Treatment with Implant-Supported Fixed Dental Prostheses in Patients with Congenital and Acquired Neurologic Disabilities: A Prospective Study

Anders Ekfeldt, LDS, Odont Dr, PhD[a]/Mia Zellmer, RDH[b]/Gunnar E. Carlsson, LDS, Odont Dr, PhD[c]

Purpose: To study the medium- to long-term outcome of implant treatment in patients with neurologic disabilities. ***Materials and Methods:*** Twenty-seven patients with different disabilities and in need of prosthodontic treatment were treated with various implant-supported prostheses. Altogether, 88 threaded titanium implants were placed. General anesthesia was used in 21 patients and local anesthesia in 6 patients. Patients were recalled every 3 months by a dental hygienist and annually by a prosthodontist. ***Results:*** Five of the original 27 patients died during the 5- to 10-year follow-up period (mean, 7.2 years), but the remaining 22 patients with 70 implants could be clinically examined at the final follow-up. Twelve implants (14%) were lost, 3 before loading and 9 after insertion of the implant-supported fixed prostheses. The cumulative survival rate for placed implants was 85.8% after 10 years. Perimucositis was diagnosed in 10 patients and for 14 of the 70 implants. Three of the 15 patients with measurable radiographs and 4 implants were diagnosed with peri-implantitis. Several prosthodontic complications occurred, from minor and easily correctable to severe and requiring retreatment. ***Conclusions:*** Patients with different neurologic disabilities present more problems during implant treatment and maintenance compared with healthy patients. Nevertheless, it was possible to carry out treatment, and outcomes were relatively favorable. The results indicate that implant treatment can be a valid option in oral rehabilitation of patients with neurologic disabilities. *Int J Prosthodont 2013;33:517–524. doi: 10.11607/ijp.3511*

The successful use of dental implants for the treatment of completely and partially edentulous patients is well documented in numerous studies and books.[1–6] Survival rates of ≤ 95% have been found in systematic reviews of studies with follow-ups of at least 5 years.[7,8] Reports of implant treatment in individuals with rare diseases are limited and mainly consist of anecdotal reports and case presentations.[9,10] A search in PubMed for articles on oral rehabilitation using dental implants in patients with rare disorders up to July 2012, supplemented with a manual search of references in the retrieved papers, revealed the continuing publication of case reports but few controlled studies.[11] One study described the relatively favorable outcome 3 to 113 months after implant loading in 18 patients with various degrees of physical and mental impediments.[12] A case series study of 24 special care patients demonstrated a cumulative survival rate after 5 years of 93.4%; the survival rate of the prostheses was 100%.[13] A retrospective study of 1 to 16 years (mean, 4.6 ± 3.1 years) after implant treatment in 61 patients with severe epilepsy and additional motor and/or intellectual impairments reported good results.[14] All three retrospective studies concluded that dental implants offer a viable option for special care patients with various disabilities.

A prospective study of dental implant treatment for individuals with neurologic disabilities described the early experience as containing both possibilities and difficulties.[15] This study concluded that it was possible to carry out treatment with relatively good

[a]*Professor, Department of Prosthetic Dentistry and Oral Function, Institute of Clinical Dentistry, Faculty of Dentistry, University of Oslo, Oslo, Norway.*
[b]*Dental Hygienist, National Orofacial Resource Centre for Rare Disorders, Gothenburg, Sweden.*
[c]*Professor Emeritus, Department of Prosthetic Dentistry, Institute of Odontology, The Sahlgrenska Academy, University of Gothenburg, Göteborg, Sweden.*

Correspondence to: *Dr Anders Ekfeldt, Department of Prosthetic Dentistry and Oral Function, Institute of Clinical Dentistry, University of Oslo, PO Box 1109 Blindern, NO-0317 Oslo, Norway. Fax: +4722 852 344. Email: anders.ekfeldt@odont.uio.no*

