Swedish Dental Journal

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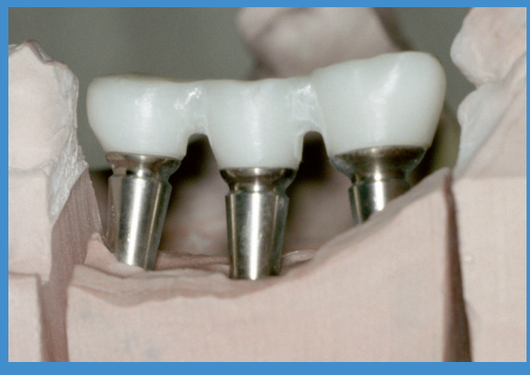

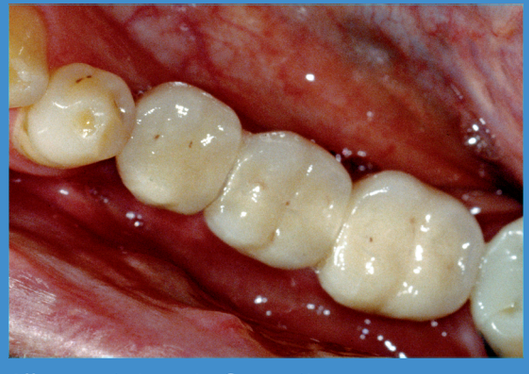

All-ceramic two- to five-unit implant-supported reconstructions
A randomized, prospective clinical trial

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Instructions to authors

Introduction

Swedish Dental Journal, the scientific journal of The Swedish Dental Association and the Swedish Dental Society, is published 4 times a year to promote practice, education and research within odontology. Manuscripts containing original research are accepted for consideration if neither the article nor any part of its essential substance has been or will be published elsewhere. Reviews (after consultations with the editors), Case Reports and Short Communications will also be considered for publication. All manuscript will be exposed to a referee process.

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The Abstract should be short and concise and not exceeding 300 words. The Swedish Sammanfattning can be somewhat more extensive.

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All-ceramic two- to five-unit implant-supported reconstructions

A randomized, prospective clinical trial

CHRISTEL LARSSON, PER VULT VON STEYERN, BO SUNZEL, KRISTER NILNER

Abstract

The purpose of this study was to evaluate the clinical performance of two to five-unit implant-supported all-ceramic reconstructions and to compare the results of two different all-ceramic systems, Denzir® (DZ) and In-Ceram Zirconia® (InZ). Eighteen patients were treated with a total of 25 two- to five-unit implant-supported reconstructions. Nine patients were given reconstructions of the DZ system and the other nine reconstructions of the InZ system. The reconstructions were cemented with zinc phosphate cement onto preparable titanium abutments and were evaluated after 6 and 12 months. At the 12-month follow-up, all reconstructions were in function; none had fractured. Superficial cohesive (chip-off) fractures were, however, observed in 6 of the 18 patients (8 of 25 reconstructions). Nine units in the DZ group (in 7 of 13 reconstructions) and one in the InZ group (1 of 12 reconstructions) had chip-off fractures. The difference between the two groups regarding frequency of chip-off fractures was statistically significant ($P < 0.01$). Marginal integrity was rated excellent at 34 abutments (56%) and acceptable at 27 (44%). Results from this 12-month trial suggest that all-ceramic implant-supported fixed partial dentures of two- to five-units may be considered a treatment alternative. When comparing the two ceramic systems under study, however, this study concludes that the DZ system exhibits an unacceptable amount of veneering porcelain fractures and thus cannot be recommended for the type of treatment evaluated in this trial. Further studies and long-term follow-ups must be performed before the materials and technique can be recommended for general use.

Key words

Ceramic, dental implants, dental porcelain, fixed partial dentures, reconstructions

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Helkeramiska två- till femleds rekonstruktioner på implantat. En randomiserad, prospektiv klinisk studie

CHRISTEL LARSSON, PER VULT VON STEYERN, BO SUNZEL, KRISTER NILNER

Sammanfattning

Syftet med denna studie var att kliniskt utvärdera helkeramiska två- till femleds rekonstruktioner på implantat, samt att jämföra två olika keramiska system, Denzir® (DZ) och In-Ceram Zirconia® (InZ). Arton patienter behandlades med totalt 25 två- till femleds rekonstruktioner på implantat. Nio patienter fick rekonstruktioner utförda i DZ och nio patienter fick rekonstruktioner utförda i InZ. Rekonstruktionerna cementerades med zinkfosfatcement på preparerbara titandistanser. Rekonstruktionerna utvärderades efter 6- och 12 månader. Vid uppföljning efter 12 månader var alla 25 rekonstruktioner i funktion, inga hade frakturerat. Ytliga kohesiva, sk. chip-off, frakturer noterades däremot hos 6 av 18 patienter (8 av 25 rekonstruktioner). Nio led i DZ-gruppen (7 av 13 rekonstruktioner) och ett led i InZ-gruppen (1 av 12 rekonstruktioner) uppvisade chip-off frakturer. Skillnaden mellan de båda grupperna var statisktiskt signifikant ($p< 0.01$). Kantanslutningen bedömdes som utmärkt vid 34 stöd (56%) och acceptabel vid 27 stöd (44%). Resultat från denna 12 månaders uppföljning indikerar att helkeramiska två- till femleds rekonstruktioner på implantat kan övervägas som behandlingsalternativ. Vid jämförelse mellan de båda keramiska systemen är slutsatsen att DZ-systemet uppvisar oacceptabelt många frakturer i ytporslinet och därför inte kan rekommenderas för den typ av behandling som utvärderats här. Fortsatta studier och långtidsuppföljningar är nödvändiga innan ovan nämda material och teknik kan rekommenderas för allmänt bruk.

Introduction

All-ceramic fixed partial dentures (FPDs) were introduced as a treatment alternative in the mid-1960s. Owing to poor performance of the early constructions, however, it was not until the development of new high-strength ceramic core materials—often referred to as oxide ceramics—that the use of all-ceramic FPDs increased. The results of laboratory studies on oxide ceramics are promising, and the success rates of the few clinical studies that have been published are close to those of porcelain-fused-to-metal (PFM) FPDs (6, 7, 14, 15, 18, 20 , 21).

These clinical studies have so far concerned FPDs supported by natural teeth. When teeth are lost because of caries or periodontal disease, implants can be used to replace the natural abutments. Today, implant-supported FPDs have become an increasingly common treatment alternative. No clinical studies on all-ceramic FPDs supported by dental implants, however—apart from a case report—have been published (3). Since the results of studies on tooth-supported all-ceramic FPDs cannot be directly transferred to implant-supported reconstructions, clinical studies are needed to confirm or reject such procedures. Results from a laboratory study comparing tooth- and implant-supported all-ceramic reconstructions favour implant support (22). One possible explanation is that the solid support gained from implants might contribute to the fracture strength of all-ceramic reconstructions, owing to reduced stress and strain levels in the prostheses when loaded on implants compared to when loaded on natural teeth.

Aim

The aim of the present study was to evaluate the clinical performance of two- to five-unit all-ceramic reconstructions supported by dental implants and to compare the results of two different all-ceramic systems, Denzir® (DZ) and In-Ceram Zirconia® (InZ). The hypothesis was that the success rates of all-ceramic, implant-supported reconstructions for the two material systems are equal and similar to those of PFM reconstructions.

Materials and Methods

Twenty-five implant-supported all-ceramic reconstructions were made for 18 patients, 12 of InZ (Vita Zahnfabrik, Bad Säckingen, Germany) and 13 of DZ (Decim AB, Skellefteå, Sweden).

A total of 320 persons who regarded themselves in need of prosthetic treatment responded to an advertisement in a local newspaper. After a short preliminary interview, followed by a panoramic x-ray examination, 18 patients who were partially dentate met the inclusion criteria, which were indications for one or more two- to five-unit implant-supported reconstructions. Satisfactory oral hygiene was another prerequisite for inclusion. Two- to five-unit reconstructions were to be supported by two to three implants. Exclusion criteria were bone dimensions insufficient for implant installation, deep occlusion, and bruxism. None of the 18 patients, however, were excluded and all—12 women and 6 men between 37 and 78 years—assented to participate. The patients were informed about the risks with and alternatives to the proposed therapy and all gave their written consent. An extended warranty for the reconstructions in case of failure was offered.

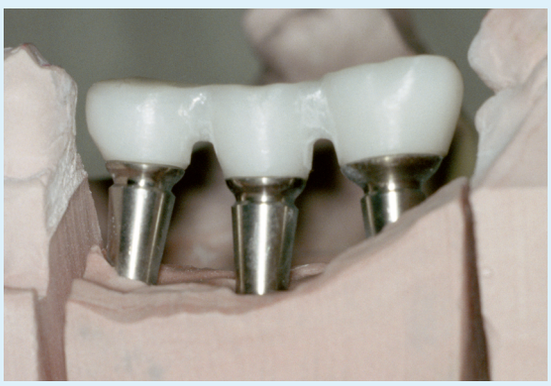
The treatment was performed at the Department of Prosthetic Dentistry, Malmö University. Two dentists treated the patients, one dentist 11 and the other 7.

Dental implants (Astra Tech standard or ST, Astra Tech, Mölndal, Sweden) were installed in a one-stage surgical procedure according to the surgical instructions of the manufacturer. The healing time before prosthodontic treatment was a minimum of 3 months in the lower jaw and 6 months in the upper jaw. The patients were subsequently divided into two groups of nine, one group for treatment with reconstructions made of DZ® and one for InZ®. The patients were randomized to the two groups by drawing lots. Eighteen lots, nine with "Denzir" and nine with "In-Ceram Zirconia" written on them, were enclosed in 18 envelopes. One of the dentists drew an envelope for each patient at the beginning of treatment. Ethical approval for the project plan was obtained from the local committee on ethics.

Full-arch impressions were made with a polyether impression material (Impregum®, ESPE, Germany) in disposable trays (SOLO®, DAVIS, Hertfordshire, U.K.) to allow use of the open-tray technique. Impressions of the opposite jaw were made in rigid standard stainless steel trays with alginate (Svedia, Svedia Dental Industri, Enköping, Sweden), and finally inter-occlusal registrations in centric relation were made in aluminum wax (Alminax®, Associated Dental Products, Wiltshire, Great Britain). Preparable titanium abutments (Astra Tech ST) were used. The supporting implant abutments were prepared with a cervical shoulder depth of 1.2 mm and slightly rounded inner angles. The preparations allowed a minimum material thickness of 1.7 mm occlusally and 1.5 mm buccally, approximally, and lingually.

A

B



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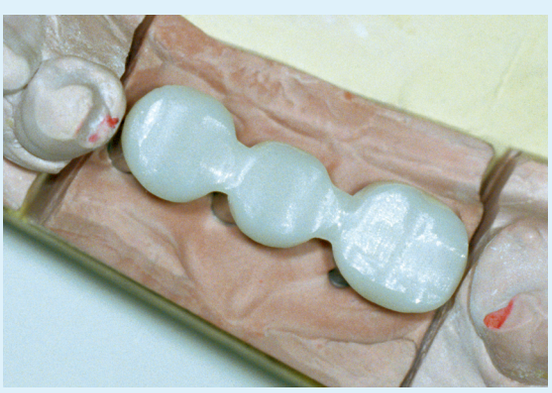

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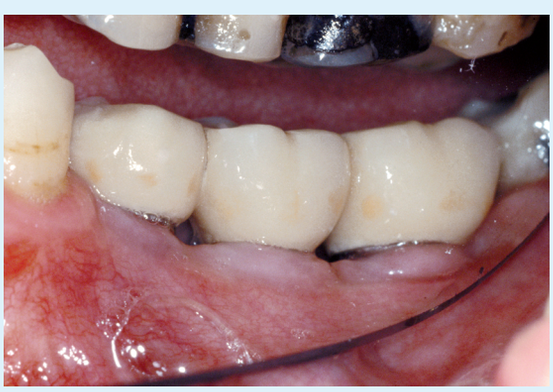

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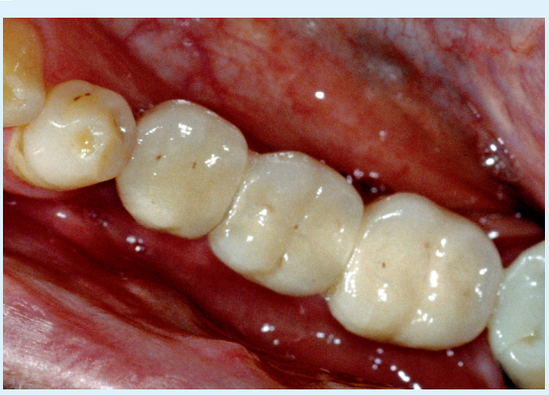


Figure 1A.
Prepared titanium abutments, shoulder with rounded inner angle.

Figure 1B.
Finished core (Denzir®), buccal view.

Figure 1C.
Finished core (Denzir®), occlusal view.

Figure 1D.
Cemented construction in place, buccal view.

Figure 1E.
Cemented construction in place, occlusal view.

Table 1. Margin integrity according to the modified California Dental Association (CDA) protocol

Score	Criteria
Romeo (exellent)	No visible evidence of crevice along margin into which the explorer can penetrate No discoloration on the margin between the restoration and the implant abutment
Sierra (acceptable)	Slight marginal discrepancy detectable; repair is unnecessary Discoloration between restoration and implant abutment
Tango (retrievable)	Faulty margins that cannot be properly repaired Penetrating discoloration between restoration and implant abutment Retained excess cement
Victor (unacceptable)	Mobile restoration Fractured restoration Fractured secondary implant component Fractured fixture

Table 2. Surface according to modified California Dental Association (CDA) protocol

Score	Criteria
Romeo (exellent)	The surface of the restotarion is smooth. No irritation of adjacent tissue
Sierra (acceptable)	The surface of the restoration is slightly rough or pitted. Can be polished but is unnecessary
Tango (retrievable)	The surface is grossly irregular, not related to anatomy, and not subjected to correction. Can be polished
Victor (unacceptable)	The surface is fractured, or there are gross porosities in the material. Cannot be corrected by polishing. Anatomical form functionally insufficient

The desired angle of convergence was 15°.

All laboratory procedures were carried out at one commercial dental laboratory, which had been authorized by the manufacturers of the material systems. The dentists responsible for the treatment inspected and measured the thickness of the inner constructions and connectors. The minimum acceptable diameter of the connection between crown and pontic was 3 mm for anterior and premolar replacements, as suggested previously (8, 13). In cases of molar replacement, the minimum diameter for the pontic connectors was set at 4 mm according to suggestions made by *Vult von Steyern et al.* (20, 21). For reconstructions with no pontics, the minimum diameter between connecting abutments was set at 3 mm. Radiographic examinations of the frameworks were performed from the occlusal and buccal aspects to detect whether any flaws were present. Reconstructions that exhibited visible pores or other defects were not accepted and were remade. After inspection, the cores were veneered with porcelain as recommended by the manufacturer and fired accordingly in calibrated furnaces. Esprident Triceram (Dentaurum, Ispringen, Germany) veneering porcelain was used for DZ and Vitadur-α (Vita Zahnfabrik, Bad Säckingen, Germany) for InZ.

