costs of labour, material, technique and overhead. Data about these components were gathered during the consecutive treatment phases in the first year. The results show that the resources used to treat a patient with an overdenture on a transmandibular implant are seven times as expensive as a complete new set of dentures. Comparison of the cost ratio of an implant-retained overdenture on permucosal implants and a regular new prosthesis proves less unfavourable: 1:3. A new set of dentures after preprosthetic surgery is almost as expensive as treatment with permucosal implants.

The presented chapter is partly based on the following paper:
Wijk, P. van der; Bouma, J.; Waas, M.A.J. van; Oort, R.P. van; Rutten, F.F.H. The cost of Dental Implants as Compared to That of Conventional Strategies. *International Journal of Oral and Maxillofacial Implants,* 13: 4, 546-553.

3.1 Introduction

The costs of the health care sector grew explosively in many Western societies during the eighties. Cost containment was, and still is, a dominant theme within the health care sector. Reliable information about the costs of alternative treatment strategies is therefore vital and will be presented here regarding the various options for treating edentulousness.

Dental implants were developed as an alternative to conventional dentures and their efficacy and effectiveness have been established during the last decade. The growing evidence of the effectiveness calls for research into costs and effects of this treatment. Many articles have been published about clinical aspects. The main criterium for clinical success seems survival[1-7] although other objective criteria such as the gingival index, the plaque index, pocket depth and the mobility of the implant are frequently described[1,8-11]. In a number of other publications the psychosocial effects of dental implants are mentioned[12-16]. Over all, these studies show considerable improvement in the psychological well-being of patients treated with dental implants. Only one article is known to assess costs[17].

The purpose of this study is to compare real costs of treatment with overdentures on dental implants with the costs of conventional strategies during the first year after treatment. Four possible treatment alternatives are included. Surgery for permucosal implants (**PI**) was performed under local anaesthesia. Two different, two phase implant systems were applied: the Brånemark system, a titanium screw-type cylinder, and the IMZ system, a titanium cylinder with titanium-plasma-spray coating. During the first step, the fixture installation, two fixtures were interforaminally inserted under local anaesthesia. The mean length of the fixture operation was 73 minutes. After this operation, the patient was seen twice for check-ups of 15 minutes. Patients were not allowed to wear the mandibular denture during the first two weeks. After initial woundhealing the denture was adjusted with a soft-liner and a soft diet was prescribed. The abutment connection took place after a healing period of three to six months. At that moment the titanium abutments were connected to the implants. The mean operating time of this second operation was 41 minutes, followed by one routine check of 15 minutes. For both systems an implant-tissue supported overdenture was used with a single-bar attachment.

Transmandibular implants (**TMI**) were placed under general anaesthesia. The implant was inserted extraorally[3]. Mean operating time, including the

impression for the superstructure, was 2 hours and 11 minutes. The superstructure was placed, consisting of a triple-bar construction with cantilever extensions. The patient was checked three times before the superstructure was placed (taking 60 minutes, in total). Preprosthetic surgery (**PPS**) took place under general anaesthesia. Thirty patients were treated surgically by interforaminal vestibuloplasty and deepening of the floor of the mouth. The operation itself lasted 1 hour and 30 minutes, two hours more were needed for diagnostics, checks and relining of the prosthesis.
The group of patients who received a new set of dentures did not have any surgery. In all groups the dentures were manufactured with an optimal fit and according to the balanced occlusion principle.

3.2 Material and methods

Patient selection

A randomised clinical trial was conducted at the Department of Oral and Maxillofacial Surgery and Maxillofacial Prosthodontics (University Hospital of Groningen) and the Department of Oral and Maxillofacial Surgery (University Hospital of Nijmegen). Treatment with implant-retained mandibular overdentures on two permucosal implants (Brånemark or IMZ) was compared with treatment with a mandibular overdenture on a transmandibular implant and with two conventional treatments with a new mandibular denture, one after preprosthetic surgery and one without. All patients received a new maxillary denture. In total 240 patients were randomly assigned to one of the above groups. For the economic evaluation two separate trials were put together in the ADIOS-group (Academic Dutch Overdenture Study). In Nijmegen three groups of 30 patients were treated with mandibular overdentures, overdentures on permucosal implants or with regular new dentures. All these patients had a maximum mandibular bone height of 14 mm. In Groningen a selection was made based on the mandibular bone height. For the group of patients with a mandibular bone height above 15 mm three treatment options were available: overdentures on permucosal implants, new dentures after preprosthetic surgery or regular new dentures. For the patients with a lower bone height (8-14 mm) preprosthetic surgery as in this group the obtainable increase of the denture bearing area would be insignificant[18], so for the group with lower jaws only two treatment options were available: overdentures on permucosal implants or regular new dentures. The whole concept, ordered by the National Health Insurance Council of the Netherlands, resulted in an uneven distribution of patients. Nevertheless, it had several advantages: similar treatment procedures were used and evaluated and a larger