Table 1 Details of the Study Population and Treatments

Patient	Sex	Age at delivery (y)	Diagnosis	Prosthodontic treatment	Implant location*	Function (y)
1†	M	48	Down syndrome, epilepsy	Tooth-supported fixed prosthesis in maxilla, ISFP in partially edentulous mandible	46, 44, 43	6
2	F	41	Mental retardation	Single-tooth implant	11	10
3	F	51	Mental retardation, epilepsy	Single-tooth implant	11, 21	9.5
4	F	55	Mental retardation	ISFP in completely edentulous mandible	44, 43, 31, 33, 34	8
5	M	53	Fragile X	ISFP in partially edentulous maxilla	16, 14, 13	9.5
6	M	24	Autistic syndrome, epilepsy	Single-tooth implant	21	9.5
7	F	46	Down syndrome	Single-tooth implant	21	9
8	F	55	Mental retardation, epilepsy, schizophrenia	ISFP in completely edentulous maxilla	15, 13, 11, 21, 23, 25	8
9†	F	36	Retts syndrome, epilepsy	Single-tooth implant	21	2
10	F	53	Mental retardation, epilepsy	ISFP in partially edentulous maxilla	13, 11, 23	8
11	F	19	Mental retardation, multiple disabilities	ISFP in partially edentulous maxilla	12, 22	8
12	M	50	Mental retardation	Single-tooth implant	24	8
13	F	53	Mental retardation, epilepsy	Single-tooth implant	24	8
14	M	33	Mental retardation	Single-tooth implant	21	8.5
15	F	35	Severe mental retardation	Single-tooth implant	21	7.5
16	M	58	Dystrofia myotonica	ISFP in completely edentulous mandible	44, 43, 41, 33, 34	7.5
17	M	41	Aspberger syndrome	ISFP in completely edentulous mandible	45, 43, 31, 33, 34	7.5
18	M	56	Mental retardation	ISFP in partially edentulous maxilla	14, 15, 16	7
19	M	47	Mental retardation, epilepsy, short in stature	ISFP in completely edentulous maxilla and mandible	15, 13, 11, 21, 23, 25 45, 43, 31, 33, 34	7
20	M	58	Mental retardation	ISFP in completely edentulous mandible	45, 43, 41, 33, 34	6.5
21†	M	54	Down syndrome	Single-tooth implant	11	Not loaded
22	M	19	Down syndrome	Single-tooth implant	13, 23	6.5
23†	M	80	Mental retardation	Implant-supported overdenture in completely edentulous mandible	43, 31, 33	3
24	M	22	Cerebral palsy, mental retardation	ISFP in partially edentulous maxilla	13, 11, 21, 22	5.5
25	F	52	Prader Willi	ISFP in partially edentulous maxilla ISFP in completely edentulous mandible	12, 21, 23, 25 45, 43, 31, 33, 34	5.5
26†	F	55	Dystrofia myotonica	ISFP in partially edentulous maxilla	24, 25	2
27	F	49	Mental retardation	2 ISFPs in partially edentulous maxilla	14, 15 12, 11, 21, 23	5

ISFP = implant-supported fixed prosthesis.
*FDI system.
†Deceased.

results despite the fact that all patients had severe disabilities including mental retardation and different degrees of autistic behavior. This short-term report dealt with a group of 14 patients with a follow-up of 1 year or more for only 6 of them. The present paper will cover the entire group of patients followed for > 5 years. The purpose of this prospective study was to provide a medium- to long-term report of implant treatment in patients with neurologic disabilities.

Materials and Methods

The 27 patients had been referred to the National Orofacial Resource Centre with different disabilities, mainly neurologic disorders, causing various orofacial dysfunction problems (Table 1). They were completely or partially edentulous and considered suitable for prosthodontic treatment with implants. The background of the study and details of the early

Table 2 Distribution of Implants Placed and Lost

Length (mm)	Ma RP + NP	TiUnite Mk III + IV RP	Replace Select RP + NP	Speedy Groovy tapered RP	Lost before loading	Lost after loading
7		2			1 (TiU)	1 (TiU)
8.5		2				
10	1	3				1 (TiU)
11.5		3				1 (TiU)
13	4	12	2			
15	6	41		2	2 (Ma)	1 (Ma) 5 (TiU)
16			4			
18	2	4				
Total	13	67	6	2	3	9

Ma = machined; RP = regular platform; NP = narrow platform; TiU = TiUnite.

experiences of the first 14 treated patients have been previously published.[15] The Swedish Parliament decided on "necessary dental care" in 1998 to increase financial support and service given to persons with disabilities who were dependent on nursing staff.

