Single Molar Replacement with a Progressive Thread Design Implant System: A Retrospective Clinical Report

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Many clinical studies have shown that replacement of molars with only 1 implant is commonly associated with various functional complications, such as implant fracture and screw loosening. Thus, multiple implants have been recommended to withstand the high occlusal forces present in the molar region. The aim of this retrospective study was to evaluate the clinical response to the use of single implants with a progressive thread design (Ankylos) in the replacement of molar teeth. Fifty-eight implants (10 in the maxilla and 48 in the mandible) were placed in 51 patients. The implants were in situ for 29.30 ± 16.52 months and in function for 20.60 ± 16.64 months. All crowns were cemented to the abutments. The crown occlusion was adjusted to obtain minimal normal contacts in the centric occlusion and eccentric positions. Implants were clinically and radiographically evaluated, and clinical indices (Plaque Index, Sulcus Bleeding Index, probing pocket depth, keratinized mucosa width, Periotest) were recorded immediately before the placement of the prosthesis and once annually. Vertical and horizontal bone loss were also examined radiographically. Two implants were lost (1 because of fracture in a patient who was a bruxer and another because of abutment fracture in the endosseous part of the implant). All clinical and radiographic parameters of most of the implants were comparable to the values found for the same type of implant in other clinical indications. The reduced incidence of failure (96.55% survival rate) found in this study with the Ankylos implant system compared to the results reported in the literature indicate that this system can be used for the replacement of molars using single-implant–supported restorations. (Int J Oral Maxillofac Implants 2000;15:831–836)

Key words: *biomechanics, molar, single-tooth dental implants*

A review of recent studies concerning molar replacement with endosseous implants showed that single implants may be associated with many complications, such as screw loosening and implant fracture.[1] Loosening of gold retaining screws was recorded as one of the main complications for most of these implants, and in some cases it was observed more than once.[1] Bending moments may be the reason for the implant fractures when 1 molar is replaced by 1 implant. This has been examined in in vitro fatigue tests and in clinically retrieved fractured Brånemark System implants (Nobel Biocare, Göteborg, Sweden).[2] In different clinical investigations, failures of 3.75-mm-diameter Brånemark System implants related to fracture of the endosseous part or abutment screw accounted for 14% of the examined implants replacing single molars.[3] The higher rate of failures and complications using 3.75-mm-diameter implants for molar replacement calls into question the use of these implants in the molar region. For that reason, it has been suggested that wider implants be placed or that the number of implants replacing 1 molar be increased to help the restoration withstand occlusal forces. [4]

The placement of more than 1 implant has also been clinically recommended because in most cases the crown/root ratio is unfavorable after placement of a single implant in the molar region.[5] This may

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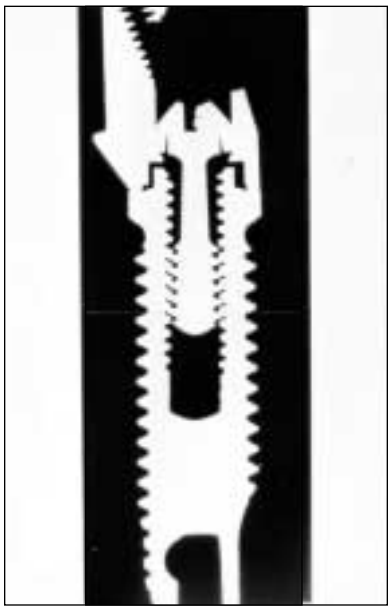


Figs 1a and 1b (*Left*) Section of a Brånemark System implant connected with the abutment showing gaps between the 2 components. (*Right*) This is contrasted with the conical (gap-free) connection in the Ankylos implant.

be the reason for occlusal overloading, which must be eliminated to avoid the loss of single molar implants. Furthermore, it has been suggested that discrepancies between the dimension of the occlusal surface of the restoration and the implant diameter result in bending forces.[1,4]

Rangert et al, in a discussion of the biomechanical consequences of implant loading and analysis of causes of excessive bending forces, have suggested that the occlusal buccolingual dimension must be reduced and occlusal contacts be minimized.[4] Other authors have excluded bruxers from their studies because of increased biting forces and recommend a reduced dimension of the occlusal surface because of the high risk of gold screw loosening.[1] Based upon these reports, Balshi and coworkers[5] suggested the placement of 2 implants for the replacement of 1 molar.