research population was established.
Patients included in this study all had severely resorbed mandibles and persistent problems with their conventional set of dentures. They were referred to a University clinic by general practitioners. The criteria for inclusion were edentulousness in both jaws for at least twelve months, a mandibular bone height of 8 to 25 mm and no general contra-indications for implants or surgical procedures. All subjects were informed about different treatment options, possible risks and the method of treatment assignment. Written informed consent was required for participation in the trial. Treatment was assigned by means of a balancing procedure aiming for an equal distribution of patients over the treatment groups with regard to variables that may interfere with the outcome of the study[16,19]. This pre-treatment comparability was ensured by balancing all groups for age, gender, period of edentulousness in the mandible, age of the present mandibular denture and mandibular bone height. No significant differences were found on either one of these aspects. Table 1 shows the structure of the treatment groups and their most relevant characteristics.

Table 1: Patient characteristics at baseline

Treatment		Transmandibular implants	Permucosal surgery	Preprosthetic dentures	New set of dentures
		N = 30	N = 89	N = 28	N = 89
Age		53	55	53	57
Gender	M (%)	28	23	37	29
	F (%)	72	77	63	71
Number of years edentulous in lower jaw		21	22	20	23
Number of mandibular dentures		3,5	2,8	2,3	2,8
Mean age mandibular denture		6,4	7,2	8,2	6,9

Only the number of dentures in the lower jaw proved different in the various treatment groups (2-way-ANOVA).

Study design

In association with this clinical trial, we performed a cost analysis of all different treatment modalities. One important consideration should be kept in mind. It was possible for patients to refuse the allocated treatment. In nine cases this happened. For these patients the 'Intention to treat' principle was applied, implying that patients are evaluated in the originally allocated treatment group regardless of their actual treatment. However, for the cost

analysis this is of no importance, because people who are not treated do not generate any costs. The same principle holds for attriters: as long as they did not show up at the dental clinic, no treatment costs were made. If effects would have been taken into account exclusion of attriters would have been a probable source of bias.

The integral cost analysis is based on data about actual costs, and not data about fees. Fees are just a revenue for the provider and do in most cases not reveal actual costs. As we were interested in actual costs, and not in fees, the patients were followed through the treatment process during the first post-treatment year. Detailed hospital data were collected for each patient. Costs were subdivided into the costs of labour, equipment, technique and overhead during the different treatment phases: examination, fixture operation, abutment operation, prosthodontic treatment, controls and complications until one year after treatment. A procedure was used that compares with the Resource Based Relative Value Scale[20,21]. Cost components were divided in the total work of physicians' labour and practice expenses. A Conversion Factor was not used, because for all components actual costs were assessed completely, and not relatively to other medical procedures.

The cost of labour was based on a registration of treatment time at the individual patient level. Actual costs were then determined using gross salary of the dental staff. Costs of labour can be divided into surgical costs and prosthodontic costs. The estimation of labour costs included the duration of the treatment, but not the intensity.
Practice expenses were subdivided in cost of material, hospital costs and overhead costs. Costs of material includes the costs of the dental implants, the new set of dentures, the abutments, etc. All those different cost components were gathered on an individual patient level too. Further costs were accumulated on the hospital level, as a variety of diagnostic tests (blood tests, X-rays) was conducted on patients undergoing general anaesthesia: the TMI-group and the group of patients who received preprosthetic surgery (PPS). Information on whether or not the test was performed on individual patients was not always recorded. The costs of diagnostic tests were estimated from the treatment protocol. Other hospital costs were generated because patients who received a transmandibular implant or preprosthetic surgery had to stay in hospital for three days. Last, there are the cost of overheads. Each treatment makes use of the normal hospital facilities. These costs include: costs of reusable equipment, capital costs of the building and the inventory,

consumables, laundry services, cleaning, maintenance, electricity, administration, etc. An estimate of the cost of floor space was made by calculating the size of the dental department and multiplying it by the historical value of office and clinical space. All other costs (laundry, cleaning, maintenance) were approximated by using hospital expenditure for the different components within the total budget.