To avoid creating microcracks and flaws in the material during removal, no temporary cementation was performed, and the completed reconstructions were fitted, adjusted, and cemented permanently with zinc phosphate cement (De Trey® Zinc Crown & Bridge Fixodont® Plus, Dentsply De Trey GmbH, Konstanz, Germany) in one sitting. The occlusion was checked with GHM-Hanel single-sided occlusion foils (Hanel-GHM-Medizinal, Nurtingen, Germany) and if necessary adjusted using high-speed turbine cooled with copious water spray and very fine grit diamond burs (Two-striper VF-grit, Abrasive technologies Ohio U.S.A) and thereafter polished with rubber points (Identoflex, Identoflex AG, Buchs SG, Switzerland) and (Temrex DIAMOND, Temrex Co Freeport, USA). The patients were thereafter scheduled for final check-ups 1–2 weeks after cementation. Follow-up examinations were performed by two calibrated dentists who were not responsible for the treatment after 6 and 12 months. Future follow-ups will be made at 24, 36, 48, and 60 months.

Marginal integrity and surface were rated as excellent, acceptable, retrievable, or not acceptable accor-

Table 4. Distribution of chip-off fractures at the 12-month follow-up

Group/ distribution	Patients (n=18)	Reconstructions (n=25)	Patients with chip-off fractures	Reconstructions with chip-of fractures	Units with chip-off fractures
In-Ceram Zirconia	9	12	1	1	1
Denzir	9	13	5	7	9

Table 3. Placement of the reconstructions, material system, and location of fratures

RECONSTRUCTIONS #	Material system	Units				
1	DZ	25➤	26			
2	DZ	44	45			
3	DZ	35	36➤			
4	InZ	34	35	36		
5	InZ	22		24	25	➤
6	DZ	24	25			
7	DZ	16 ➤	17			
8	DZ	36	37			
9	DZ	35	36➤			
10	DZ	44	45 ➤	46		
11	InZ	44	45			
12	InZ	34	35	36		
13	DZ	11		13	14	
14	DZ	25	26			
15	DZ	15	16			
16	InZ	44	45	46		
17	InZ	35	36			
18	InZ	35		37		
19	InZ	44		46		
20	DZ	35 ➤	36	37 ➤		
21	DZ	34	35 ➤	36 ➤		
22	InZ	46	46	47		
23	InZ	24	25			
24	InZ	34	35	36		
25	InZ	45	46	47		

Abutment (numbers indicate the region for implant position according to the FDI 2-digit tooth numbering system)

Pontic

Denotes upper jaw

Denotes lower jaw

➤Chip-off fracture

ding to a slight modification of the California Dental Association (CDA) quality assessment system (17). The modifications consisted of an adaptation of the CDA system to implant-supported reconstructions as shown in the tables.

The differences in fracture mode were calculated using Fisher's exact probability test.

Results

At the 12-month follow-up, all reconstructions were in use and all patients were fully satisfied with the treatment. For details of placement of the reconstructions see Table 3. None of the reconstructions had fractured. Superficial cohesive (chip-off) fractures were, however, observed (Table 4) in 6 of the 18 patients (8 of 25 reconstructions). Nine units in the DZ group (54%) and one in the InZ group (8%) had chip-off fractures. The difference between the two groups was statistically significant ($P < 0.01$).

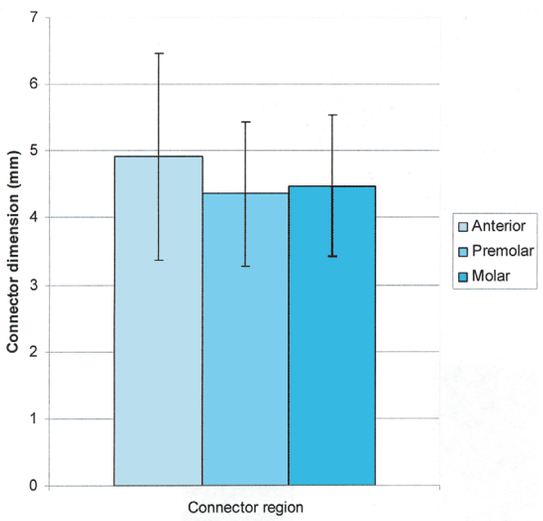
The diameter of the connector between the crown and pontic for anterior replacement varied between 3.2 and 7.2 mm. For premolar replacement, the diameters varied between 4.2 and 5.0 mm. Corresponding values for molar replacement were 4.3 and 6.0. For reconstructions with no pontics, the diameter between connecting abutments varied between 3.0 and 7.5 mm. (Table 5)

Marginal integrity was rated Romeo (excellent) at 34 abutments (56%) and Sierra (acceptable) at 27 (44%) abutments. No margins were rated Tango or Victor. The differences in marginal integrity between the two materials were statistically non-significant.

Discussion

The interest in durable, metal-free, esthetic alternatives to PFM FPDs has led to a higher use of FPDs based on oxide ceramics. Studies on all-ceramic FPDs in general have found 93%–100% 1-year survival rates. Those studies concern both alumina- and zirconia-based FPDs while other studies restricted to FPDs based on zirconia only report survival rates of 100% (15, 19, 20, 21).

Table 5. The connector dimensions: mean values and SDs.



Clinical studies on all-ceramic FPDs have so far concerned FPDs supported by natural teeth. When teeth are lost due to caries or periodontal disease, implants can be used to replace the natural abutments. Since implant-supported FPDs are nowadays a routine treatment alternative and since the results from studies on tooth-supported all-ceramic FPDs cannot be directly transferred to implant-supported reconstructions, clinical studies are needed to confirm or reject such procedures (22). Such clinical studies are lacking, apart from a few case reports (3).

A number of clinical studies on all-ceramic FPDs have shown that catastrophic failures almost always involve the core. This is quite different from the types of failure that occur in conventional FPDs (4, 13, 14, 18, 21). To reduce the problem with the brittle nature of ceramic materials, bending forces in all-ceramic prostheses must be reduced to a minimum. Because implants provide a relatively solid support compared to natural teeth and thereby reduce bending forces in an FPD, they have been suggested as suitable abutments for all-ceramic FPDs (22).

The InZ and the DZ systems represent two different all-ceramic materials and techniques which make them interesting to compare. InZ is a glass-infiltrated, presintered, zirconia-toughened aluminum oxide (ZTA). DZ, on the other hand, is a densely sintered, hot isostatic pressed (HIP), yttria-stabilized zirconium dioxide (Y-TZP). InZ is manufactured by hand by the dental technician whereas frameworks made of DZ are processed using CAD/CAM techniques. CAD-CAM is being used in many new material systems to produce the FPD cores under optimized industrial conditions by milling a substructure from a blank. In this way, it can be assumed that the number of intrinsic flaws in the new materials could be reduced in both number and size compared to traditional ceramics. Thus, it is possible to produce a core with enhanced integrity and strength (2).

Manufacturing FPDs with the In-Ceram technique means few limitations in designing the FPD framework. With the CAD/CAM technique, however, the software, as well as the milling of blanks, can limit the possibilities of giving the restoration a desired shape. The shape of the high-strength inner construction serves to support the less strong veneering material. With CAD/CAM, there is an inherent risk that the shape is insufficient regarding veneer support. This could be one explanation of why there were significantly more fractures of the veneering material in the DZ group than in the InZ group, although the frameworks were checked as described above and no obvious differences between the two materials were noted.

The minor occlusal chip-off fractures experienced in this study were not a cause for replacing any of the reconstructions, especially since many of the patients were unaware of them until the clinical examination. That the chip-off fractures occurred is important to discuss, however, since a fracture is always undesirable and is in one way a failure and indicates merely survival rather than success of the restoration.

One possible reason for veneer fractures is mechanically defective microstructural regions in the porcelain, including areas of porosities, agglomerates, inclusions, and large-grained zones (10,11). The reconstructions were, however, all veneered in the same laboratory according to the manufacturers' recommendations. Two dental technicians made the veneerings, one all the DZ and one all the InZ reconstructions. No differences in the handling or in the environment were detected that could explain the large differences in the results.

Other possible explanations for the fractures could instead lie in the bond strength between the core material and the veneering material. Presence of a glass phase in the core material can facilitate bonding of the veneering material. DZ is a densely sintered material with no glass phase—neither at the grain boundaries nor on the surface—while InZ is a partially sintered, glass-infiltrated ceramic material where the different phases could favour the bonding between core and veneer materials (12). The fracture

pattern is similar to that found in another *in-vitro* study in which alumina and zirconia were used and where veneer fractures were predominantly more frequent in the zirconia group (23).

The quality, composition and microstructure of different veneering porcelains vary. The porcelains recommended by the manufacturers and used for the two material systems differ both in strength and content of glass modifiers. The Espident Triceram porcelain used for the DZ-reconstructions is fired at a lower temperature than the Vitadur-α porcelain. This could be another factor to consider when analyzing the reason for the different numbers of chip-off fractures. Similar problems were noted when the technique of fusing porcelain to titanium was introduced (9).

As all fractures occurred within the porcelain—and not in the interface between core and veneer—it is unlikely that the differences in properties between the two core materials are the reason for the fractures. This fracture-mode corresponds to findings made by other authors who investigated the strength of the substructure and veneering porcelain interface in all-ceramic systems. Microscopic examination of failed specimens in that study showed that failure primarily occurred near the interface with residual veneering porcelain on the core (1).

Propagation of surface flaws can result in veneer fractures. Such flaws may be induced during occlusal adjustments. Other reasons could be that premature contacts are overseen, resulting in occlusal loads that exceed the porcelain's load bearing capacity. As normal procedures for occlusal adjustment were followed and the occlusion was checked before as well as after cementation, These factors were probably not the reason for veneer fractures in the present study.

Bruxism can be another cause of excessive loads. The patients in the present study did, however, not show signs of bruxism. Furthermore, the patients were randomized to one of the two materials, and any overrepresentation of possible bruxers in either of the two groups is therefore unlikely and would not explain the differences in veneer fractures.

Differences between tooth-supported and implant-supported FPDs with conventional metal-ceramic FPDs have been found: significantly fewer porcelain fractures are reported in the first group (4). One explanation of this finding could be the role played by the periodontal membrane which allows for shock absorption, sensory function and, furthermore, tooth movement (4,5). Implants, on the other hand, if well integrated, are characterized by direct contact between the bone and the loaded implant and a lack of shock absorption, sensory response, and movement. Hence, the veneering porcelain appears to be subjected to excessive loads that exceed its load-bearing capacity, resulting more often in chip-off fractures when the reconstruction is supported by implants than when supported by teeth. Further studies are needed to clarify the true reasons for these cohesive chip-off fractures in all-ceramic FPDs.

Evaluation of marginal integrity yielded 34 abutments rated excellent and 27 acceptable. The abutment-fixture connection for the implant system used requires a provisional splinting for the positioning of the abutments. As this is a sensitive procedure that could influence the fit of the reconstructions, it was decided not to draw any conclusions of the fit observed. Furthermore, the preparation design used—a shoulder preparation—has a different marginal fit than a slice or chamfer design; comparisons with conventional PFMs are therefore not valid (16).

Aspects of the method used

The patients in the present study were all recruited through an advertisement in a local newspaper. This approach allows assessment of the behaviour of the studied ceramic material, but no inferences should be drawn regarding the outcome of the treatment modality in larger population groups. On the other hand, the process of selecting which material system should be used for each patient was randomized, which allows for comparisons between the materials. Another factor that could influence conclusions on treatment outcome is that all patients were treated at a specialist clinic restricted to prosthodontic treatment; this limits the applicability of the treatment outcome to other groups of treatment providers (24).

Conclusions

Results from this 12-month trial suggest that all-ceramic implant-supported reconstructions of two- to five-units may be considered a treatment alternative. When comparing the DZ and the InZ ceramic systems, however, this study indicates that the DZ system as used in the present study (Denzir in combination with Espident Triceram) cannot be recommended for the type of treatment evaluated until further studies have solved the problem with the unacceptably high frequency of veneering porcelain fractures. Long-term follow -up studies are thereafter needed

before this material system can be recommend for use in combination with dental implants.

Acknowledgement
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Decreased gum bleeding and reduced gingivitis by the probiotic *Lactobacillus reuteri*

PER KRASSE[1], BIRGITTA CARLSSON[1], CARINA DAHL[1], ANNETTE PAULSSON[1], ÅSA NILSSON[1], GABRIELA SINKIEWICZ[2]

Abstract

◎ The primary aim of this study was to assess if the probiotic *Lactobacillus reuteri* could be effective in the treatment of gingivitis and further to evaluate the influence of the probiotic on plaque and the lactobacilli population in the saliva.

A randomised, placebo-controlled, double blind study was performed over 2 weeks. Fifty-nine patients with moderate to severe gingivitis were included and given one of two different *Lactobacillus reuteri* formulations (LR-1 or LR-2) at a dose of 2×10^8 CFU per day, or a corresponding placebo. At baseline (day 0) gingival index and plaque index were measured on two surfaces and saliva for lactobacilli determination was collected. The patients were instructed how to brush and floss efficiently and study treatment was started. The patients returned on day 14 for final assessment of gingivitis and plaque and saliva was collected.

20 patients were randomised to LR-1, 21 to LR-2 and 18 to placebo. Gingival index fell significantly in all 3 groups ($p < 0.0001$). LR-1, but not LR-2 improved more than placebo ($p < 0.0001$). Plaque index fell significantly in LR-1 ($p < 0.05$) and in LR-2 ($p < 0.01$) between day 0 and day 14 but there was no significant change in the placebo group. At day 14, 65% of the patients in LR-1 were colonised with *Lactobacillus reuteri* and 95% in the LR-2 group.

Lactobacillus reuteri was efficacious in reducing both gingivitis and plaque in patients with moderate to severe gingivitis.

Key words

Gingivitis, Lactobacillus reuteri, probiotics

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Minskad gingival blödning och gingivit efter användning av tuggummi innehållande *Lactobacillus reuteri*

PER KRASSE, BIRGITTA CARLSSON, CARINA DAHL, ANNETTE PAULSSON, ÅSA NILSSON, GABRIELA SINKIEWICZ

Sammanfattning

Avsikten med studien var att undersöka om dagligt användande av ett probiotiskt kosttillskott innehållande *Lactobacillus reuteri* kunde ge positiva effekter på patienter med måttlig eller svår gingivit. I försöket testades placebotuggummi mot 2 olika *L. reuteri* formuleringar (LR-1 och LR-2) innehållande 100 miljoner laktobaciller per tuggummi. Tuggummi togs 2 gånger per dag, på morgonen och på kvällen efter tandborstning. Studien var dubbelblind, randomiserad och löpte över 2 veckor. Totalt deltog 59 patienter.