The inclusion criterion for the study population was patients with different neurologic disorders, either congenital or acquired, including mental retardation and with different degrees of autistic behavior. They were referred to the clinic because they were judged to need treatment with implant-supported prostheses. Patients were excluded if they themselves or their legal guardian or personal caregiver had negative views of prosthodontic treatment with implants. Despite sometimes serious disabilities, all patients in this study lived in their own homes or in residential housing with the help of personal caregivers.

The study was approved by the Regional Ethics Committee in Region Västra Götaland, Sweden, Dnr 151–11, on April 20, 2011.

The prospective study was planned for 30 patients and completed for 27 patients referred to the clinic between 2000 and 2006.

The prosthodontist first examined all patients and planned their treatments. Before implant placement, the prosthodontist once again examined all patients together with the oral surgeon and discussed the treatment concept. Because of behavior problems among some of these patients, panoramic and other relevant radiographs were not always available at the time of examination and had to be taken under general anesthesia at the time of implant placement.

Oral surgeons made all implant placements except in one patient in whom the first author placed the implants. The first author did most of the abutment operations and all prosthodontic treatment. The implants were placed under general anesthesia in 21 patients and with local anesthesia in 6 patients.

In the first 17 patients, a very strict surgical protocol for Brånemark implant placement (Nobel Biocare) was used. It included a two-stage procedure using antibiotics pre- and postoperatively, chlorhexidine for mouth rinse, analgesic when needed, and frequent postoperative controls. A two-stage procedure was also used in 4 more patients with limited bone quantity and quality. In 3 patients with an edentulous mandible, a one-stage procedure was used with loading of the implants within 2 months. In 2 more patients, a one-stage procedure was used but with a healing period of 6 months. One patient was treated with immediate loading (Nobel Guide).

The types and lengths of implants placed varied, but the great majority of them were 15- or 13-mm long TiUnite Mark III and IV with a regular platform (Rp, Nobel Biocare) (Table 2).

Radiographic examination was planned after placement of the implant and at control visits up to the final follow-up. Because of severe problems due to the physical and mental condition of some patients, radiographs of acceptable quality could be obtained from only 15 of the 27 patients, including 52 implants. A trained radiologist made all estimations of periimplant bone loss by measuring changes in exposed threads from the radiographs taken at placement of the implant-supported restoration up to the last examination.

The following variables were recorded: presence or absence of parafunction, tooth wear, implant failure, implant bone level, surgical and/or prosthetic complications, as well as the design of the prostheses and number of visits. The patients and/or their caregivers were asked questions on patient experience of the

implant treatment and satisfaction with the restorations. The anatomical form, surface, color, and fit of the fixed prostheses were recorded according to the California Dental Association (CDA) system for quality evaluation for dental care.[16] Oral hygiene in general and visible plaque on abutments were also recorded by a dental hygienist. Soft tissue pathology, such as perimucositis or peri-implantitis, and fistulas was recorded according to recent definitions.[17,18]

Implant success was determined using the criteria established by Albrektsson and Zarb.[19] Implant stability was checked relative to the actual implant and superstructure, in combination with inspection of the peri-implant mucosa and radiographs of the implants. However, the prosthesis was not removed at the evaluation of implant stability. The bone quality and shape of the alveolar crest were classified according to Lekholm and Zarb.[20]

Parafunctions such as daytime bruxism were recorded according to a scale with five degrees: no, little, sometimes strong, strong, and continuous bruxism. The data were obtained through questioning the patients' personal caregivers. Tooth wear was assessed at the clinical examinations using a five-point scale.[21]

Each implant placed was given a prognostic score from 1 to 4 (1 = uncertain and 4 = very good). The criteria evaluated for each implant were: *(a)* implant placed in bone of good quality, *(b)* implant shows good initial stability, *(c)* no exposed threads, and *(d)* placement was done according to the standard protocol. The implant was given a score of 4 if all four criteria were fulfilled.

All patients and their caregivers were given an individual prophylactic program by a dental hygienist, including a chart of photographs presenting suitable toothbrushes for optimal cleaning of the prostheses. Patients were recalled every 3 months for an oral hygiene check-up by a dental hygienist (MZ) and annually by a prosthodontist (AE) up to the year 2007. Thereafter, an experienced hospital dentist made the examinations and performed any necessary treatment. Final clinical and radiographic examinations of all available patients were performed in 2012.