Statistical analyses

To make the results more comprehensive mean values are used in the tables. Differences in patient characteristics were tested by means of a two-way ANOVA with a significance-level of a= 0,05. For all cost data a 95%-confidence-interval was calculated based on the standard error of the mean of all groups. No differences in costs were found relating to bone height.

3.3 Results

Costs of surgical procedures

Table 2 shows the total time of each different profession within treatment and the resulting costs.

Table 2: Total treatment time and costs (in dollars) per treatment group

	Transmandibular implants		Permucosal implants		Preprosthetic surgery		Complete dentures	
	Hours	Costs	Hours	Costs	Hours	Costs	Hours	Costs
Dental surgeon	4 h 06	250	3 h 34	217	3 h 30	213	-	-
Nurses	6 h 22	174	6 h 07	136	3 h 00	82	-	-
Anaesthetist	2 h 41	163	-	-	0 h 30	30	-	-
Assistant anaesth.	-	-	-	-	1 h 30	64	-	-
Administrative	0 h 30	12	0 h 40	15	0 h 15	9	-	-
Prosthodontic procedure								
Prosthodontist	4 h 38	197	4 h 40	200	3 h 58	168	4 h 06	175
Assistent	4 h 38	100	4 h 40	102	3 h 58	84	4 h 06	87
Total		**896**		**670**		**650**		**272**
95%-confidence interval		[875-917]		[648-692]		[616-684]		[248-296]

Time invested by prosthodontist and assistant do not differ very much. In the implant groups more time is needed to construct to the superstructure and of course the operation time is higher. Especially for the transmandibular implant this leads to pronounced additional costs.

Costs of prosthodontic procedure

All groups had the prosthodontic treatment performed according to a standard procedure. The permucosal implant group started the prosthodontic treatment about three weeks after the second operation. The group of patients with a transmandibular implant had the superstructure placed within 24 hours of surgery and the new set of dentures were made two months later. The PPS-group was transferred to the prosthodontist one month after the vestibuloplasty. Patients who received a new set of dentures started their treatment at the prosthodontists. Mean treatment time for the production of a new set of dentures was calculated on individual patient level. Table 2 presents the results, including all check-ups until 6 weeks after treatment.

Other costs

All patient groups undergoing surgery had the costs of the usage of an operating room included. Table 3 shows the practice expenses for all treatment groups.

Table 3: Practice expenses per treatment group, in dollars

		Transmandibular implant	Permucosal implants	Preprosthetic surgery	Complete Dentures
Hospital costs					
Laboratory tests		75	-	75	-
X-ray		63	63	63	-
ECG		18	-	18	-
Hospital days		1,500[a]	-	1,500[a]	-
Operating room,	min.	469[b]			
	max.	1,594	434	469	-
Medication		12	12	12	-
Material costs					
Equipment		345	175	-	-
Implants		2,130	455	-	-
Prosthesis		1,475	1,220	570	575
Overhead		400	412	392	211
Total		**6,487-7,612**	**2,771**	**3,099**	**786**
95%-confidence interval		[6,387-7,712]	[2,669-2,873]	[3,038-,160]	[752-820]

[a] Average length of stay was three days in a university hospital

[b] Due to the insurance system in the Netherlands, part of the costs of the transmandibular implant are accounted for in the bill of the operating room. Nobody knows exactly what part. The minimum estimation reveals a situation in which the implant is paid largely out of this fee, the maximum estimation shows the cost of a very heavy operation and almost no payment for the implant itself.

For the operational procedures a standard package of diagnostic tests (including an ECG) was done. Patients under general anaesthesia (TMI and PPS) stayed in hospital for three days, costing $ 1,500,-. Medication consisted of antibiotics and analgesics. Material costs were divided into costs of equipment, implants and prosthesis. Different equipment and instruments are used for each treatment during the surgical and the prosthodontic procedure. The instrument case of the transmandibular implant was averagely used for the operation of 30 patients. The total costs of an instrument case with tray including an adjustable drill guide, the superstructure drill guide, several screw

drivers, drill sleeves, tap sleeves, fasteners and lock screws are about $ 6000, or $ 200 per patient. This does not include drills and taps ($ 145 if converted per patient). The usage of disposables for the permucosal implants is somewhat different for the Brånemark- and the IMZ-system. The Brånemark-system uses special disposables for implant patients. IMZ uses the regular machinery of a surgeon. However, the resulting differences in costs per patient were not dramatical (ca. $ 50 pp), so the average cost of both systems was used. Total costs of disposables were $ 175 per patient (drills, screw taps, screws and the capital costs of a control unit).
Other material costs represent mainly the costs of the implants itself, the costs of the abutments and the superstructure, and the costs of the dental prosthesis. Costs of overhead were accounted to the treatment groups on the basis of total treatment time. Table 3 provides an overview of the material and overhead costs per treatment group.