Två tandytor på varje patient utvaldes och gingival index och plack index mättes för varje yta, både startdagen och efter 2 veckor. För att minimera risken för observatörsberoende bedömning av index utfördes alla bedömningar på en och samma dag av en enda observatör, både vid start och avslut. Tandytorna fotograferades också för att ge ytterligare konsistens i bedömningen. Efter bedömning av index, rengjordes samtliga tandytor och patienterna instruerades av tandhygienist om korrekt tandborstning och behovet av dagligt användande av tandtråd.

Salivprover togs både före och efter test behandling för att avgöra skillnader i laktobacillpopulationen över tiden.

20 patienter randomiserades till LR-1, 21 till LR-2 och 18 till placebo. Gingival Index förbättrades signifikant i samtliga grupper över de 14 dagarna. LR-1 formuleringen var dessutom signifikant överlägsen placebo. Plackindex var också signifikant förbättrat över tiden i de båda reuteri-grupperna.

LR-1 koloniserades i 65% av patienterna och LR-2 i 95%.

Introduction

Gingivitis is one of the most common chronic infections and is caused by accumulation of bacteria in the gingival crevices causing an inflammatory reaction. If the inflammation and degradation of collagen increases the gingivitis may develop into periodontitis.

The first measure for treating gingivitis is to improve the patient's oral hygiene either by mechanical cleaning or by using antiseptic rinses. However, in our clinical experience we see an abundance of patients with recurrent gingivitis in spite of earlier successful treatment.

Anecdotal data has led us to speculate that daily ingestion of the probiotic Lactobacillus reuteri may positively affect the oral microflora, which could be of benefit in terms of reduced gingivitis and gum bleeding. As shown in a recently published study (9), L. reuteri effectively reduces the load of Streptococcus mutans infection in healthy volunteers, indicating that L. reuteri may influence oral microecology.

Probiotics, i.e. bacterial strains with documented health benefits, are becoming increasingly interesting not least because of the good risk-benefit ratio. The potential benefits of probiotics have been studied in gastrointestinal disorders, gynecology, immunology and allergy. LR is a natural component of the lactobacilli population, which inhabits the gastrointestinal tract of humans and animals. The organism has been extensively studied as a probiotic over the last fifteen years and found to possess a number of interesting properties, which constitutes the basis for its current use as a health-promoting bacterium. For comprehensive reviews on probiotics in general, see *Reid et al* (11) , and for L. reuteri specifically, *Casas & Doborgosz* (2).

Although the involvement of the oral microflora on dental and gingival health has been extensively studied (12) only very few reports describe how probiotics impact oral health. Two reports from Finland (1, 8) showed that dental caries and caries risk factors could be reduced by ingestion of probiotic dairy products containing Lactobacillus rhamnosus. Similar results were recently demonstrated for yoghurt containing L. reuteri in Japan (9) where Streptococcus mutans concentrations could be reduced by up to 80% within two weeks. Finally, although *Ishikawa et al* (4) have noted the possible positive effect of a Lactobacillus salivarius strain on pathogenic bacteria in the oral cavity, the only report of probiotic effects on periodontal diseases is an open case study published in Germany 1953 (5) which suggested beneficial effects on gingivitis.

The primary aims of the present study were to investigate two separate Lactobacillus reuteri formulations for their effects on gingivitis, the levels of plaque in gingivitis patients and to what extent the Lactobacillus ecology is influenced by supplementation with L. reuteri.

Material and Methods

The study was designed as a double-blind, placebo controlled prospective randomized study. Patients coming for yearly check-up were invited to participate in the study. They were in general good health and had not participated in any clinical trial during the previous 4 weeks. None had ongoing antibiotic treatment. Only patients with moderate or severe gingivitis were included in the study and a gingival index score of 2-3 on entry was an inclusion criteria. After written informed consent was given, the patients were randomized into three different groups. Group 1 and 2 received one of two different L. reuteri (LR) formulations ("LR-1" and "LR-2", respectively), each containing 100 million colony forming units (CFU) live bacteria. Group 3 received placebo. The L. reuteri strains used in the two formulations were different, both being of human origin. The patients were examined after inclusion (Day 0) according to normal routine and photos of the gingiva were taken before and after probing and thereafter all surfaces were thoroughly cleaned. In order to reduce observer bias, all patients were started the same day and all assessments were carried out by the same observer (P.K.). Two surfaces for each patient were selected for assessment of gingival index (G.I.) (0 = no sign of gingivitis; 1= bleeding, small spot; 2 = bleeding, line at gingiva lining; 3 = bleeding, filling the approximal space) and Plaque Index (P.I.) (0 = no plaque; 1 = a film of plaque adhering to the free gingival margin, apparent on tip of probe; 2 = moderate accumulation of soft deposit, seen with the naked eye; 3= abundance of soft matter within gingival pocket and tooth surface). Assessment of G.I. and P.I. were made chair-side and the photos were later used to verify the initial assessments.

After this examination, the patients started to take the study products. All study products were formulated as chewing gum, identical in shape, texture and taste. The patients were instructed to take one chewing gum in the morning and one in the evening, both after brushing the teeth. In accordance with the normal routine in our clinic, the patients were also instructed how to brush and floss efficiently. The

study continued for 14 days (a total of 28 pieces of chewing gum) after which the patients returned for the 2nd and final assessment.

Salivary samples (no less than 1 ml) were taken on Day 0 and Day 14, collected into sterile plastic containers with 9 ml 0.9% saline solution, and placed immediately in the refrigerator before being analysed for L. reuteri and total lactobacilli content. Within 24 h of sampling, samples were serially diluted (10^{-2} to 10^{-5}) in 0.9% saline solution and plated on modified (plus 2% sodium acetate and 50 mg/L vancomycin) De Man Rogosa Sharpe (MRS, Acumedia, Sweden) agar for the analysis of L. reuteri and on Lactobacillus Selection (LBS, Becton Dickinson, USA) agar for the analysis of total lactobacilli counts. Plates were incubated anaerobically (AnaeroGen, Oxoid, Sweden) at 37°C for 48 h, after which colonies were confirmed as L. reuteri using a BioGaia AB proprietary method (3) based on reuterin production.

As both G.I. and P.I. are qualitative measures only statistical methods for categorical data were used when assessing these parameters. All measured surfaces were included in the analyses. The Wilcoxon Signed-Rank Test (2-sided) was used to analyse differences within groups between days 0 and 14 and the Chi-square test was used to analyse differences between the active groups and the placebo group. The level of statistical significance was set to $P < 0.05$

The study protocol was in accordance with the Helsinki Declaration of Human Rights and approved by the local Ethical Committee at the University of Lund, Sweden.

Results

A total of 59 patients were asked to participate and all were included in the study of which 20 (10 men and

Figure 1. Distribution (%) of G.I. scores at Day 0 (top) and Day 14 (bottom).

(■ = Group 1, ■ = Group 2, ■ = Placebo)

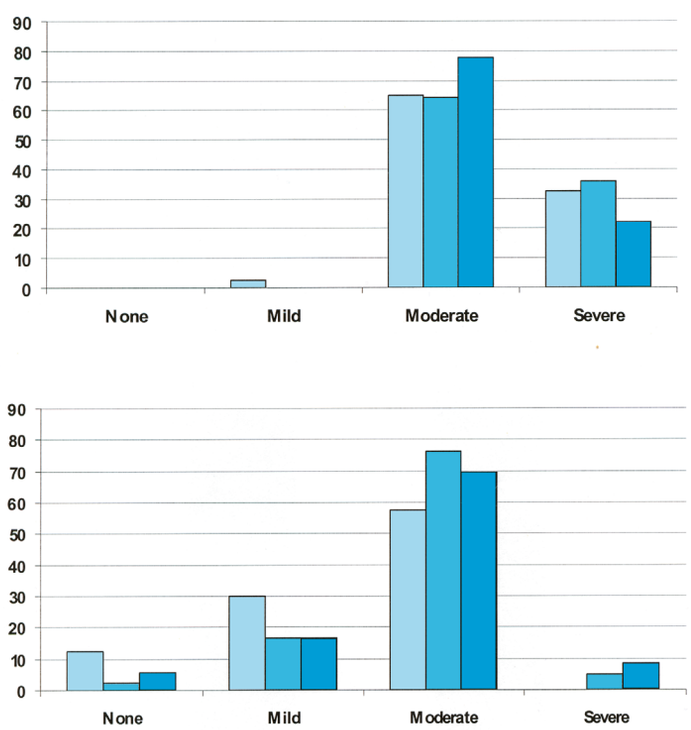

Figure 2. Distribution (%) of P.I. scores in Group 1 (top), Group 2 (middle) and Group 3 (bottom).

(□ = None, ■ = Light, ■ = Moderate, ■ = Severe)

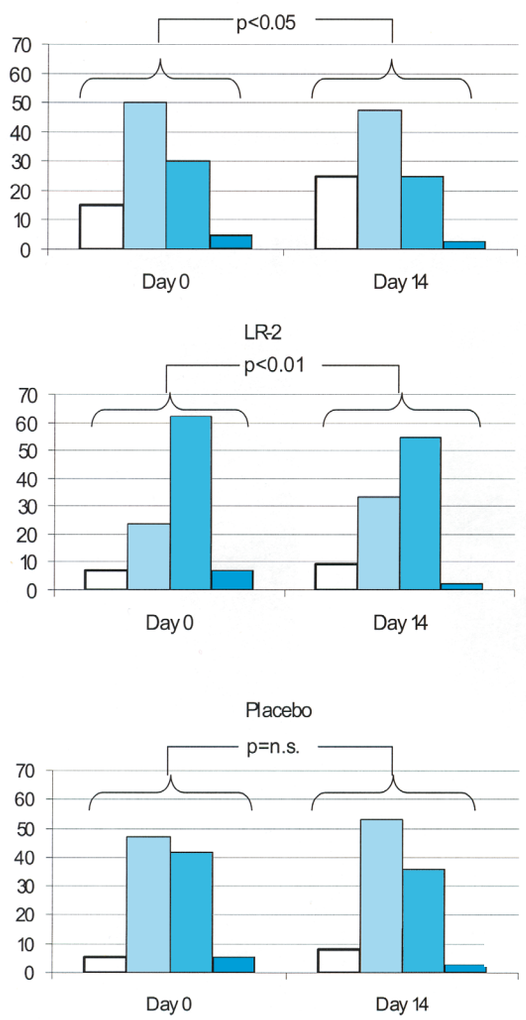

Table 1. Total *Lactobacillus* and *L. reuteri* counts in saliva samples, median values per ml saliva.

	Group 1 LR1 n=20	Group 2 LR2 n=21	Group 3 Placebo n=18
Total *Lactobacillus* (CFU)			
Day 0 (% colonized)	1.35×10^5	4.0×10^3 (76%)	4.3×10^4 (89%)
Day 14 (% colonized)	1.75×10^5 (95%)	1.2×10^4 (100%)	3.2×10^4 (94%)
L. reuteri (CFU)			
Day 0 (% colonized)	0 (0%)	0 (9.5%)	0 (0%)
Day 14 (%colonized)	7.7×10^3 (65%)	2.0×10^4 (95%)	0 (6%)
% of total *Lactobacillus*, Day 14	35%	62%	0%

10 women) were randomized to receive LR-1 (Group 1), 21 to LR-2 (Group 2) (9 men, 12 women) and 18 to placebo (Group 3) (10 men and 8 women). The mean age for Groups 1, 2 and 3 was 55.9 (SD 16.8), 51.7 (SD 16.3) and 50.7 (SD 15.0) years, respectively. There were no statistical demographic differences between the groups.

The outcome of the G.I. scoring is given in Figure 1. The randomization procedure was successful as there were no statistical differences between the three groups on Day 0 (Kruskal-Wallis, p=ns). At Day 14, there was a statistically significant shift within all groups towards a milder G.I. score compared with Day 0 (Wilcoxon Signed-Rank Test, $p<0.0001$). Compared with placebo, the G.I. on Day 14. in Group 1 was significantly improved (Chi-square, $p<0.0001$), but there was no statistically significant difference in G.I. between placebo and Group 2 on Day 14. Moreover, there were significantly higher numbers of improved surfaces in Group 1 on Day 14 compared with Group 3 (77,5% vs 44,4%; $p<0.05$, Fisher's Exact).

P.I. scores are given in Figure 2. Unfortunately, the distribution of P.I. scores was not equal at Day 0 (Kruskall-Wallis, $p<0.025$) and Group 2 started the study with a significantly more severe distribution of P.I. scores compared with both Group 1 and placebo (Chi-square, $p<0.001$). However, after 14 days of supplementation, both Group 1 and Group 2 had attained significantly lower P.I. scores compared with Day 0 (Wilcoxon Signed-Rank, $p<0.05$ and $p<0.01$, respectively). The change within the placebo group was not significant.

Lactobacillus total counts and L. reuteri counts varied considerably (Table 1). On Day 0 the majority of the patients were colonized with lactobacilli in the oral cavity but only 2 patients (both in Group 2) had L. reuteri present in the saliva. After 14 days, 65% of the patients in Group 1 were colonized with L. reuteri which accounted for 35% of the total Lactobacillus population. In Group 2, 95% were colonized with L. reuteri, accounting for 62% of total Lactobacillus population. Thus, the L. reuteri strain in the LR-2 formulation given to Group 2 seemed to have better colonizing ability than the strain used in Group 1.

Two patients, one in Group 2 and one in Group 3 reported that they had been treated with antibiotics during the test-period. 1 patient in Group 2 reported increased bowel movements under the period, otherwise there were no reports on adverse events and the test products were well-tolerated.

Discussion

It is well known that the effect of professional cleaning of teeth and gingiva is effective in the short-term treatment of gingivitis. In our experience, this effect usually lasts 1-3 weeks before plaque and gingivitis start to re-appear. The cleaning effect was clearly demonstrated in the present study as the gingival index was strongly reduced in all three groups, including the placebo group. Despite this effect of professional cleaning, however, the reduction in gingival index was stronger and significantly better than placebo in subjects supplemented with L. reuteri LR-1. There were also significantly more improved surfaces in this group compared with the placebo group.

The positive effect on plaque is less obvious than the effect on gingivitis although significant reductions in P.I. were also observed in both L. reuteri supplemented groups.

Before supplementation, the patients had total Lactobacillus counts ranging from 90 000 CFU/ml up to 500 000/ml and the inter-individual differences were very large. Lactobacilli were found in most of the patients. At day 14 the total count had increased slightly as expected in the two LR groups. LR-2 seems to be the better oral cavity colonizer of the two LR strains, achieving colonization in all but

one of the patients at day 14. This is also consistent with in vitro findings that the LR-2 strain displays better binding to salivary mucus than LR-1 (results not shown). Our findings indicate that both strains of L. reuteri have positive effects on oral health and that they may be complementary.