Cumulative survival rates for the implants were calculated through life table analysis.[22]

Results

All patients participating in this study had some degree of mental retardation from neurologic impairment, congenital defect, trauma, or genetic syndromes such as Down syndrome. Often, the patients had other medical disorders such as thyroid dysfunction or epilepsy, sometimes in combination with different degrees of autistic behavior (Table 1). Many of the patients had a list of medications that included substances such as thyroid hormone, antiepileptics, antidepressives, megaloblastics, neuroleptics, and tranquillizers.

Some persons had developed finger and/or oral habits, eg, tongue movements that increased the risk of postsurgical complications. Frequent check-ups and the use of a soft splint to cover the surgical area postoperatively were found to be valuable.

Five of the original 27 patients died during the observation period, but all remaining 22 patients with 70 implants were clinically examined at the final examination. The implant-supported prostheses had then been in function 5 to 10 years after implant treatment.

The distribution of the scores of bone quality and shape of the alveolar crest, according to Lekholm and Zarb,[20] for the 29 treated arches at implant placement were: A1 (n = 2), A3 (n = 2), A4 (n = 1), B2 (n = 4), B3 (n =6), C2 (n = 3), C3 (n = 10), and D4 (n = 1).

In all, 12 implant-supported single crowns were placed and none lost; 17 implant-supported fixed dental prostheses were placed and three had to be remade due to implant loss. One overdenture was in use until the death of the patient. The survival rate of prosthetic constructions was 27/30 (90%).

The implant-supported fixed prostheses (n = 8) in edentulous arches were fabricated using Nobel Procera (Nobel Biocare, titanium framework and acrylic resin teeth). All fixed partial prostheses (n = 10) were made of metal-ceramic with a framework of gold. The single-tooth restorations (n = 12) were either made as all-ceramic crowns using the CeraOne System (Nobel Biocare) (n = 10) or with individual abutments in titanium (n = 2).

Biologic Complications and Implant Failure

Twelve implants (14%) were lost, three before loading and nine after insertion of the implant-supported fixed prostheses (ISFPs) (Table 2). Both of the 7-mm-long implants failed, whereas none of the 10 longest (16 and 18 mm) failed. The prognostic score did not prove fully reliable even if the most optimistic score, 4, had the lowest failure rate (5%), whereas the rate for the other scores (3, 2, and 1) varied (25%, 11%, and 14%, respectively) (Table 3).

Biologic Complications and Bone Loss

Among the 22 patients examined at the final follow-up, 10 (45%) exhibited perimucositis according to the definition of bleeding on probing (BoP) and pocket depth ≥ 4 mm; 14 of the 70 implants (20%) had this

Table 3 Abnormal Incidents Noted in Surgical Records of 88 Originally Placed Implants in Relation to the Prognostic Score* and Implant Loss

Score	No. of implants	Exposed threads	Rupture of mucoperiosteal flap	Infection	Lost before loading	Lost after loading
4	40		2	4	1	1
3	32	11	2	2	2	6
2	9	2	1			1
1	7					1

*Range, 1 to 4 where 4 is very good and 1 is uncertain.

Table 4 Peri-implant Bone Loss and Number of Implants According to Time in Function

Exposed threads	Time (y)				
	5.0–5.9	6.0–6.9	7.0–7.9	8.0–8.9	9.0–10
≤ 0	8	3	4	5	7
0.1–1.0			6	4	
1.1–2.0		1	4		
2.1–3.0		1	2	2	
3.1–4.0			2		
4.1–5.0			1	1	
5.1–6.0					
6.1–7.0					
7.1–8.0				1	
Total	8	5	19	13	7