In the present retrospective study, single implants with a progressive thread design (Ankylos, Degussa-Hüls AG, Hanau, Germany) were used to replace molars. The Ankylos implant system was developed by Nentwig and Moser[6] and has been in clinical use since 1987. The implant is made of pure titanium with a highly polished, smooth transmucosal collar of 2 mm. The surface is sandblasted and the thread design has a special progressive form that influences load distribution in different areas of the jaw bone. Different 3-dimensional finite-element studies[7] and photoelastic examinations[8] have shown that loading forces increase in the apical direction because of changing thread design. This provides conservative load transmission into the elastic, cancellous bone, which is in close contact with the apical part of the implant.

In contrast to the Brånemark System implant examined in clinical studies as a single-molar replacement, the Ankylos system connects the endosseous component via a cone, which provides gap-free locking and assures a rotation-stable connection for the prosthetic restoration (Figs 1a and 1b).

MATERIALS AND METHODS

Fifty-eight Ankylos implants were placed in 51 patients (29 male and 22 female) with a mean age of 45.1 (± 10.66) years. In all patients included in this study, implant placement was indicated according to the general medical and local anatomic situation. The edentulous ridge was completely healed and had adequate width for implant placement, with no need for bone grafting. The implants were placed in different areas of the maxilla (10 implants) and mandible (48 implants), as presented in Table 1. Length and diameter of the implants are indicated in Table 2.

The implants were placed in fully (45 implants) or partially (13 implants) bone-regenerated sockets and had excellent primary stability. Most of the implants were placed after tapping (45 implants; 77.58%). Bone quality, judged during surgery according to the subjective criteria of the surgeon, is shown in Table 3.

Table 1 Distribution of Implants Placed

Tooth location	No. of implants
Maxillary right first molar	6
Maxillary left first molar	2
Maxillary left second molar	2
Mandibular left first molar	25
Mandibular left second molar	3
Mandibular right first molar	16
Mandibular right second molar	4

Table 2 Distribution of Implants According to Length and Diameter

	Implant length (mm)				
Implant diameter	8.0	9.5	11.0	14.0	Total
3.5 mm	3	2	13	4	22
4.5 mm	0	2	29	4	35
5.5 mm	0	0	1	0	1
Total	3	4	43	8	58

Table 3 Classification of Bone Quality According to Surgeons' Observations During Drilling

Bone quality	No. of implants	Percentage
Normal	35	60.34
Hard	4	6.60
Soft	19	32.75

Based on histologic criteria.

Table 4 Cumulative Clinical Measurements of the Implants in the 20-Month Follow-up Loading Period

Clinical measurement	Mean ± SD
Plaque Index	0.43 ± 0.58
Sulcus Bleeding Index	0.59 ± 0.70
Probing pocket depth (mesial)	2.45 ± 0.68 mm
Probing pocket depth (buccal)	2.03 ± 0.58 mm
Width of keratinized mucosa	3.16 ± 1.30 mm
Periotest value	0.43 ± 1.75

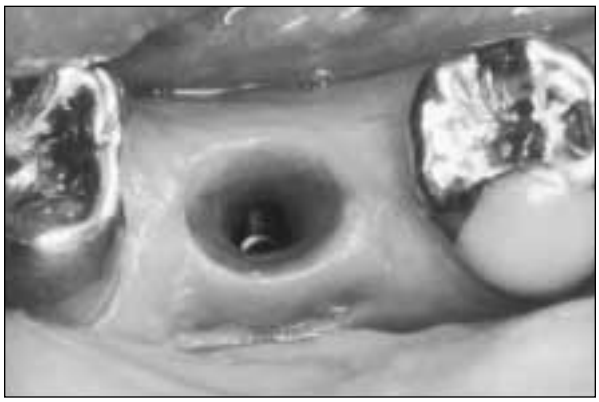
All the implants presented in this study were placed in sites without augmentation or any bone expansion surgical procedure (ie, bone spreading or splitting). The implants were in situ for a period of 29.30 (± 16.52) months; 18 implants were in situ for 10 to 30 months, 28 for 31 to 60 months, and 12 for more than 60 months. All implants, regardless of their anatomic location, healed in a submerged fashion, and second-stage surgery was performed 3 to 4 months after placement. Abutments were connected using a torque controller with a force of 15 Ncm (for angulated abutments) or 25 Ncm (for straight abutments); crowns were then fabricated. All crowns had a non-reduced buccolingual dimension, with occlusal contacts precisely controlled. Only light contacts in centric occlusion were accepted, and special care was taken in situations with occlusal discrepancies in lateral movements. Excessive loading contacts were reduced. All of the placed crowns were cemented.