The possible mechanisms of action of L. reuteri on gingivitis and plaque remain to be elucidated. Earlier studies point to at least three possible mechanisms which should be considered for further study. Firstly, L. reuteri is known to produce an anti-microbial substance, reuterin, that effectively inhibits a wide range of pathogenic bacteria (2). Secondly, strains of L. reuteri have demonstrated an ability to block binding of pathogenic bacteria to host tissue (7). Finally, the emergence of data to suggest anti-inflammatory effects of L. reuteri on the intestinal mucosa through the inhibition of pro-inflammatory cytokines in vitro (6) and in vivo (10) might be the basis of a direct or indirect effect of this bacterium on the gingiva in subjects with gingivitis.

To our knowledge, this is the first double-blind clinical study demonstrating an effect of probiotics on periodontal disease and we conclude that L. reuteri may be a useful aid in improving the oral health of gingivitis patients. The mechanisms of action of L. reuteri on gingivitis remains to be shown and further studies should be performed to confirm our initial findings in larger populations.

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Functional appliance treatment outcome and need for additional orthodontic treatment with fixed appliance

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Abstract

The objectives of this study were to investigate (1) the results of treatment with functional appliances in mixed dentition run by general practitioners, (2) factors associated with a final treatment result of overjet of ≥5 mm and (3) the need of additional treatment with fixed appliances.

The study was designed as a retrospective, cross sectional survey and conducted in one of the Public Dental Clinics and the Orthodontic Clinic in Lidköping, Sweden.

122 patients (aged 7.6 - 13.2 years) with an overjet of ≥7 mm and consecutively collected for treatment with functional appliance therapy.

Patient files were analysed with regard to gender, age, initial class II severity, type of functional appliance, co-operation, overall growth, number of missed appointments and treatment time. The treatment results were studied and correlated with the above-mentioned variables. The need for additional treatment with fixed appliances was evaluated.

A final overjet of ≤5 mm was observed in 61.5% of the patients, 48.4% interrupted treatment prematurely and 33.6% received additional treatment with fixed appliances. Good co-operation and extended treatment time was found to be correlated with a final overjet of ≤5 mm. Other factors not associated with treatment outcome were age, gender, overjet, overbite, molar relation, type of functional appliance, overall growth and number of missed appointments.

Activator treatment was successful in reducing overjet to 5 mm or less in almost two thirds of the treated patients. Mainly because of poor functional appliance treatment results or relapse, one third of the patients were retreated with fixed appliance. Since good co-operation is one of the main factors for successful treatment outcome, evaluation of the motivational level of both the parents and the patient before treatment start is crucial.

Key words

Activator, class II treatment, general practitioner, headgear activator, mixed dentition.

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Resultat efter behandling med aktivator och behovet av ytterligare behandling med fast apparatur

SARA RIZELL, BENGT SVENSSON, CHRISTINA TENGSTRÖM, HEIDRUN KJELLBERG

Sammanfattning

Många patienter med klass II bett, som behandlas med fast apparatur, har tidigare fått behandling med aktivator med bristande resultat. Syftet med denna studie var att (1) undersöka resultatet av behandling med aktivator som utförts inom distriktstandvården (2) undersöka faktorer som är associerade med reduktion av den horisontella överbitningen till ≤5 mm (3) kartlägga kvarstående behov av ytterligare behandling med fast apparatur. Etthundratjugotvå patienter med horisontell överbitning ≥7 mm och som behandlats med Andresen aktivator eller EOD-aktivator inkluderades i denna retrospektiva studie. Från patientjournalerna registrerades kön, ålder, horisontell och vertikal överbitning, molarrelation, typ av apparatur, kooperation, längdtillväxt, antal uteblivanden samt behandlingens duration. Behandlingsresultatet studerades och korrelerades till ovan nämnda variabler. Om patienten genomgått eller tackat nej till erbjudande om ytterligare behandling registrerades likaså. En horisontell överbitning på ≤5 mm erhölls hos 61,5 % av patienterna, 48,4% avbröt behandlingen i förtid och 33,6% genomgick ytterligare behandling med fast apparatur. God kooperation och längre behandlingsduration var de enda faktorer som kunde korreleras till horisontell överbitning ≤5 mm efter avslutad behandling. Sammanfattningsvis erhölls en reduktion av den horisontella överbitningen till 5 mm eller mindre i nästan två tredjedelar av behandlingarna med aktivator. En tredjedel av patienterna fick ytterligare behandling med fast apparatur framför allt pga bristande resultat vid aktivatorbehandlingen eller recidiv. Eftersom god kooperation är en av huvudfaktorerna för tillfredsställande behandlingsresultat är utvärdering av motivationen hos både patient och föräldrar av stor betydelse.

Introduction

Many patients with the diagnosis class II malocclusion that are treated with fixed appliances in the permanent dentition have previously been treated with a functional appliance without reaching satisfying results. Twenty percent of a patient group treated only with removable functional appliances still had an overjet of ≥6 mm at 19 years of age, whereas none of the class II cases treated with fixed appliances showed such an unfavourable outcome (8). Moreover, treatment of a class II division 1 malocclusion was more effective (i.e. a larger reduction of PAR within a shorter time) if it was performed with a fixed appliance as compared with an activator or a combination of both (22).

In a recent paper the advantages of treating patients in two phases, starting with a functional appliance to facilitate later fixed appliance treatment, was studied. The authors found that neither the extraction frequency (as a measure of the severity of the treatment needed) nor the treatment time with fixed appliances decreased with previous functional appliance treatment as compared with patients treated with fixed appliances only (19). The fact that total treatment time was longer for combined treatment has also been confirmed by other authors (22). It has also been shown that no difference exists after completed treatment when comparing skeletal change, alignment and quality of the occlusion in patients treated with an activator followed by fixed appliances versus patients treated with fixed appliances only (19).

Despite the depressing results of functional appliance treatment, it is a commonly used method in class II treatment. The advantages of using it are the low risk for iatrogenic effects, the possibility to use it in mixed dentition, its easiness to handle and relative low cost, provided no further treatment with fixed appliances is needed. However, removable functional appliances seem to be difficult or inconvenient to use and activators dominate among treatments with removable appliances that are prematurely interrupted (11). Discontinued treatments consume a considerable portion of the overall budget of orthodontic treatment at the Public Dental Clinics (6, 11). In Sweden, both general practitioners and orthodontists perform orthodontic treatment of children. Somewhat simplified, the general practitioners treat patients that need interceptive treatment (mainly with removable appliances) under the guidance of a consulting orthodontist. The orthodontists treat more severe cases and most of the patients requiring fixed appliances. Therefore, the aims of this study were to (1) investigate the results of treatment with functional appliances in mixed dentition, run by general practitioners, (2) find factors correlated with a final treatment result of overjet ≤5 mm and (3) evaluate the need of additional treatment with fixed appliances in the permanent dentition.

Materials and methods

All patients with an initial overjet of ≥7 mm from one of the Public Dental Clinics in Lidköping that finished treatment with removable functional appliances during the years 1989 to 2001 were included in the sample. The number of patients that fulfilled the inclusion criteria was 131. There were nine dropouts because of missing patient records (5 patients) or the patients moved during treatment (4 patients). There is no reason to believe that the dropouts were different from the remaining sample. The remaining sample consisted of 122 individuals (mean age 10.0 years, range 7.6-13.2 years). Of these, 72 were boys (mean age 10.2 years, range 7.6-13.2) and 50 girls (mean age 9.8 years, range 7.6-13.0).

Functional appliance treatment (first phase treatment)

Nine general practitioners at the National Dental Clinic in question treated the patients with functional appliance while one orthodontist performed all the orthodontic consultations. Twenty patients were treated with an Andresen activator and 102 with a headgear activator (Figure 1). The indication for both the studied appliances was Angle II:1 cases, where there was a possibility of good occlusion in a protruded position and where a retroclination of upper and proclination of lower incisors was beneficial. Andresen activator was chosen in low angle cases, in cases with deep overbite and aims to correct equally in upper and lower jaw simultaneously as it promotes eruption of the lateral segments. The headgear activator was chosen in high angle cases and when the intrusive and distalizing effect of the upper dentition was the main objective. Variables that might have an impact on the treatment result were extracted from the patient files. These variables included gender, age at treatment start, initial overjet, initial overbite, initial molar relation on right and left side, type of appliance, co-operation, overall growth in height, treatment duration and number of missed appointments. Post-treatment overjet was noted as well. Information about additional treatment or reasons for premature interruption of treatment was also obtained.

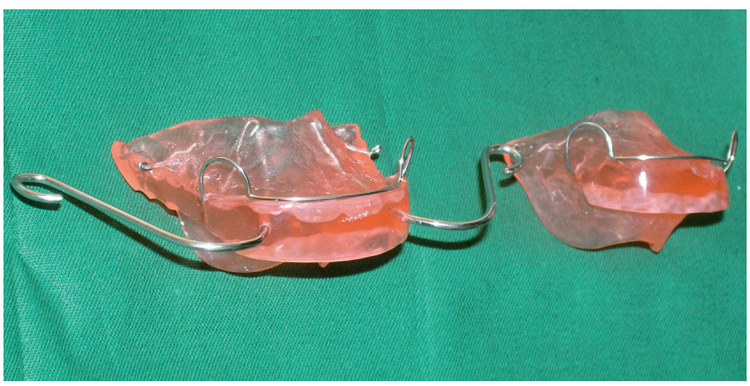


Figure 1: The Andresen activator was constructed with: springs mesial to the maxillary first molars, a facial bow, acrylic capping of lower incisors and grinding to allow eruption of buccal segments in maxilla and mandible. The headgear activator was constructed with: springs mesial to the maxillary first molars, facial bow, acrylic capping of lower incisors, headgear built into the acrylic, high pull extraoral traction and grinding to allow eruption of the mandibular buccal segment only (if deep overbite).

Comments on some of the variables:

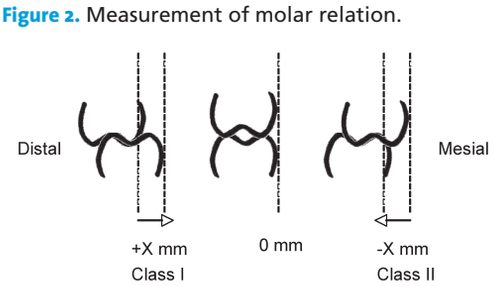
Initial molar relation: The sagittal distance between the mesial surfaces of the maxillary first molar and mandibular first molar was measured (Figure 2). Cusp to cusp molar relation was noted as zero, Class III and neutral molar relation as positive values and Class II molar relation as a negative value.

Co-operation: Patient co-operation was subjectively estimated to "co-operation", "non co-operation" or "varying co-operation" according to the daily notes in the patient files. Non co-operation was defined as not using the appliance according to instructions. Patients were judged to have varying co-operation if the co-operation was fluctuating, for example the patient co-operated in the beginning of treatment but ceased to do so later in treatment.

Overall growth in height: The patient's overall body height was measured several times during treatment. To calculate mean growth the difference between body height at the appointments nearest to treatment start and treatment finish was divided by the number of years between the two appointments.

Treatment duration: Treatment duration was calculated from the appointment in which the patient received the appliance until he or she no longer used the appliance, i.e. treatment duration included both active treatment and retention time.

Figure 2. Measurement of molar relation.



Treatment result: The patients were divided into two groups depending on the treatment outcome, one group with final overjet of ≤5 mm and one group with final overjet of >5 mm.

Statistics

Concerning the final overjet, a t-test was used to test associations with the quantitative variables and the chi-square test or Fisher's exact test was performed to test the qualitative variables. Logistic regression was performed to confirm the results and test all of the variables in a large model.

Fixed appliance treatment (second phase treatment):

Of the 122 patients from the first treatment phase, 36 were referred to the Orthodontic Clinic in Lidköping for additional treatment with fixed appliances. Before fixed appliance treatment, the overjet was measured on plaster casts from the registration appointment. The patients were divided into three groups according to the reason for their additional treatment with fixed appliances:

1. Final overjet of ≤5 mm, supplementary treatment was indicated because of other diagnoses, such as crowding or eruption disturbance.
2. Final overjet of >5 mm.
3. Final overjet of ≤5 mm but a later relapse to >5 mm at the registration appointment at the Specialist Clinic.

Results

The frequency of patients having no additional treatment after the functional appliance treatment was 49.6%, including 15.1% in which fixed appliance treatment was discussed but the patient refused this service (Figure 3). After functional appliance treatment, 26.0% of the patients were treated with additional removable appliances at the Public Dental

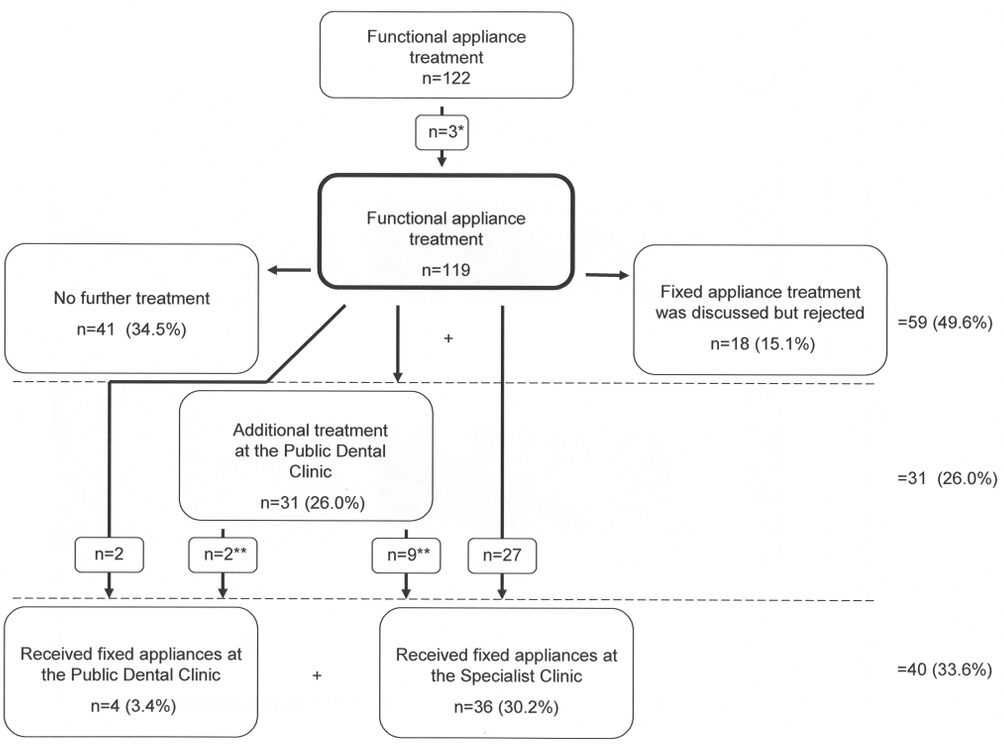


Figure 3. "Flow of patients" from phase one to phase two.
*Three patients moved from the area after fixed appliance treatment. No information is available about eventual supplementary treatment.
**Eleven patients (9.2%) were treated with both additional removable and fixed appliance after functional appliance treatment.