Table 5 Prosthodontic Complications and Their Management

Patient	Complication	Management
1	ISFP loose, 1 implant failed before loading	Failed implant removed, ISFP shortened and later reinserted on new implant and new ISFP made
4	Loss of 1 implant before loading, another one when the ISFP was to be inserted	ISFP inserted on 3 implants awaiting new implants to be placed and new ISFP constructed
5	Fracture of porcelain crown	Polishing of fractured area
12	Extremely hard biting individual: porcelain fracture, crown loose (thrown away by patient), fracture of neighbor tooth (intact canine)	New implant-supported crown, which fractured after 6 months, crown on fractured tooth
17	Self-destructive behavior (banged head against walls), ISFP loosened several times, ISFP fractured, implants lost, severe wear	Several reinsertions of ISFP, removal of failed implants, back to implant overdenture, and, finally, conventional complete denture
19	Fractures of abutment and fixed partial denture screws, fracture of acrylic parts of superstructure at epileptic seizures	ISFP rebuilt with occlusal contact on titanium splint to protect the acrylics
23	Implant overdenture poor retention (patient removed it repeatedly with his tongue), overdenture fractured	Overdenture repaired but only used at rare social events
25	Implant lost after 4 years, ISFP loose	ISFP reinserted awaiting new implant placement

ISFP = implant-supported fixed prosthesis.

diagnosis. Three of the 15 patients with measurable radiographs (20%) and 4 implants (8%) were diagnosed with peri-implantitis using the definition bone loss ≥ 3 threads and BoP.[17]

The peri-implant bone loss was small to moderate in most patients (Table 4). It should be noted that the seven implants in the four patients followed for 9 to 10 years showed no measurable bone loss. Altogether, 27 (52%) of the 52 implants with acceptable radiographs had no measurable bone loss after 5 to 10 years, and for a further 10 (19%), the bone loss corresponded to, at most, one thread during this period. The greatest peri-implant bone loss observed, corresponding to eight threads, occurred in one patient before loading, early after placement, probably as a consequence of a postoperative dehiscence of the mucoperiosteal flap. This implant remained stable and no more bone loss was seen up to the last examination shortly before the death of the patient after 6 years. In another patient with a maxillary full-arch ISFP, bone loss was above average around three implants (eight, five, and three threads, respectively), whereas the bone loss measured one thread around the remaining 3 implants. The ISFP was stable and well functioning all through the 9-year follow-up period.

Prosthodontic Complications

Several prosthodontic complications occurred, from minor and easily correctable to severe requiring retreatment (Table 5). The most severe complication occurred in a patient with Aspberger syndrome and

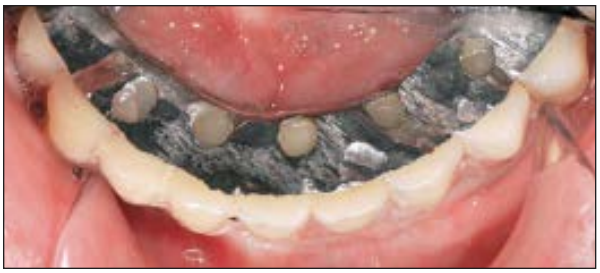

Fig 1 Extensive wear related to hard biting and epileptic seizures associated with patient no. 19's disorders. ISFP rebuilt with occlusal contact on titanium splint to protect the acrylics (mandible).

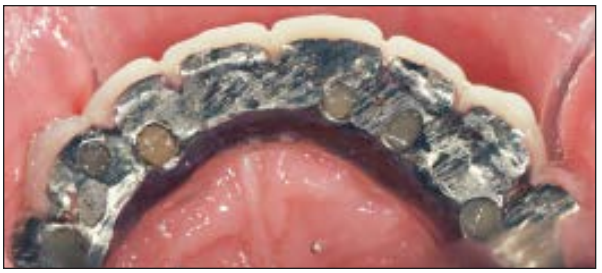

Fig 2 Maxilla in patient no. 19.

Table 6 Quality Assessment According to California Dental Association Criteria

Assessment	Surface and color	Anatomical form	Margin integrity
Satisfactory			
Excellent	12	10	13
Acceptable	13	12	12
Not acceptable			
Repair or correct	2	3[a]	2
Replace[b]		2	

[a]Porcelain fractures (all three became acceptable after polishing).
[b]ISFP failed after multiple implant failures (provided with an implant overdenture and eventually a complete denture; single-tooth implant crown: all porcelain fractured (provided with a new crown).