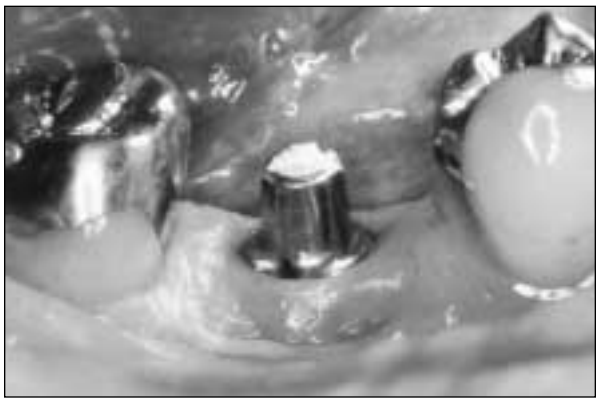
The implants have been functionally loaded for 20.60 (± 16.64) months (27 implants for 10 to 30 months, 24 implants for 31 to 60 months, and 7 for more than 60 months). They were examined clinically and radiographically immediately before cementation of the crowns and then followed up annually. Periodontal indices, such as Plaque Index according to Silness and Löe,[9] Sulcus Bleeding Index,[10] probing pocket depth, width of the keratinized mucosa, and Periotest values, were determined and assessed. Radiographic examination provided information related to horizontal and vertical bone loss in relation to the implant length. Bone loss was classified as follows:

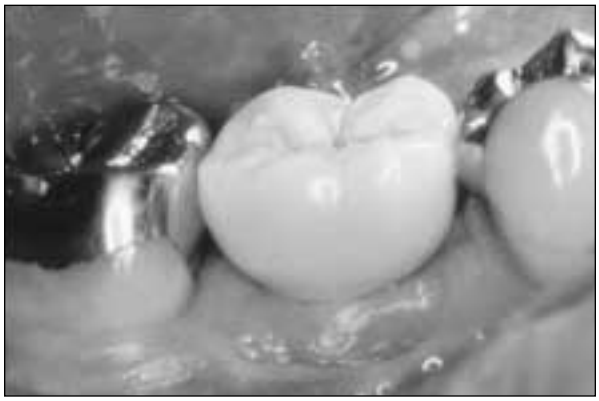
- Group 0: No bone loss
- Group M: Minimal bone loss (less than 2 mm at the crestal aspect of the implant)
- Group 1: Bone loss involving ¼ of implant length
- Group 2: Progressive bone loss, between ¼ and ½ of implant length

RESULTS

Two implants were lost. One implant fractured during the loading phase, probably the result of bruxism (information according to the patient record). This implant was placed in the maxilla (left first molar), was 11 mm long and 3.5 mm in diameter, and had an unfavorable crown/root relationship. The other failed implant was lost during the loading period because of fracture of the abutment screw (mandibular right first molar; 11 mm long and 4.5 mm in diameter). This screw was broken very deep in the endosseous part of the implant, so that replacement was not possible and the implant had to be removed. The cumulative survival rate of the present material was 96.55%. In the sites of failed implants a wider-diameter implant was placed and another single-crown restoration was fabricated. No further complications were observed. All of the clinical indices determined at the most recent examination of these implants are presented in Table 4.







Figs 2a to 2c Clinical situation (mirror photography) of an Ankylos implant for molar replacement *(above left)* before and *(above)* after abutment connection, illustrating the healthy mucosal condition, as well as *(left)* immediately after cementation of the prosthetic restoration.

Table 5 Horizontal and Vertical Bone Loss Around Implants During the 20-Month Loading Period

Group	Implants with horizontal bone loss	Implants with vertical bone loss
0	51	48
M	3	7
1	4	2
2	0	1

0 = No bone loss; M = minimal bone loss; 1 = bone loss involving 1/4 of implant length; 2 = bone loss involving 1/4 to 1/2 of implant length.

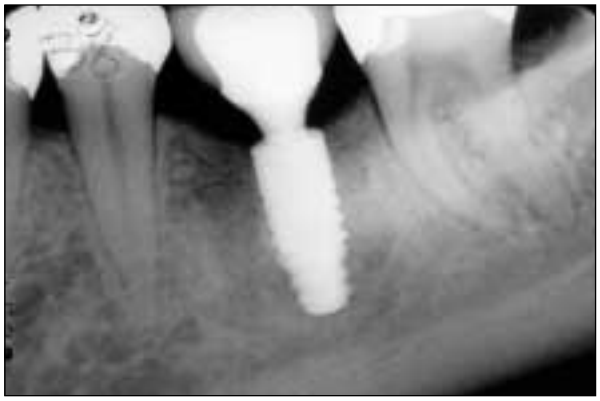


Fig 3 Radiograph (2 years postsurgery) of the implant replacing the molar. No pathologic findings were observed.