Costs during follow-up (until one year)
In some cases complications occurred which had great influence on the total cost per individual patient. The costs of follow-up in this study were calculated according to the number of visits to the dentist and to the average treatment time of those visits. Furthermore, costs of material and overhead were accounted for as described earlier. In table 4 the labour time of follow-up treatment is shown per treatment group. Both implant groups are significantly more expensive than the conventional treatments with respect to follow-up, due to visits to the dental surgeon and the dental hygienist. In total these costs mount up to more than $ 300,- for the first year, while people with a new denture cost less than $ 100,-.
During the first year the average time needed by the dentist for the implant groups was between 48 minutes (PI) and 67 (TMI) and between 50 (PI) and 35 (TMI) minutes with the dental hygienist. This time was needed for aftercare and maintenance of a proper oral condition.

Table 4: Time and costs of follow-up per treatment group in hours and dollars

	Transmandibular implant		Permucosal implants		Preprosthetic surgery		Complete dentures	
	Hours	Costs	Hours	Costs	Hours	Costs	Hours	Costs
Dental surgeon	0 h 50	55	0 h 40	33	0 h 10	11	-	-
Dentist	0 h 67	52	0 h 48	37	0 h 20	16	0 h 40	30
Dentist-assistent	0 h 67	30	0 h 48	22	0 h 20	9	0 h 40	17
Dental hygienist	0 h 35	19	0 h 50	29	-	-	-	-
Total labour	**-**	**156**	**-**	**121**	**-**	**36**	**-**	**47**
Material		68		119		13		19
Overhead		118		77		10		28
Total costs of follow-up		**342**		**317**		**59**		**94**

Total costs in the first year

The costs of each treatment strategy can be broken up into their components (table 5): labour, material and overhead.

Table 5: Total cost of treatment during the first year in dollars

	Transmandibular implant	Permucosal implants	Preprosthetic surgery	Complete dentures
Labour				
-Surgery	599	368	398	-
-Prosthodontics	297	302	252	262
-Check-ups	156	121	36	47
Practice expenses				
Materials				
-Implants	2,975	370	-	-
-Instruments	199	99	-	-
-Disposables	145	114	-	-
-Prosthesis	631	1,220	570	575
-Aftertreatment	68	119	13	19
Overhead				
-Treatment	400	412	392	211
-Aftertreatment	118	77	10	28
Hospital costs				
-Hospital stay	1,500	-	1,500	-
-Operating room	469-1,594 434	469	-	
-Diagnostic tests	168	75	168	63
Total costs	**7,605-8,830**	**3,711**	**3,808**	**1,205**
95%-confidence	7,494-8,951	3,644-3,858	3,712-3,894	1,170-1,240
Index	631-733	308	316	100

Table 5 is gives an aggregate of table 2,3, and 4. It shows that the total costs in the first year of treatment mount up to between $ 7.600 and $ 8.800 for an overdenture on a transmandibular implant. The total cost is 7 times as much as the costs of treatment with a new set of dentures. Treatment with an overdenture on permucosal implants or new dentures after vestibulum surgery are similar with respect to treatment costs. They cost almost 3.2 times as much as regular new dentures. The high costs of the transmandibular implant and the preprosthetic surgery result from an operation under general anaesthesia (hospital stay, diagnostic tests, operating room costs). Costs of aftercare were included for the first year. In these costs failures of new dentures were concluded.

Sensitivity analysis

The purpose of a sensitivity analysis is to test the validity of conclusions made over a range of reasonable values for the assumptions made in the base line analysis. In this sensitivity analysis we calculated the threshold-values at which the conclusions about the total costs would change. A summary of the sensitivity analysis and its relation to the main analysis is shown in table 6.