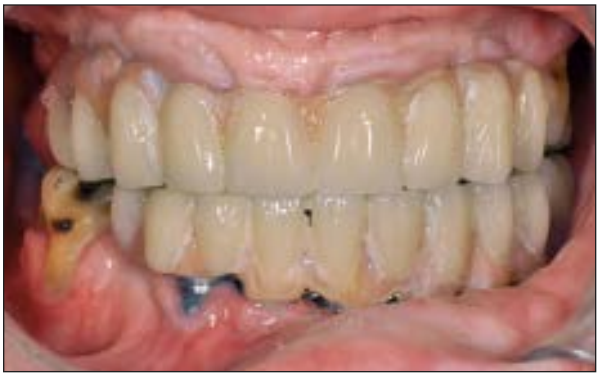

Fig 3 The oral hygiene was not optimal in patient no. 19 despite the assistance of personal caregivers.

Table 7 Life Table Analysis of Placed Implants (Re-operated Implants Not Included)*

Time period (y)	No. followed	No. failed	Success rate within group (%)	CSR (%)
Placement–loading	88	3	96.6	96.6
Load–1	84	1	98.8	95.4
1–2	80	2	97.5	93.0
2–3	77	0	100	93.0
3–4	77	1	98.7	91.8
4–5	76	3	96.1	88.2
5–6	73	2	97.3	85.8
6–7	70	0	100	85.8
7–8	49	0	100	85.8
8–9	24	0	100	85.8
9–10	7	0	100	85.8

CSR = cumulative survival rate.
*Five patients died and their nine implants were not included in further calculations.

self-destructive behavior. He often banged his head against walls, which repeatedly led to the loosening of the ISFP and, eventually, fracture and loss of both implants and the prosthesis. An overdenture was constructed on one remaining implant, but this implant was also lost, resulting in a return to a complete denture, which the patient seldom uses.

The great majority of the ISFPs still in use were satisfactory according to the CDA quality assessment. Because of various complications, five prostheses (19%) were considered not acceptable, although three porcelain fractures became acceptable after polishing (Table 6).

All patients and/or caregivers were satisfied with the appearance and function of the ISFPs and agreed that they would consider implant treatment again, if necessary.

It was difficult to obtain reliable answers to questions on parafunctional habits. However, some of the prosthodontic complications were probably related to various parafunctions and/or extremely hard biting (Table 5). The same cause was probable for a few patients with severe tooth wear (Figs 1 to 3).

Survival Rate

The cumulative survival rate (CSR) for placed implants was 85.8% after 5 to 10 years. No implant was lost after 6 years (Table 7).

Discussion

There is no doubt that the group of patients with different neurologic and other disabilities, often including mental retardation, presented/offered greater problems during implant treatment and maintenance compared with healthy patients. Nevertheless, it was possible to carry out the treatment, and the outcome was relatively favorable and led to improved dental appearance and oral function.

The implant failure rate (12 of 88 placed implants lost = 14%) was much greater than in a series of healthy patients.[7,23] However, the CSR (Table 7) changed little from 5 years (88.2%) to 10 years (85.8%). The 10-year results are somewhat lower than the outcomes presented in systematic reviews of implant therapy. For example, according to meta-analyses, the 10-year estimated survival of ISFPs was 93.1%.[8] This may indicate that the problems in disabled patients are greatest during the first period after implant placement, after which the situation can stabilize.

However, the relationship between implant failure and the patients' diagnoses can only be speculated. As discussed earlier,[15] the implant loss in patient no. 1 might be associated with the reduced resistance to infections in subjects with Down syndrome in combination with macroglossia and oral habits. Two of the new implants placed in this patient after the early loss of one implant also failed.

An increased risk of implant failures in patients with Down syndrome has been reported in a study of 18 patients with various handicaps, 4 of whom had Down syndrome. Of four implants placed in 2 patients with Down syndrome, three failed.[12] The suitability of patients with Down syndrome as candidates for implant placement has been questioned because of macroglossia, osteoporotic-like alveolar bone, and a tendency toward poor cooperation.[24]

In contrast, in a study of special care patients, including three subjects with Down syndrome, no implants failed.[13] In this study, there were three more patients with Down syndrome who did not exhibit any implant failure, although one of them died before the implant was loaded. Several of the prosthodontic complications including different types of fractures were probably caused by oral habits, trauma, hard biting, and epileptic seizures associated with the patients' disorders (Table 5). Surprisingly, a retrospective study covering 1 to 16 years of patients with severe epilepsy reported excellent results with few implant failures and other complications and no progression of the frequent perimucositis to peri-implant bone loss.[14] It should be mentioned that only a small percentage of the patients were followed for more than 6 years.