Table 1: Initial registration of patients in phase one and post-treatment overjet. Initial molar relation is measured as displayed in Figure 1.

	Mean (mm)	Range (mm)	n
Initial molar relation, right side	-1.8	-6.0 - +3.0	119
Initial molar relation, left side	-1.7	-6.0 - +5.5	119
Overbite	3.9	0.0 - 7.0	97
Pre-treatment overjet	8.4	7.0 - 11.8	122
Post-treatment overjet	5.0	1.0 - 11.0	122

Table 2: Number of appointments, missed appointments and treatment duration in phase one.

	Mean ± SD	Range
Number of appointment with general practitioner	12.3 ± 5.66	2-30
Number of consulting appointments	3.5 ± 1.31	1-8
Number of missed appointments	0.6 ± 1.08	0-6
Treatment duration (in months)	21.0 ± 10.60	2-55

Clinic. Additional fixed appliance treatment was performed in 33.6% of the patients. After functional appliance treatment, 11 patients (9.2%) received treatment with both removable and fixed appliances.

The initial severity of the class II malocclusion is shown in Table 1. Negative values of molar relations in this table indicate Class II relations. Positive values, which indicate Class I or Class III relations, are due to single patients with asymmetric molar relations or are due to mesial drift because of extractions. The mean overall growth was 5.9 cm/year (range 1.9 – 12.8 cm/year, n=84). The number of visits, missed appointments and treatment duration are presented in Table 2.

Concerning patient co-operation, the data indicated that 43.4% of the patients were co-operative, 37.7% were non-co-operative and 18.9% expressed varying co-operation. Fifty-nine patients (48.4%) interrupted their treatment before completion. The reasons why treatment was not completed could be

divided into the following four groups:

1. Practical problems with usage: "allergy to acrylic", "appliance is removed during sleep", "breathing problems", "gingival vesicles", "exfoliating teeth", "mouth breathing", "sleeps with open mouth", "sleeping problems", "sore soft tissues", "nauseating feeling", "sweating because of extra oral traction", "tender teeth", "illness", "allergy", "frequent colds", "activator broken" or "appliance eaten by the dog"
2. Lack of treatment results: "Patient does not use the appliance", "appliance does not work", "no treatment results" or "poor co-operation"
3. The patient or the parent indicates the interruption: "Parent wishes to interrupt treatment", "patient wishes to interrupt treatment", "lack of interest" or "have become tired of treatment"
4. Odontological indication for interruption: "Trauma", "poor transversal expansion", "posterior teeth do not erupt" or "changed therapy because of crowding"

The distribution of the different groups is given in Table 3. In 15 of the patients in group one the appliance came out during the night and in 12 patients the appliance could not be worn because of breathing problems. Seven patients (5.7%) were planned from the start to have functional appliance treatment continued with fixed appliances. However, only three of these seven patients received fixed appliance treatment.

The mean overjet after functional appliance treatment was 5.0 mm (range 1 mm to 11 mm) (Table 1). A final overjet of ≤5 mm was found in 61.5% of the patients.

Statistically significant correlations between a final overjet of ≤5 mm and patient co-operation as well as long treatment duration were observed (Table 4). None of the remaining variables was associated with final overjet.

The reasons for a second treatment phase with fixed appliances, were divided into three categories as shown in Table 5.

Table 3: Reasons why patients interrupted treatment prematurely in phase one.

	Number of patients	%
1. Practical problems with the usage	34	57.6
2. Lack of treatment result	14	23.7
3. Patient or parent indicates the interruption	8	13.6
4. Odonttological indication for interruption	3	5.1
Total	59	100.0

Table 4: Results of the correlation between tested variables and treatment outcome.

Variable	Final overjet ≤5 mm/ Final overjet of >5 mm s/ns	p
Gender	ns	0.7068
Type of appliance	ns	0.3916
Co-operation	s	<.0001
Age at treatment start	ns	0.8082
Initial molar relation, right side	ns	0.2449
Initial molar relation left side	ns	0.6109
Initial overket	ns	0.7581
Initial overbite	ns	0.9653
Overall growth in height	ns	0.7102
Treatment duration	s	<.0001

Table 5: Reasons for phase two treatment with fixed appliances at the Specialist Clinic.

Reasons for phase two treatment	Patients	%
1. Final overjet of ≤5 mm, other indication	5	13.9
2. Final overjet of >5 mm	22	61.1
3. Final overjet of ≤5 mm mm. later relapse	9	25.0
Total	36	100

Discussion

This study has evaluated the results of treatment with removable functional appliances. A final overjet of ≤5 mm was reached by 61.5% of the patients. The main part of the patients (66.4%) received no additional fixed appliance treatment. This study has the advantage to include all consecutively patients with an initial overjet of ≥7 mm that were treated with functional appliance at the clinic in question. The study reflects the outcome of the treatment in a normal Swedish general practice overviewed by an orthodontist. However, because it is a retrospective study, weak points are obvious, such as missing data and uncontrolled conditions during treatment. The patients were divided into two groups, based on post-treatment overjet. Although more careful recordings may have been made if the patients were followed prospectively, a large overjet, in combination with incompetent lips, is the main measure for class II cases to determine whether activator treatment should be performed. Therefore, the information obtained from this study is deemed important. The border line for the two groups based on treatment outcome was chosen to be an overjet of ≤5 mm, which may seem as a rather broad defi-

nition. This figure was chosen because of that we do not consider an overjet of 5 mm to be any indication for orthodontic treatment, unless it is not combined with other diagnosis. Varying frequencies of successful functional appliance treatment have been reported (1, 2, 5, 6). This variation, of course, depends on the fact that definitions for successful treatment outcome are based on different measures. Furthermore, authors are using different limits of overjet to define successful outcome combined with additional factors such as a certain overbite, stable class I occlusion and alignment of upper incisors (2, 5, 6). The rather large variation used in defining successful treatment makes it hazardous to compare between different studies. The variability of treatment results in our investigation was large, with a post-treatment overjet ranging from 1 to 11 mm. Similar varying results have been reported in other studies (17, 20)

A considerable number of patients interrupted treatment. This high figure and the reasons for the interruption of treatment indicate that patients commonly find functional appliances inconvenient and have difficulty using these devices. These findings are supported by a Swedish study in which 17% of all orthodontic treatments at the actual Public General Clinic were prematurely interrupted, and where activators dominated among the interrupted treatments (11). All possible measures should therefore be undertaken that could decrease the number of interrupted treatments, such as using open activators to reduce breathing difficulties or measures to retain the appliance better in the mouth. In the present study one third of the patients had additional treatment with fixed appliances. *Bondevik* found that 35 out of 49 patients needed a second phase of treatment with fixed appliances, suggesting stringent criteria for satisfactory treatment results (3). In Bondevik's material patients that exhibited poor co-operation or were initially planned to have second-phase treatment were excluded and still this figure is surprisingly high.

Because treatment with removable functional appliances in many cases end with interruption or disappointing results, selection of cases suitable to obtain as high a rate of satisfactory treatment as possible seems difficult. Co-operation was one of the factors that we found to be correlated with treatment outcome. Moreover, it was the only variable *Bondevik* found that could be significantly linked to satisfactory results (2). *Tulloch et al.* reported contradictory results and found no correlation between treatment outcome and co-operation (18). However, it is difficult to obtain a reliable measure regarding how long time per day the appliance is actually worn. Several authors have tried with varying success to quantify objectively the time the appliance is used, either with patient logs, special devices or subjective judgement by the clinician (13, 18). Careful evaluation of breathing pattern, as well as the motivation of both the child and the parents before treatment is started might be one approach to decrease the number of interrupted treatments. It is important to be assured that the patient has parental support and that they are aware that the treatment is an inconvenience demanding considerable effort and co-operation. The importance of support from parents has also been noted by other authors, especially in the younger patient groups (11, 16). Because the general practitioner knows how the patient and family have co-operated concerning previous dental treatment, his or her knowledge is paramount concerning the decision of class II treatment.

The treatment duration was significantly higher in the group with a final overjet ≤5 mm. The group of patients interrupting treatment within a few months and only achieving minor improvement of the overjet probably influenced this result.

We found no association between final overjet and initial severity of the class II malocclusion (measured as overjet, overbite and molar relation). This finding is not consistent with that found in other studies, which have shown that patients with successful treatment had less initial overjet (21). *Wheeler et al.*, demonstrated that patients with mild initial molar class II severity were 10 times more likely to achieve successful treatment than patients with a severe class ll molar relation. Their results suggest that the most severe class II cases are prone to poor treatment results and risk additional treatment with fixed appliances in the permanent dentition.

Favourable facial growth has been reported if the dentofacial orthopaedic treatment is performed close to the peak height velocity (10). Repeated measuring of standing height is a method being used to predict pubertal growth spurt (9, 15). However, we could not find a significant association to overall growth or age and treatment outcome. The lack of correlation between treatment outcome and age has been confirmed by *Tulloch et al.*, who measured chronological, skeletal and dental age (20). There are studies reporting that two-phase treatment did not result in a reduction of average time in fixed appliances or a reduction in complexity of treatment in phase two (12, 19). On the other hand, there are ad-

vantages with starting class II treatment early. For example, it has been found less external apical root resorption following two-phase treatment as compared with one-phase treatment (4). Early treatment to reduce large overjet could also prevent incisor trauma (7, 14).

Conclusions

• A final overjet of ≤5 mm was obtained in 61.5% of the patients treated with functional appliances.
• 33.6% of the patients treated with functional appliances received fixed appliance treatment, primarily because of poor treatment results or relapse.
• Co-operation and longer treatment duration were associated with a favourable treatment outcome. No association was noted between gender, age, initial overjet, overbite, molar relation, type of appliance, overall growth, number of missed appointments and treatment outcome. The importance of evaluating the motivation of the patient and parents before treatment begins is crucial in that functional appliance treatment is associated with wearing inconvenience and higher rates of patients dropping out of treatment prematurely.

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Pain relief after scaling and rootplaning by monochromatic phototherapy (Biolight®)

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Abstract

The present clinical trial was designed to evaluate pain relief after scaling and rootplaning treatment, of patients with periodontal disease, by the use of monochromatic phototherapy (Mpht) (Biolight®) vs. placebo. 20 randomly selected patients, 35-75 years of age, with at least ten tooth pockets, with probing depths ≥ 5mm, equally shared between at least two opposite quadrants were chosen. Patients using anti-inflammatory drugs or painkillers were excluded. Scaling and rootplaning under local anaesthesia was performed by a dental hygienist, on randomly selected quadrants in all patients. Additional treatment with placebo or monochromatic phototherapy was given to the patients. The patients registered pain on a Visual Analogue Scale (VAS) (100 mm) on two occasions, the first after the effect of the local anaesthetic had worn off and the second 24 hours post-treatment. The results showed that, no pain relief could be obtained after monochromatic phototherapy compared to placebo.

Key words

phototherapy, scaling and rootplaning (SRP), pain, pain relief, Visual Analogue Scale (VAS).

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Smärtlindring efter depuration med hjälp av monokromatisk fototerapi (Biolight®)

DIMITRIOS TAKAS, GEORG TELLEFSEN, GUNNAR JOHANNSEN

Sammanfattning

Målet med studien var att utvärdera den smärtlindrande effekten av monokromatisk fototerapi (Biolight®) vs placebo, efter depuration och rotplaning, hos parodontit patienter. Slumpmässigt valdes 20 patienter mellan 35 och75 år. Patienterna hade minst 10 tandköttsfickor med fickdjup ≥ 5mm, lika fördelade mellan minst två motstående kvadranter. Patienter som använde antiinflammatoriska och smärtstillande mediciner exkluderades. En ”split-mouth” design valdes där patienterna utgjorde sina egna kontroller. Patienterna fick lokal anestesi. Depuration och rotplaning utfördes av tandhygienist på slumpmässigt valda kvadranter på alla patienter. Dessutom fick patienterna monokromatisk fototerapi dvs Biolight® behandling eller placebo behandling. Smärtupplevelsen registrerades av patienterna på en VAS (Visual Analogue Scale) 100mm vid två tillfällen, dels efter avslutad bedövningseffekt samt efter 24 timmar. Denna procedur upprepades på motstående kvadrant. Resultaten visade inte någon smärtlindrande effekt efter behandling med Biolight® jämfört med behandling med placebo.

Introduction

Monochromatic phototherapy (Mpht) is a treatment method based on light qualities, patented under the trademark Biolight®. Mpht (or pulsating monochromatic light) is claimed to facilitate wound healing and be effective in the treatment of inflammatory conditions (4, 19). The electromagnetic qualities of light can be of use in healthcare and medical care e.g. UV radiation is used in the treatment of psoriasis, laser is used in surgery amongst other things. In Seasonal Associated Depression (SAD) light treatment may be recommended. Light consists of electromagnetic radiation in different wavelengths.

Treatment with Mpht (with a specific amount of energy and a specific wavelength) is based on the assumption that the cells in the area of the body irradiated will be provided with energy, which increases cell activity and speeds up healing (19). Mpht can have a positive effect on microcirculation of the skin in the ulcer margins of pressure ulcers, (amongst hospitalised patients) and therefore may increase oxygen supply in the tissues, thus probably contributing to ulcer healing (19). *Dehlin et al* (4) investigated the effect of Biolight® versus placebo in the capacity of reducing ulcers and found a positive effect using Biolight®.

Periodontal diseases are specific mixed bacterial infections, which cause periodontal destruction in the appropriately susceptible host (6, 15). They are also chronic multifactorial diseases that are mainly caused by gram-negative microorganisms present in the plaque adjacent to the gingiva, resulting in stimulation of host cells to produce molecules important in the immune inflammatory response (9). Regarding gingivitis, many studies have demonstrated the causal relationship between the amount of bacterial plaque and the degree of gingival inflammation (8, 10, 20). While the belief that gingivitis, in time, progresses to periodontitis has been abandoned most believe that, at some point, periodontitis must be preceded by gingivitis (12, 17). Mpht has been used in order to influence the gingivitis process (18). *Persson & Klinge* (18) found that Mpht had an effect on the plaque formation process and gingival inflammation especially in patients with more pronounced gingivitis. A major objective of periodontal treatment is to remove soft and hard supra- and subgingival deposits from the root surface in order to stop disease progression (16). The most commonly used procedure for root surface debridement is mechanical SRP. Postoperative inconvenience such as pain is often reported following SRP. Minimizing this pain is therefore of great importance.

The hypothesis of the present study was that Mpht is better than placebo in reducing pain after SRP. The main purpose of this study therefore was to evaluate the effect of treatment with Mpht in combination with SRP and postoperative pain in patients with periodontal disease. Possible interactions of Mpht with gender, age and smoking habits were also analysed.