Table 6 Summary of the main analysis (average costs) and the sensitivity analysis (additional costs under various assumptions), all in dollars

	Transmandibular implant	Permucosal implants	Preprosthetic surgery	Complete dentures
Main analysis	8,216	3,748	3,776	1,179
Survival implants - 10%	822	375	0	0
Aftercare + 25%	86	79	15	24
Operating time + 25%	150	92	97	0
Material costs + 25%	1,006	482	145	148
Overhead costs + 25%	156	129	104	78
Hospital costs + 25%	665	158	534	16

The model is based on the costs for the first year. One of the most important assumptions for generalisation is the survival rate. If 100% of the implants in patients in the transmandibular and the permucosal treatment group would survive, the treatment costs would have been $ 7.394 and $ 3.363 respectively ($822 and $375 cheaper). The other costs components do not have a very important differentiating impact on total costs between groups, except material costs. If the costs of the dental equipment necessary to use dental implants

would decrease with 25%, total costs of the implant groups would decrease with $ 1.006 and $ 482. The annual figures do not change dramatically if one of the other estimates is varied.

3.4 Discussion

This paper has described in some detail the total treatment costs of a specific new technology: dental implants and overdenture treatment. Although not many articles on this particular subject have been published in the dental literature, information about this aspect will be crucial in the future with resources running dry for the health care sector. As regards to labour, material and hospital costs the information collected was very detailed and enabled costing to be conducted on an individual basis. The resources used to treat a patient with an overdenture on a transmandibular implant can almost provide seven patients with a complete new set of dentures. If we compare a regular new prosthesis with an implant-retained overdenture on permucosal implants the proportion of costs becomes more favourable, namely 1:3. New dentures requiring preprosthetic surgery are almost as expensive as treatment with an overdenture on permucosal implants. These figures compare to those of Jönsson and Karlsson[17], except for the permucosal implant group. In their study this treatment alternative is much more expensive, but this is only logical because they evaluate implants with a fixed bridge.

The results of the study seem rather robust as the sensitivity analysis shows that threshold values for various cost estimates, for which conclusions alter, are unrealistic. Furthermore, the confidence intervals are rather small, which suggests that collecting individual data is an accurate method to estimate cost prices. The relatively small standard deviations confirm the relative homogeneity of the research group. Only in very few cases enormous costs had to be made to improve the oral health status. The presented data seem useful for other purposes, because the outcomes look comparable to the literature[1,3,7,10]. In the first year a survival of the implants of 92% was measured. The abovementioned authors all claim survival rates between 89% and 96%.

The method used for cost analysis resembles closely the Resource Based Relative Value Scale adopted by the Congress in 1989. Such a system provides information that better reflects the resource cost required to deliver a service. Although in the Netherlands it was not used for determination of reimbursement levels, the system gives better understanding of true costs than tariffs do. The relative comparison of different types of maxillofacial

procedures becomes well-founded. The cost figures cannot only be used for societal comparisons, but also give insight in financial flows in institutions and for individual dentists. A discussion about inadequate reimbursement levels may be the result.

Although the present data support general conclusions, this study has several shortcomings. In the study patients were treated in a clinical setting in an academic hospital. This can create certain biases. First, dentists connected to a hospital may be more experienced than general practitioners. Therefore, the survival rates could become somewhat overstated. Second, the overhead costs in an academic hospital are probably much larger than in a general practice. In addition, only people with a marginal bone height between 8 and 25 millimetre were selected. All patients had a very long experience with dentures and they still had complaints. The population could be described as "dental cripples". Therefore, it is possible that the reported costs are somewhat higher than the costs of implants placed in routine practice settings would have been. However, the ratio between the treatment costs of the different treatment options to other settings can be generalised.

One of the most important shortcomings of such a comparison is the lack of data about long term costs. In the short run dental implants are more expensive. Probably, parts of these additional short-term costs will lead to savings in the future due to for example fewer rebasings and relinings. As this study has shown that considerable additional investment is necessary for dental implants as compared to traditional treatment. Costs of aftercare are considerably high in the implant groups, so initial differences in costs during the treatment phase will most probably not be compensated for in the long run. Of course part of the conventional prostheses as well as overdentures on implants will fail. For both treatment options all complications during the first year were included. In all circumstances the patients finished that first year in their own treatment group. Therefore, it was not possible to say something about the costs of failure in the long run. However, in our study between 25% and 33% of the patients in the CD-group opted for implants after one year[22]. Furthermore, in 17% of the patients adjustments to their prosthesis had to be made. The ratio seen in this study may actually decrease in the long run, thereby making implant supported prostheses less economically undesirable relative to conventional prostheses.
In the end the questions remains whether the reported benefits of dental implants[1-17] justify the additional investment mentioned here. This is the cost-

effectiveness issue, about which we will report elsewhere.

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