It is well known today that good oral hygiene is important to maintain healthy conditions around teeth and implants. Most of the patients in this study could not maintain good oral care on their own but required help from caregivers and regular control and service by a dental hygienist. Still, many of the patients had a large amount of plaque and almost half of them exhibited perimucositis (Fig 3). Other series of disabled patients have reported similar problems with poor oral hygiene and a high prevalence of peri-mucosal inflammation but good functional results from implant treatment.[12–15]

The more severe condition, peri-implantitis, including bone loss, was diagnosed in 20% of patients and for 8% of implants, according to the definition used.[17] The prevalence, definition/diagnosis, clinical importance, as well as the etiology of peri-implantitis are controversial.[25–29]

Even if much is not yet known regarding these conditions, it is agreed that bacterial inflammation is an essential part and the disease may develop from perimucositis to peri-implantitis.[30] Therefore, maintaining good oral hygiene is important but difficult in this group of patients. It is necessary that these patients are helped by informed caregivers in daily oral care and also given regular professional support.

The results of the present study and of earlier reports[11–15] indicate that implant treatment can be a valid option in the oral rehabilitation of patients with neurologic disabilities, although maintenance often requires the management of more complications compared with healthy implant patients.

Conclusion

Patients with different neurologic and other disabilities, often including mental retardation, present greater problems during implant treatment and maintenance phases than healthy patients generally do. Nevertheless, it was possible to carry out the treatment, and the outcomes were relatively favorable. The results indicate that implant treatment can be a valid option in oral rehabilitation of patients with neurologic disabilities.

Acknowledgments

The authors wish to thank Lisbeth Heijel-Berndtsson, Clinical Coordinator, National Orofacial Resource Centre for Rare Disorders, Gothenburg, for organizing the clinical examination of these patients. The authors also wish to thank the team of oral surgeons: Drs Göran Widmark, Carl Johan Ivanoff, Cecilia Larsson, and Lucy Kartous, and oral radiologist Dr Eva Borg, Specialist Clinics of Oral and Maxillofacial Surgery and Oral and Maxillofacial Radiology, Mölndal Hospital, Mölndal. We also wish to thank

the staff at the Department of Oral and Maxillofacial Radiology, Institute of Odontology, University of Gothenburg, Sweden. This study has been supported by grants from Praktikertjänst, Stockholm, Sweden.