Materials and Methods

Subjects:

Twenty patients were randomly selected amongst the registered patients in the Community Dental Clinic, Norrtälje, Sweden. The first twenty patients who fulfilled the criteria for inclusion in the study and who accepted to participate were chosen. Selected patients participating in the study had chronic periodontitis, measured as having at least ten pockets with probing depths ≥ 5mm and equally shared between at least two quadrants. There were 13 male and 7 female patients between the ages of 35-75 years, with an average age of 58 years. Patients using anti-inflammatory drugs or painkillers, were excluded.

Instruments:

Biolight® device (Biolight®, Danderyd, Sweden). The Biolight® beams red and infrared light according to "programmes" specifying a combination of red and infrared light in different quantities and pulsations (wavelengths varying from 637nm to 957nm pulsed from 1Hz up to 9000Hz) designed by Biolight® (www.biolight.se). The Biolight® device is approved for use in the European Union (CE). There are no reports of any known side effects by the use of Biolight®.

To evaluate pain the VAS (Visual Analogue Scale) 100mm was used.

Test procedure:

A split mouth design was used where the patients received six minutes of pre-treatment with monochromatic phototherapy (Biolight®) or placebo, extraorally against the cheek where the SRP was planned. Thereafter local anaesthesia was administered and the SRP was carried out. Within ten minutes after accomplished SRP the patient received ten minutes of post- treatment with Biolight® or placebo against the same cheek. The quadrant that was treated first was randomly chosen. The test subjects then evaluated their experience of pain using a VAS on two occasions, first when the effect of the local anaesthesia had ceased and secondly one day later. The forms were completed by the patients after they had left the

clinic. This procedure was repeated for the same patients on the opposite quadrant after a week's time. The dental hygienist who carried out the SRP during the study was consistent.

On the first visit pre- and post- treatment with placebo and on the second visit pre- and post- treatment with "active" Biolight® was used. Neither the patient nor the dental hygienist were informed about the placebo or active Biolight®. The subjects were their own controls. The Biolight® treatment program was designed according to the manufacturer's instructions. Registration of the participants smoking habits showed that ten of the patients were smokers, two occasional smokers and eight non-smokers. Therefore a specific analysis of smoking influence was made.

Informed and written consent was obtained from the patients. The study was approved by the Ethics Committee of Stockholm (04-907/1).

Statistical methods:

All data analyses were made by using SPSS.11.5 software. A number of paired t-tests were used to compare means after both conditions (placebo and "active" illumination). To correct for multiple comparisons Bonferroni´s method was considered. The non-parametric Wilcoxon signed ranks test was also used due to differences in variances between groups in many comparisons.

Results

The results after "active" and placebo Biolight (Mpht) treatments are shown in Table 1. Table 1 shows that pain is reduced after 24 hours in both groups. However no statistically significant differences between the groups were apparent. Table 2, shows that there were no differences regarding men's and women's experience of pain. Table 3 shows the age of patients the median age which was 58 years was selected as a boarder for grouping and pain in subjects <58 years and >58 years was analysed respectively. No differences could be found here either. In Table 4, the subjects were divided into smokers and non-smokers. No differences regarding pain when comparing the groups could be found.

An inspection of the means show that in 15 out of 16 comparisons the average self-rated pain was higher after "active" illumination than in the placebo condition. Although not statistically significant, this is opposite to what was expected. Six patients (30%) reported no differences between "active" illumination and placebo conditions immediately after the SRP treatment and nine patients (45%) reported no differences 24 hours after the SRP treatment. Seven patients (35%) perceived less pain immediately after "active" illumination than after placebo and four patients (20%) perceived less pain 24 hours after "active" illumination than after placebo. All comparisons were re-analyzed by using Wilcoxon signed ranks

Table 1. Pain after "active" and placebo Biolight® treatment respectively

		N	Mean	± SD	p-value
Pair 1 **	Pain immediately after placebo treatment	20	6.75	7.4348	NS*
	Pain immediatley after active treatment	20	8.975	14.28329	NS
Pair 2	Pain 24 H after placebo treatment	20	1.175	2.08551	NS
	Pain 24 H after active treatment	20	2.75	5.18982	NS

* Not significant (=NS)

** Pair 1=the same person before and after irradiation

Table 2. Pain after "active" and placebo Biolight treatment respectively, gender differences

Male=1 Female=2		N	Mean	± SD	p-value
1 Pair **1	Pain immediately after placebo treatment	13	7.1538	7.47324	NS*
	Pain immediatley after active treatment	13	10.3077	16.87891	NS
Pair 2	Pain 24 H after placebo treatment	13	1.2692	2.24179	NS
	Pain 24 H after active treatment	13	2.3846	3.90595	NS
2 Pair 1	Pain immediately after placebo treatment	7	6	7.89515	NS
	Pain immediately after active tretment	7	6.5	8.07775	NS
Pair 2	Pain 24 H after placebo treatment	7	1	1.91485	NS
	Pain 24 H after active treatment	7	3.4286	7.34523	NS

* Not significant (=NS)

** Pair=the same person before and after irradiation

test due to the large differences in variances between groups. The main result did not change i.e. no significant differences were found. Given the small sample the power was low but due to difficulties to calculate the clinically relevant difference and accordingly the standardised difference, power could not be stated more precisely than between 15 and 30%.

Discussion

Mpht is being used by some dental practitioners to enhance healing and reduce pain following, different kinds of periodontal treatment. With this in mind it is important to scientifically evaluate these claimed effects.

The present study gives no support to the hypothesis of a mitigated SRP induced pain when "active" Biolight® was administered compared to placebo. The "active" Biolight® is a combination of monochromatic light with wavelengths varying from 637nm to 957nm pulsed from 1Hz up to 9000Hz which is patented by the producing company (21). *Mokhtar et al* (14) looked at a combination of monochromatic light/low intensity laser irradiation therapy (660nm-950nm J/cm; pulsed at 16 or 73 Hz) upon experimental ischaemic pain in humans and no convincing evidence for hypo-analgesic potential were found.

It might be argued that the study should have been balanced in the respect that the placebo and "active" Biolight® should have been randomly administered. The reason for administering placebo first was to exclude any possible risk for long-term systemic effect of Biolight®. Still, this was blinded both to the patients and to the dental hygienist. The most commonly used methods for the evaluation of pain are the Verbal Rating Scale (VRS), the Numerical Rating Scale (NRS) and the Visual Analogue Scale (VAS). The present study used a VAS, a subjective but well-known and accepted way to evaluate pain. Although scientific validation is difficult, VAS seems

Table 3. Pain after "active" and placebo Biolight treatment respectively, age differences.

age <58=0, age > 58=1		N	Mean	± SD	p-value
0 Pair 1 **	Pain immediately after placebo treatment	12	4.875	6.23088	NS*
	Pain immediately after active treatment	12	5.625	9.90667	NS
Pair 2	Pain 24 H after placebo treatment	12	0.7917	1.49937	NS
	Pain 24 H after active treatment	12	2.5833	5.69622	NS
1 Pair 1	Pain immediately after placebo treatment	8	9.5625	8.59999	NS
	Pain immediately after active treatment	8	14	1874643	NS
Pair 2	Pain 24 H after placebo treatment	8	1.75	2.76457	NS
	Pain 24 H after active treatment	8	3	4.69042	NS

* Not significant (=NS)

** Pair=the same person before and after irradiation

Table 4. Pain after "active" and placebo Biolight treatment respectively, smoking differences.

occasional smokers=0 non-smokers=1, smokers=2		N	Mean	± SD	p-value
0 Pair 1 **	Pain immediately after placebo treatment	2	16	1.41421	NS*
	Pain immediately after active treatment	2	18	22.62742	NS
Pair 2	Pain 24 H after placebo treatment	2	3	1.41421	NS
	Pain 24 H after active treatment	2	0.5	0.70711	NS
1 Pair 1	Pain immediately after placebo treatment	8	7.0625	7.27244	NS
	Pain immediately after active treatment	8	8.25	13.97702	NS
Pair 2	Pain 24 H after placebo treatment	8	0.875	1.80772	NS
	Pain 24 H after active treatment	8	2.125	3.4821	NS
2 Pair 1	Pain immediately after placebo treatment	10	4.65	7.16492	NS
	Pain immediately after active treatment	10	7.75	14.19947	NS
Pair 2	Pain 24 H after placebo treatment	10	1.05	2.36232	NS
	Pain 24 H after active treatment	10	3.7	6.70075	NS

* Not significant (=NS)

** Pair=the same person before and after irradiation

the most accurate and reproducible scale (2). A pilot assessment of alternative methods of quantifying dental pain with particular reference to dentine hypersensitivity by *Gillam et al* (7) confirmed previous conclusions that both verbal and non-verbal techniques quantify sensory and affective aspects of pain. The VAS could be a reliable method to assess pain in a clinical setting (1). The VAS is also a simple, reliable and reproducible method for the assessment of quality of life in urogynecologic research (13). In the present study, a horizontally oriented VAS was used. Breivik & Skoglund (3) evaluated the differences between using a vertically and horizontally oriented VAS and concluded that both were equally effective in assessing pain after oral surgery.

Some of the patients reported postoperative dentine hypersensitivity. Supragingival and subgingival scaling might cause more or less transient occurrence of dentine hypersensitivity (5). This study did not evaluate Biolight´s pain reducing effect on dentine hypersensitivity.

One possible explanation for the findings in the present study is that the pain after SRP is not of such a magnitude for the influence of Biolight® treatment to be detected. A number of test subjects did not experience any pain at all. The results may have been different if a more pain causing therapy had been chosen and evaluated. Further research is recommended to evaluate the effect, if any, of Biolight® as a pain reducing aid, in combination with more intense pain causing therapies.

Conclusion

This study revealed no benefits regarding reduction of pain after SRP following the use of Mpht (Biolight®).

Acknowledgements

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20-year follow-up of patients receiving high-cost dental care within the Swedish Dental Insurance System: 1977–1978 to 1998–2000

KERSTIN PETERSSON, MADELEINE PAMENIUS, ALF ELIASSON, BIRGER NARBY, FRIEDA HOLENDER, SIGVARD PALMQVIST, JAN HÅKANSSON

Abstract

The objective was to perform a long-term follow-up study of patients that had received high cost dental care within the Swedish National Dental Insurance System in 1977-1978 with special focus on remaining teeth, periodontal disease progression, change in the prevalence of root-filled teeth and teeth with apical periodontitis as well as the survival of fixed prosthetic reconstructions.

All 262 patients who had had their treatment plans sent for approval for high-cost dental care in 4 local health insurance districts and who were sampled for base-line studies in 1977-1978, were offered a free clinical examination including radiographs in 1998. 177 patients (68 % of the original sample) could be reached for telephone interview and 104 of them (40 % of the original sample) were examined clinically and radiographically. Comparisons were made with records and radiographs from 1977-1978. The analyses were performed with the individual patient as the studied unit.

The low progression of severe periodontal disease during the 20-23 year follow-up period and the decrease in number of teeth with apical periodontitis among a majority of the patients examined, indicated that the dental care received resulted in a limitation of dental disease on the individual level. Furthermore 63 % of the patients had the fixed prosthetic reconstructions, received after approval 1977-1978, in full extention after 20-23 years. However, more tooth losses were observed among the patients in this study than in similar studies in Swedish general populations over the same decades. Furthermore multiple tooth extractions were significantly more frequent in patients with severe periodontitis at baseline and in patients with less apical periodontitis at follow-up in this study. Thus it seems that tooth extraction not seldom was a treatment choice for teeth with severe periodontitis and apical periodontitis among the patients examined clinically in this study.

Key words

Dental health surveys, national health insurance, follow-up studies, fixed partial dentures

Faculty of Odontology, Malmö University, Malmö; Institution of Odontology, Karolinska Institute, Huddinge; Post Graduate Dental Education Centre, Örebro County Council, Örebro; Uppsala County Council, Uppsala; National Social Insurance Board, Stockholm: Sweden

20 års uppföljning av patienter som erhållit kostnadskrävande behandling inom Tandvårdsförsäkringen

KERSTIN PETERSSON, MADELEINE PAMENIUS, ALF ELIASSON, BIRGER NARBY, FRIEDA HOLENDER, SIGVARD PALMQVIST, JAN HÅKANSSON

Sammanfattning

Syftet med studien var att göra en långtidsuppföljning av patienter som fått kostnadskrävande behandling inom Tandvårdsförsäkringen 1977-1978. Vid uppföljningen studerades kvarvarande tänder, parodontitprogression, förändring i förekomst av rotfyllda tänder och tänder med apikal periodontit samt överlevnaden av fasta protetiska rekonstruktioner. Analyserna genomfördes på individnivå.

262 patienter vars behandlingsförslag förhandsprövats i fyra försäkringskasseområden: Stockholm, Örebro, Uppsala och Malmö med Malmöhus län och som valts ut för base-line undersökning 1977-1978, blev 1998 erbjudna en kostnadsfri undersökning inklusive röntgenundersökning. 177 patienter (68 % av urvalet) kunde nås för telefonintervju och 104 av dessa (40 % av urvalet) accepterade att bli kliniskt undersökta inklusive röntgenundersökning. Jämförelser gjordes med förhandsprövningsformulär och röntgenbilder från 1977-1978.

Den låga progressionen av allvarlig parodontit under den 20-23 år långa uppföljningstiden och den minskning av tänder med apikal periodontit som 53 % av de kliniskt undersökta patienterna uppvisade indikerar att den tandvård de erhållit lett till en begränsning av oral sjukdom på individnivå. Vidare hade 63 % av patienterna de protetiska rekonstruktioner, som de erhöll efter godkänd förhandsprövning 1977-1978, kvar i full utsträckning efter 20-23 år. Emellertid observerades fler tandförluster hos patienterna i denna studie än i studier av svenska normalpopulationer under motsvarande tid. Patienter med allvarlig parodontit vid base-line och patienter med färre tänder med apikal periodontit vid uppföljningen hade oftare fått multipla tandextraktioner. Det tycks som om tandextraktion inte sällan var ett behandlingsalternativ för tänder med parodontit och apikal periodontit hos de kliniskt undersökta patienterna i denna studie. En sådan behandlingsstrategi har den fördelen att den begränsar orala sjukdomar som parodontit och apikal periodontit men leder samtidigt till större tandförluster.

Introduction

National dental insurance was included in the Swedish health insurance system in 1974 with the explicit purpose of making good dental care available and affordable for all citizens (17). The National Swedish Dental Insurance system included free dental care for children and care for adults was based on the following principles: A fixed fee-per-item system and two reimbursement levels; 50 % reimbursement for costs up to a certain level (700 USD in 1977-1978) and 75 % reimbursement for costs above this level. For high-cost treatments yielding 75 % reimbursement, treatment plans including radiographs had to be sent to the local health insurance offices for approval.

The treatment plans sent for approval comprised all dental treatment needed at the time of examination, that means treatment for dental diseases, restorative treatment and prosthetic rehabilitation. The cost for the suggested prosthetic rehabilitation (fixed partial dentures and/or single crowns) led to the total calculated cost exceeding the high-cost level.