References

1. Adell R, Eriksson B, Lekholm U, Brånemark PI, Jemt T. Long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws. Int J Oral Maxillofac Implants 1990;5:347–359.
2. Ekelund JA, Lindquist LW, Carlsson GE, Jemt T. Implant treatment in the edentulous mandible: A prospective study on Brånemark system implants over more than 20 years. Int J Prosthodont 2003;16:602–608.
3. Johansson LA, Ekfeldt A. Implant–supported fixed partial prostheses: A retrospective study. Int J Prosthodont 2003;16: 172–176.
4. Zarb GA, Albrektsson T, Baker G, Eckert SE, Stanford C, Tarnow DP (eds). Osseointegration: On Continuing Synergies in Surgery, Prosthodontics, and Biomaterials. Chicago: Quintessence, 2008.
5. Jokstad A (ed). Osseointegration and Dental Implants. Ames, Iowa: Wiley-Blackwell, 2009.
6. Charyeva O, Altynbekov K, Zhartybaev R, Sabdanaliev A. Long–term dental implant success and survival: A clinical study after an observation period up to 6 years. Swed Dent J 2012;36:1–6.
7. Pjetursson BE, Brägger U, Lang NP, Zwahlen M. Comparison of survival and complication rates of tooth–supported fixed dental prostheses (FDPs) and implant-supported FDPs and single crowns (SCs). Clin Oral Implants Res 2007;18(suppl 3): 97–113.
8. Pjetursson BE, Thoma D, Jung R, Zwahlen M, Zembic A. A systematic review of the survival and complication rates of implant-supported fixed dental prostheses (FDPs) after a mean observation period of at least 5 years. Clin Oral Implants Res 2012;23(suppl 6):22–38.
9. Bergendal B. The role of prosthodontists in habilitation and rehabilitation in rare disorders: The ectodermal dysplasia experience. Int J Prosthodont 2001;14:466–470.
10. Bergendal B. Evidence and clinical improvement: Current experiences with dental implants in individuals with rare disorders. Int J Prosthodont 2006;19:132–134.
11. Durham TM, King T, Salinas T, Franco T, Ross J. Dental implants in edentulous adults with cognitive disabilities: Report of a pilot project. Spec Care Dentist 2006;26:40–46.
12. López–Jiménez J, Romero-Domínguez A, Giménez-Prats MJ. Implants in handicapped patients. Med Oral 2003;8:288–293.
13. Oczakir C, Balmer S, Mericske–Stern R. Implant-prosthodontic treatment for special care patients: A case series study. Int J Prosthodont 2005;18:383–389.
14. Cune MS, Strooker H, van der Reijden WA, de Putter C, Laine ML, Verhoeven JW. Dental implants in persons with severe epilepsy and multiple disabilities: A long-term retrospective study. Int J Oral Maxillofac Implants 2009;24:534–540.
15. Ekfeldt A. Early experience of implant-supported prostheses in patients with neurologic disabilities. Int J Prosthodont 2005;18:132–138.
16. Quality Evaluation for Dental Care. Guidelines for the Assessment of Clinical Quality and Professional Performance. Los Angeles: California Dental Association, 1977.
17. Roos–Jansåker AM, Lindahl C, Renvert H, Renvert S. Nine-to fourteen-year follow-up of implant treatment. Part II: Presence of peri-implant lesions. J Clin Periodontol 2006;33:290–295.
18. Lindhe J, Meyle J; Group D of European Workshop on Periodontology. Peri-implant diseases: Consensus Report of the Sixth European Workshop on Periodontology. J Clin Periodontol 2008;35(8, suppl):282–285.
19. Albrektsson T, Zarb GA. Current interpretations of the osseointegrated response. Clinical significance. Int J Prosthodont 1993; 6:95–105.
20. Lekholm U, Zarb GA. Patient selection and preparation. In: Brånemark P-I, Zarb GA, Albrektsson T (eds). Tissue-Integrated Prostheses: Osseointegration in Clinical Dentistry. Chicago: Quintessence, 1985:155–163.
21. Carlsson GE, Johansson A, Lundqvist S. Occlusal wear. A follow-up study of 18 subjects with extensively worn dentitions. Acta Odontol Scand 1985;43:83–90.
22. Pocock SJ. Clinical Trials. A Practical Approach. New York: Wiley, 1983:221–224.
23. Jung RE, Pjetursson BE, Glauser R, Zembic A, Zwahlen M, Lang NP. A systematic review of the 5-year survival and complication rates of implant–supported single crowns. Clin Oral Implants Res 2008;19:119–130.
24. Lustig JP, Yanko R, Zilberman U. Use of dental implants in patients with Down syndrome: A case report. Spec Care Dent 2002; 5:201–204.
25. Fransson C. Prevalence, Extent and Severity of Peri–implantitis [thesis]. Göteborg: University of Gothenburg, 2009.
26. Ekfeldt A, Fürst B, Carlsson GE. Zirconia abutments for single-tooth implant restorations: A retrospective and clinical follow-up study. Clin Oral Implants Res 2011;22:1308–1314.
27. Chvartszaid D, Koka S. On manufactured diseases, healthy mouths, and infected minds. Int J Prosthodont 2011;24:102–103.
28. Zarb GA, Eckert SE. On widening the stream. Int J Prosthodont 2012;25:319.
29. Alrektsson T, Buser D, Sennerby L. On crestal/marginal bone loss around dental implants. Int J Prosthodont 2012;25:320–322.
30. Lang NP, Berglundh T, Working Group 4 of Seventh European Workshop on Periodontology. Periimplant diseases: Where are we now? Consensus of the Seventh European Workshop on Periodontology. J Clin Periodontol 2011;38(suppl 11):178–181.