A random sample of the treatment plans and examination protocols sent for approval in 1977-1978 has been studied previously (15). It was found that the subjects for whom high-cost treatment was suggested had a somewhat lower mean number of remaining teeth (20. 3) compared to the general adult Swedish population (22.2 – 23.2). These patients also had a higher mean number of endodontically treated teeth (4.5) than that reported from studies of the general Swedish population (1.9 – 2.8), indicating a more severe caries situation.

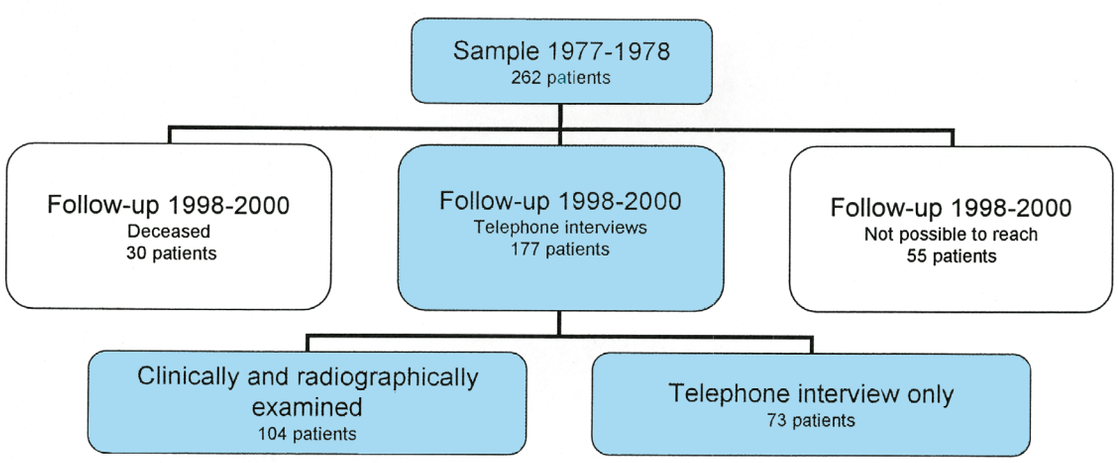
In 1982, a government committee reported that more than half of the public expenses for dental insurance were consumed by 10 % of the patients (18). Against this background, it was interesting to study the dental health of the patients who received the reimbursed high-cost dental care in 1977-1978 in a long term perspective.

The aim of this investigation was to study the dental health status after two decades in a sample of patients who received high cost dental care within the Swedish National Dental Insurance System in 1977-1978. The study was focussed on remaining teeth, periodontal disease progression and change in the prevalence of root-filled teeth and teeth with apical periodontitis on the individual level. Additionally, the outcome of the prosthodontic treatment proposed in the treatment plans in 1977-1978 was evaluated.

Material and methods

From all treatment plans made by Swedish dentists and sent to the local health insurance offices for approval, every 5th treatment plan from patients born on the 20th of each month was sampled in 1977 and 1978 for baseline studies. In 4 local health insurance districts: Stockholm, Malmöhus county with the city of Malmö, Örebro and Uppsala, all patients who had their treatment plans sampled for the baseline study (262 patients) were offered a free clinical examination including radiographs in 1998. At follow-up, 30 patients had died and 55 patients could not be reached by telephone or mail. Telephone interviews were carried out for the other 177 patients

Figure 1. Distribution of the 262 patients sampled in 1977-1978 in the 4 selected local health insurance districts, with regard to their participation in the follow-up examination in 1998-2000.



(68 % of the original sample) and 104 of them (40% of the original sample) agreed to participate in the clinical examination (Figure 1). Among the 73 patients who did not attend the clinical examination, 10 claimed to be edentulous. Other reasons for not participating included illness and weakness, lack of time, and not accepting the examination offer. All patients provided informed consent to participate in the study, which was approved by the Research Ethics Committee, Lund University, Sweden.

The age of the 104 patients examined clinically ranged from 21-70 years at the baseline examination and from 41-90 years at follow-up. The distribution according to sex and age for the different groups at baseline: patients examined clinically, patients interviewed by telephone only and patients who were unreachable (including deceased patients), is given in Table 1.

Examination protocols, radiographs and treatment plans from 1977-1978, were available for all patients. At the follow-up examination in 1998-2000, remaining teeth, prosthetic reconstructions and caries were recorded after a clinical and radiographic examination. Five of the authors performed the clinical examinations in dental clinics in Malmö, Helsingborg, Örebro, Stockholm and Uppsala. The radiographic examinations in 1998-2000 were performed in specialist clinics for oral radiography in the vicinity of the clinics where the patients were examined. Each patient received a radiographic examination comprising a panoramic radiograph and bite-wings. Teeth with periapical structures not clearly interpretable in the panoramic radiographs were also examined using periapical radiographs.

At the evaluation, the findings from the clinical and radiographic examinations carried out in 1998-2000 were compared with examination protocols, radiographs and treatment plans from 1977-1978 for each patient individually. The radiographic interpretations were made by two calibrated observers (KP and FH) who read one part of the material each.

Variables registered at the clinical examination were:

- *Remaining teeth*.
- *Prosthetic reconstructions*: Extension, material, repair, attrition and aesthetics.
- *Caries*: No caries, caries possible to detect by probing or the majority of the crown of the tooth destroyed by caries.

Variables registered in the radiographs were:

- *Remaining teeth* (*radices relictae* were also considered to be remaining teeth).
- *Extension of prosthetic reconstructions*: Single crown, 2-5 units, 6-8 units, 9 or more units.
- *Marginal bone level mesial and distal to each tooth*: In the radiographs from 1977-1978 the following categories were registered: no bone loss, bone loss less than 1/3 of the root length, between 1/3 -1/2 of the root length and more than 1/2 of the root length. On comparison of the radio graphs from 1977-1978 with those from 1998-2000, the progression of the marginal bone loss from the marginal bone level at baseline was registered as $< 20\%$ or ≥ 20 % of the root length. The root length was calculated as the distance from the cemento-enamel junction to the apex of the root. For teeth with full crown restoration the root length at baseline was calculated as the distance from the crown margin to the apex of the root. If a new crown restora-

Table 1. The distribution according to age and sex of all patients examined in 1977-1978. No significant difference regarding age and sex was found between the patients examined clinically, the patients only interviewed by telephone and the patients who were unreachable (including the patients who were deceased).

	Sex	Mean age	N	S. D
Examined clinically	Women	49.4	57	9.6
	Men	46.4	47	11.7
	Total	48.1	104	10.6
Telephone interview	Women	50.0	41	13.1
	Men	46.9	32	14.2
	Total	48.7	73	13.6
Unreachable (including the deceased)	Women	47.6	55	15.0
	Men	48.3	30	13.3
	Total	47.8	85	14.3
Total	Women	48.9	153	12.6
	Men	47.1	109	12.8
	Total	48.2	262	12.7

tion was observed at follow-up the location of the previous crown margin was estimated using the incisal part of the crown.

- *Root filled teeth*: Teeth with radiopaque material in one or more root canals were considered to be root-filled.
- *Periapical status*: Normal periapical conditions = periodontal ligament space (PDL) less than double the width in other parts of the root. Periapical bone destruction =PDL more than double the width in other parts of the root or periapical radiolucency observed.

Results based on detailed analysis on the tooth level with focus on the outcome of the fixed partial dentures and on disease development in single teeth will be published separately.

Methods for statistical analyses

The comparisons between groups for numerical variables (mean values) were made using an independent samples t-test or a one-way analysis of variance (ANOVA). The t-test was used in all comparisons between two groups and the ANOVA was used in comparisons of more than two groups. For comparisons concerning categorical variables, a chi-square test was used. An exception was made in tables with small expected frequencies where we used Fisher's exact test. A significance level of 5 % was used in all tests.

Table 2. Number of patients who had experienced no tooth extractions, 1-2 tooth extractions or 3 or more tooth extractions between 1977-1978 and 1998-2000. Distribution according to age group at baseline 1977-1978. No statistical difference between the age groups was seen (p=0.934, Fisher's Exact Test)

	Tooth-extractions from 1977-1978 to 1998-2000			
Age-group 1977-1978	**0 teeth**	**1-2 teeth**	**3 teeth or more**	**Total**
20-29 years	1	1	3	5
30-39 years	2	4	9	15
40-49 years	4	14	13	31
50-59 years	4	13	18	35
60-69 yeras	2	5	7	14
70-79 years		1		1
Total	13	38	50	101*

*In 3 patients it was not possible to evaluate the number of theeth either in the examination protocols or radiographically in 1977-1978

Results

Drop-out

There were no statistically significant differences regarding sex and age between the 104 patients examined clinically at follow-up, the 73 patients who were only interviewed by telephone and the 85 patients who could not be reached (including the 30 deceased patients) (Table 1). Neither were there any statistically significant differences between the groups regarding the number of teeth in 1977-1978 (p=0.667) and the extent of the suggested prosthetic treatment (p=0.803). (Two-sided and One-sided Analyses of Variance)

Tooth losses

It was possible to compare the clinical and radiographic examinations in 1977-1978 and in 1998-2000 to determine the number of teeth present in 101 individuals. At follow-up after 20-23 years, 13 (13 %) of these patients had no change in the number of remaining teeth, 38 (38%) had lost 1-2 teeth and 50 (50 %) of the patients had lost 3 or more teeth. This gives a mean of 3.7 lost teeth / patient for the whole group. There was no statistical difference in tooth losses during the follow-up period between the different age groups (Table 2) or between women and men. Furthermore no difference in tooth losses during the follow-up period was observed in patients who had $\leq$ 22 teeth or patients with 23 teeth or more at baseline, either analysed as groups of patients with tooth loss of 0, 1-2 or 3 teeth or more (p=0.622 Chi-Square Test) or analysed as mean number of lost teeth (p=0.862 t-test for Equality of Means).

Among the 73 patients who were only interviewed by telephone, 10 patients claimed that they now were edentulous.

Caries

At the clinical examination no caries was detected by probing in 46 (44 %) of the patients and 25 (24 %) patients had one detectable caries lesion. 6(6 %) of the patients had several ($\geq$4) detectable lesions.

Marginal bone level

Evaluation of the marginal bone level could be made for 77 patients in the radiographs from 1977-1978 and for 75 of these patients in the radiographs at follow-up. Patients were excluded if they had $\geq$ 5 sites where the marginal bone level could not be evaluated.

In 1977-1978 the marginal bone loss was less than 1/3 of the root length at all sites in 11 patients. A marginal bone loss of 1/3 or more of the root length was

observed at 1-5 sites in 24 patients and at ≥6 sites in 42 patients.

On direct comparison of the marginal bone level in the radiographs from 1977-1978 and 1998-2000, 5 patients (7 %) did not show any changes in marginal bone level at any observed site. In 23 patients (31 %) a marginal bone level reduction of < 20 % of the root length was observed at 1-5 sites and in 13 patients (17 %) at ≥ 6 sites. In 29 (39%) of the patients a marginal bone level reduction of ≥ 20 % was observed at 1-5 sites and in 5 (7 %) of the patients at ≥ 6 sites. All patients with a marginal bone level reduction of ≥ 20 % also had a marginal bone level reduction of < 20 % at one site or more (Table 3).

The 42 patients with a marginal bone loss exceeding 1/3 of the root length at ≥ 6 sites at base-line, had lost multiple teeth (≥3 teeth) during the follow-up period significantly more often than the 11 patients that had no marginal bone loss exceeding 1/3 of the root length and the 24 patients with 1-5 sites with marginal bone loss exceeding 1/3 of the root length in 1977-1978 (Fisher's Exact Test p=0.007).

Root filled teeth

In the radiographs from 1977-1978 it was possible to perform registration of root filled teeth in 85 patients. 14 of these (16 %) had 1-2 root filled teeth and 67 (79 %) had ≥ 3 teeth root filled. In 1998-2000 the radiographic images allowed a registration of root filled teeth in 99 patients. 18 of these (18 %) had 1-2 root filled teeth and 79 (80 %) had ≥ 3 teeth root filled. At follow-up, the change in number of root filled teeth could be observed in those 83 patients whose radiographs allowed registration of root-filled teeth both in 1977-1978 and in 1998-2000. 31 of these patients (37 %) had fewer root filled teeth in 1998-2000, 15 patients (18 %) had the same number and 37 patients (45 %) had more root filled teeth at follow-up.

Apical periodontitis

In the radiographs from 1977-1978 it was possible to perform registration of teeth with apical periodontitis in 70 patients. 36 of these patients (51 %) had 1-2 teeth with apical periodontitis and 26 (37 %) had ≥ 3 teeth with apical periodontitis. In 1998-2000 the radiographs allowed registration of teeth with apical periodontitis in 98 patients. 49 of these (50 %) had 1-2 teeth with apical periodontitis and 25 patients (26 %) had ≥ 3 teeth with apical periodontitis. At follow-up, a change in number of teeth with apical periodontitis could be registered in those 69 patients whose radiographs allowed registration of teeth with apical periodontitis both in 1977-1978 and in 1998-2000. 37 patients (53 %) had fewer teeth with apical periodontitis in 1998-2000, 17 patients (25 %) had the same number and 15 patients (22 %) had more teeth with apical periodontitis at follow-up.

The group of patients who presented with fewer teeth with apical periodontitis at follow-up were significantly more often found in the group of patients who had experienced ≥ 3 tooth extractions (p<0.05 Chi-Square Test). They had also fewer root-filled teeth at follow-up (p<0.005 Fisher's Exact Test). As a consequence, the patients with more or the same number of teeth with apical periodontitis at follow-up also had more or the same number of root-filled teeth at follow-up (p<0.001 Chi Square Test).

Fixed prosthetic reconstructions

For the patients examined clinically, the high cost treatments always included fixed partial dentures

Table 3. Distribution of patients according to changes in marginal bone level during the 20-23 year observation period. The quality of the radiographs in 1977-1978 and in 1998-2000 allowed evaluation in 75 patients.

Marginal bone level reduction	No of patients
No reduction	5
<20% at 1-5 sites	23
<20% at 6 sites or more	13
≥20% at 1-5 sites[1]	29
≥20% at 6 sites or more[1]	5
Total	75

All patients also had marginal bone level reduction of <20% at ≥ 1 site

Table 4. Survival of fixed prosthetic reconstructions from 1977-1978 to 1998-2000. Distribution according to age group at follow-up in 1998-2000. No statistically significant differences were found (p=0.9875 Fisher's Exact Test)

	Survivial of fixed prosthetic reconstruction			
Age groups 1998-2000	Full extension	Reduced extension	Lost	Total
40-49 years	3	1	0	4
50-59 years	9	2	2	13
60-69 years	17	6	5	28
70-79 years	26	8	10	44
80-89 years	9	1	3	13
90-99 years	0	1	0	1
Total	64	19	20	103

and/or single crowns. 27 patients received more than one fixed partial denture and 7 patients received only single crowns. In 1 patient the suggested fixed partial denture was not performed.

After 20-23 years, 63 % of the patients (n=64) retained their fixed prosthetic reconstructions in full extension, in 18 % of the patients (n=19) the extension was reduced and 19 % of the patients (n=20) had lost their prosthetic reconstructions completely.

Among the 73 patients who were only interviewed by telephone, 37 (51 %) mentioned that the fixed prosthetic reconstructions received 20 years ago were now lost.

No statistically significant difference was found between the age groups as registered in 1998-2000 regarding the survival of the fixed prosthetic reconstructions (p=0.9875 Fishers Exact Test) (Table 4). Neither was any statistically significant difference found between the sexes (p=0.575 Chi Square Test) regarding the survival of the fixed prosthetic reconstructions. After 20-23 years, 36 women and 28 men had their fixed prosthetic reconstructions in full extension, 9 women and 10 men in reduced extension and 12 women and 8 men had lost their fixed prosthetic reconstructions. The number of teeth per patient at baseline ($\leq$14 teeth compared to 15 teeth or more) did not significantly influence the survival of the fixed prosthetic reconstructions (p=0.720 Fisher's Exact Test). 70 % of the patients with 14 or fewer teeth and 60 % of the patients with 15 or more teeth in 1977-1978 retained their fixed prosthetic reconstruction in full extension after 20-23 years. There was a connection between the survival of the fixed prosthetic reconstructions and the number of teeth extracted during the follow-up period in that patients who had experienced $\geq$ 3 tooth extractions had significantly less often retained their fixed prosthetic reconstruction in full extension at follow-up (p=0.019 Fisher's Exact Test).

Discussion

The patient material received in 1977-1978 by sampling every 5th treatment plan from patients born on the 20th each month, was designed to represent the patients in private general dental practice who received high-cost dental care within the National Swedish Dental Insurance system. For the present follow-up study, a sample of these patients was chosen by selecting 4 local health insurance districts. These districts included people living in the capital of Sweden, in cities and in rural areas. At the follow-up after 20-23 years, 68 % of the patients sampled originally in the selected districts could be reached, however only 40 % of the patients sampled originally could attend the clinical and radiographic examination. The low attendance in the clinical and radiographic examination can be explained by the relatively high age of the patients in 1977-1978 in combination with the follow-up period of 20-23 years with the majority (56 %) of the patients over 70 years at follow-up and 11 % of the patients deceased. The similarity in age and sex at baseline between the patients examined clinically, the patients only interviewed by telephone and the unreachable patients (including the deceased patients) increased the probability that the limited number of patients examined was representative of the patients sampled in 1977-1978. The fact that no significant differences were observed at baseline between these groups of patients regarding the number of teeth and the suggested prosthetic treatment also indicated that the patients examined represented the sampled patients. However, it should be remembered that the patients interviewed by telephone more often appeared to be edentulous and to have lost their fixed prosthetic reconstructions than the patients examined clinically. Thus the findings from the clinical examination must be interpreted with caution.

The multi-centre character of this study is the reason why the clinical examinations were performed by five different examiners. The radiographic interpretations were made in one centre by two calibrated observers who read one part of the material each. The use of several examiners demanded clear criteria for the findings to be registered as well as agreement on the criteria. An advantage in using several examiners and observers is that the individual tendencies to under- or over-registrations can be compensated (6).

In the present study the aim was to analyse dental status on an individual level. This means that information on the single fixed partial dentures suggested for treatment as well as the healing or disease development of single teeth was not included in this study and will be presented in separate papers. The patients examined in this study seemed to have lost comparatively more teeth after the 20-year follow-up period than general Swedish populations over the same decades. A mean of 3.7 teeth / patient were lost after 20-23 years in the present study compared to 2.9 teeth / patient over the same 20 years in the general population in Stockholm and 1.4 teeth / patient over the same decades (15-18 years) in the general population in Jönköping county (8, 13). Likewise,

50 % of the patients in the present study compared to 35 % of the general population in Stockholm (8) had lost 3 or more teeth during the same observation period. Taking into account that 14 % of the patients in the present study, who were interviewed only by telephone, claimed that they now were edentulous, it appeared as if the tooth losses among the patients in the present study were more extensive over the 20-23 year follow-up period than among the two Swedish general populations referred to above. Furthermore, in a previous study, Petersson (15) found that the patients in need of high-cost dental care in 1977-1978, presented a lower mean number of remaining teeth (20.3) compared to general Swedish populations (22.2 – 23.2). Thus it seems that patients who received high-cost dental care within the National Swedish Dental Insurance System in 1977-1978 had suffered dental diseases leading to tooth extractions to a greater extent than the general Swedish population before the treatments were planned, and had also lost more teeth than general Swedish populations at the end of the follow-up period. Since no information was available on the dental status immediately after the proposed treatments were performed it was not possible to register whether or not the tooth extractions were part of the planned treatment in 1977-1978 or the result of later disease development.

The marginal bone-level reduction observed among the limited number of patients in the present study, where the marginal bone level could be observed in the radiographs both in 1977-1978 and in 1998-2000, seemed to be more modest than in the general population in Jönköping county between 1973 and 1988-1991 (13). In the Jönköping population, 33 % of the patients had no sites with a bone level reduction of > 20% and 13 % of the population had experienced bone loss of > 20% at ≥ 6 sites (13). In our study 55 % of the patients had no sites with a bone level reduction of > 20 % and only 7 % of the patients had a marginal bone level reduction of > 20 % at ≥ 6 sites, in spite of the somewhat longer observation period. The relatively few patients with adequate radiographic documentation of the periodontal bone level in the present study should be taken into consideration when analysing the findings. Nevertheless it might be of some interest that the present sample of patients who received high cost dental care in 1977-1978 and who were examined in 1998-2000 had a less pronounced marginal bone level reduction than the general population in Jönköping County over the same period. However, this observation must be interpreted in relation to the more frequent tooth extractions that were experienced by the patients in our study compared to the general population in Jönköping. Furthermore the patients who presented with severe bone loss at baseline (>1/3 of the root length at ≥ 6 sites) had significantly more often experienced multiple tooth extractions (≥ 3 teeth) at the end of the follow up period, indicating tooth extraction to be a final treatment for teeth with severe periodontal disease among patients who received high-cost dental care 1977-1978. Differences in classification of periodontal disease progression made it difficult to compare the results from the present study with the observations in other longitudinal studies of Swedish populations presented by *Papapanou et al.* (14) and by *Jansson et al.* (8). Recently, in a systematic literature review on chronic periodontitis performed by the Swedish Council on Technology Assessment in Health Care (1), 7 % - 20 % of adults were reported to suffer substantial loss of periodontal tissue, placing the findings from the present study within the limits reported from other populations.

A majority (53 %) of the patients where the periapical structures could be interpreted in the radiographs in 1977-1978 and in 1998-2000 had fewer teeth with apical periodontitis at follow-up compared to at baseline. The patients with fewer teeth with apical periodontitis at follow-up significantly more often had fewer root filled teeth at follow-up, making it unlikely that endodontic treatment was the successful treatment method for apical periodontitis. It was more likely that tooth extraction gave the successful treatment outcome regarding apical periodontitis since the patients with fewer teeth with apical periodontitis at follow-up had also experienced multiple tooth extractions (≥3 teeth) significantly more often during the observation period. In a previous study of the patients who had high-cost treatment-plans sent to the local health insurance offices in 1977-1978 we found that tooth extraction was a more common treatment suggestion than endodontic treatment for teeth with apical periodontitis (15) and these suggestions seem to have been acted upon.

Furthermore patients with a greater or the same number of teeth with apical periodontitis at follow-up also significantly more often had the same, or a greater number of root-filled teeth at follow-up. This finding indicates that the strong correlation between root-filled teeth and apical periodontitis found in the previous study performed at baseline 1977-1978 (15) still prevailed in 1998-2000. These observations correspond to the results from most epidemiologi-

cal studies in Swedish and other populations where previous endodontic treatment has been reported to be the strongest indicator for teeth with apical periodontitis (2, 3, 9, 16, 21).

The observation that no caries was detected by probing in almost half (44 %) of the patients examined and that a quarter (24 %) of them had only one detectable lesion did not indicate a severe caries problem among these patients, however only caries detected by probing was registered. Another observation was that almost half of the patients (45 %) exhibited more root-filled teeth at follow-up than at baseline probably indicating an experience of profound caries during the follow-up period for many of these patients. However other factors, for example pulpal damage caused by operative procedures for fixed prostheses, can contribute to an increased number of root-filled teeth. In long-term follow-up studies of fixed partial dentures, 8%-15 % of vital abutment teeth have shown periapical lesions at follow-up indicating a risk of pulpal damage due to fixed prosthetic therapy (7, 11, 19, 20).

The long-term survival of fixed partial dentures performed in general dentistry in Sweden has been reported previously by *Glantz et al.* (4, 5) and by *Lindquist & Karlsson* (12). *Lindquist & Karlsson* (12) found a cumulative success rate of 65 % over 20 years and *Glantz et al.* (4, 5) found that 60 % of the fixed partial dentures were still in full extension 15 years after treatment and that 47 % of abutments remained after 22 years. Although the observations in the present study were made with the individual patient as the studied unit, a similar survival rate was found with 63 % of the patients having the original fixed prosthetic reconstructions received after approval of the treatment suggestions in full extension after 20-23 years. Only 19 % of the patients examined clinically had lost the fixed prosthetic reconstructions, in most of these cases they had been replaced with new fixed prostheses. However, our observation among the 73 patients who were only interviewed by telephone, where 51 % mentioned that the prosthetic reconstructions received 20 years ago were now lost, indicated a better oral condition among the patients examined clinically than among those who were only interviewed. Together, 32 % of the examined and the interviewed patients had lost the prosthetic reconstructions. Patients who had experienced multiple tooth extractions during the follow-up period, less often had their fixed prosthetic reconstruction in full extension at the follow-up examination, indicating that the tooth extractions experienced by the patients had consequences for the survival of the fixed prosthetic reconstructions. Internationally, few long-term follow-up studies of fixed prosthetic reconstructions made in general dentistry have been performed, but in the Netherlands an 87 % survival-rate of bridges has been reported after 12 years (10).

Thus the survival rate of the fixed prosthetic reconstructions in this study, measured on the individual level, compared favourably with the survival rates of fixed prosthetic reconstructions observed in previous studies from Swedish populations (4, 5, 12). Since practically all high-cost dental care in Sweden has been performed within the National Swedish Dental Care Insurance System, the patient population in the present study is very similar to the patient populations examined by *Glantz et al.* (4, 5) and *Lindquist & Karlsson* (12). However unlike in these studies, the patients and their dentists in the present study were not aware of a follow-up study being planned, thus the outcome of the treatments can not have been influenced by a special focus on the selected patients.

In conclusion, the sample of patients examined in 1998-2000 in the present study, two decades after a base-line examination, seemed to have received dental care that has resulted in a limitation of dental disease on the individual level. This judgment was based on the limited progression of severe periodontal disease during the 20-23 year follow-up period and the fact that the majority of patients showed fewer teeth with apical periodontitis at follow-up compared to at baseline. However, more tooth losses were observed among the patients in this study than in similar studies of Swedish general populations over the same time period and multiple tooth extractions were significantly more frequent in patients with severe periodontitis at baseline and in patients with less apical periodontitis at follow-up. This may indicate that tooth extraction was not seldom chosen by the dental care providers as treatment for teeth with severe periodontitis or apical periodontitis. Consequently using tooth survival as the outcome measure the received dental care can be judged as less successful. Furthermore, multiple tooth extraction was correlated to a lower survival of the fixed prosthetic reconstructions.

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Correction

Due to technical problems at the printing office of Swedish Dental Journal two figures in the following paper have been distorted. The Journal regrets this mistake and publish the correct version of the figures below.

SWED DENT J 1 2006; 30; 9-15

Impaired positioning of the gape in whiplash-associated disorders

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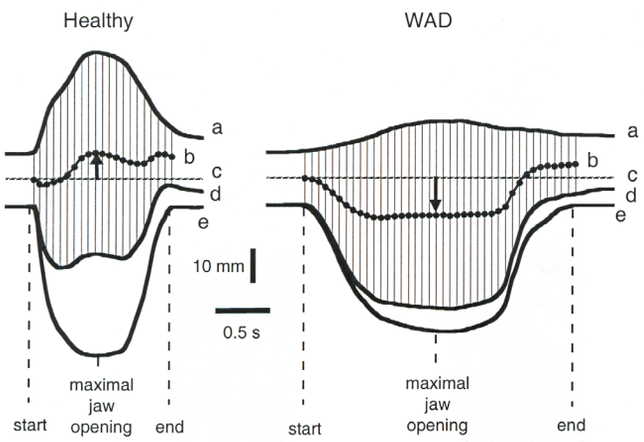

Figure 1. Recordings from one healthy and one WAD individual during one jaw opening-closing cycle, showing traces of the head-neck (a), the mandibular movement in space, i.e. the combined movement of the mandible and the head-neck (d), the mandibular movement in relation to the head (e), and the Mid-point position of the gape (b). Vertical arrows show Mid-point position of the gape at maximal jaw opening with regard to reference position at start of jaw opening (see text) (c). Note differences in healthy and WAD individual.

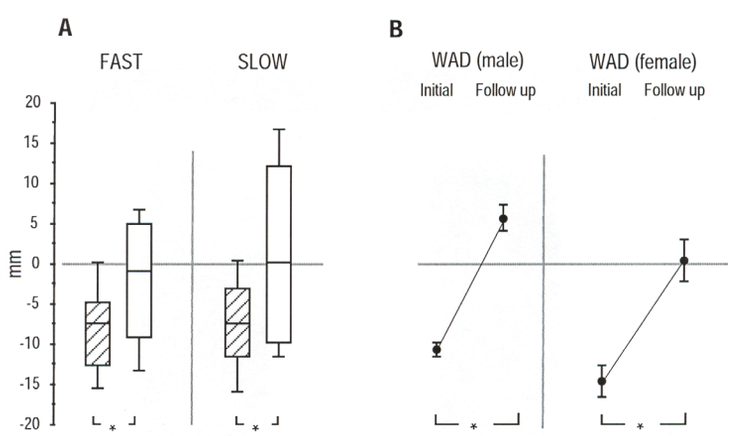

Figure 2. The Mid-point position of the gape at maximal jaw opening (MP). The zero-line corresponds to reference position at start of jaw opening (see text). A. Box and whisker plots (10th, 25th, 50th, 75th and 90th percentiles) show results of healthy (unfilled, n = 15) and WAD individuals (filled, n = 26). Differences between healthy and WAD groups are marked. B. Mean and 95 % confidence interval values of MP for two WAD individuals during pre- (initial) and post- (follow up) treatment recordings. The duration between the pre- (5 fast, 5 slow, n = 10) and post- (10 fast, 10 slow, n = 20) treatment recordings was 9 months for female and 11 months for male individual. Note "normalization" of MP following treatment.

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