The soft tissue response around the implant-supported restorations during the observation period was generally good (Fig 2). The tendency for plaque accumulation was low (96.55% of sites had a Plaque Index of 0 or 1). This reflects the performance of effective oral hygiene by the study patients. The soft tissue response remained constant over the examination period after crown cementation. Most of the implants (84.48%) had Sulcus Bleeding Index scores of no more than 1. Data on bone loss according to radiographic examination are provided in Table 5. Figure 3 presents a radiograph of an implant at 2 years post-placement.

DISCUSSION

According to Saadoun et al,[11] two 3.75-mm-diameter implants require 12.5 to 14 mm of space, so an edentulous area of at least 10 mm is required. If this space is not sufficient, orthodontic movement of the adjacent teeth is recommended before implant placement.[12] Although orthodontic treatment can optimize the surgical preconditions, it involves a long treatment period and high costs for the patient. Moreover, if the resulting space is not sufficient for the placement of 2 implants, oral hygiene may be compromised and the long-term prognosis of the implants, as well as the neighboring teeth, can be negatively influenced. However, the suggestions of Balshi and Wolfinger[12] to replace 1 molar with 2 or possibly 3 implants to control bending forces and ensure the long-term success of such implants are appropriate and scientifically important. They should be heeded because of the high costs of materials and high risk of peri-implant inflammatory reaction.

Previous studies by Jemt and coworkers[13] indicated that screw joints may cause problems. Specifically, fistulae were recorded in association with mobile abutment screws. This occurred more often (10% of the examined implants) for single-tooth implants than for implant-supported restorations in edentulous[13] or partially edentulous[14–16] patients. In the present study, no fistulae were seen, probably because of the low number of abutments loosening. Regarding the problem of screw loosening, Jemt and colleagues[13] showed that restorations in the premolar region had a higher rate of loose screws than restorations in the anterior region. Loosening of abutment screws in the first year of function was a rarer occurrence in the study of Jemt and coworkers[13] (it represented 26% of screw loosening), compared to a group of early single-tooth restorations reported by Jemt et al.[17] For that reason, the first year of functional loading may be the critical year for biomechanical complications. The problem of abutment and screw loosening continued with the period of the prosthesis in function, but after 3 years the failure rate dropped,[15] compared to the values after 1 year.[13] As a result of the findings of this 3-year multicenter study of implants ad modum Brånemark, replacement of the titanium abutment screw with a new, slightly oversized gold screw was suggested.[18]

In the present study, very few complications were seen after the definitive prosthesis was luted and functionally loaded. All of the clinical examinations with this system were conducted according to a special, well-recognized protocol similar to the examination routine of other studies reported in the literature.[13–18]

It has generally been accepted that mechanical complications (here, only 2 failures) are related to the connection between the implanted component and abutment. In the Ankylos implant system, the dimension of the conical part is always the same, independent of the diameter of the endosseous component, so that the stability of the prosthetic restoration cannot be influenced by the implant diameter. On the other hand, biologic failures (ie, those related to bone loss around the implant) are somewhat dependent on the force distribution into adjacent bone, which in turn is dependent on the implant type and form. The progressive thread design is advantageous in areas with increased occlusal forces, such as the molar region. In the present retrospective study, no implant failures caused by bone loss were seen.

Furthermore, no implant failures resulted from peri-implant infection (peri-implantitis). Soft tissue inflammatory reaction around implants with a hexagonal design implant-abutment connection has been reported.[19] With the conical abutment interface of the Ankylos system, there is no microgap, which can negatively influence soft tissue stability.

Loosening of the implant abutment is generally not observed if the abutment is connected using the torque controller at the recommended fixation force (25 Ncm for straight abutments and 15 Ncm for angulated abutments). Although for osseointegrated implants ad modum Brånemark, torque-controlled forces of 32 to 35 Ncm are recommended, a high incidence of loosening of the screws in single molar replacement with a single implant has been reported. An in vitro comparison of accepted maximum bending moments before fracture, deformation, or abutment loosening between a conical abutment interface (Astra Tech dental implant, Mölndal, Sweden) and a butt joint interface (Brånemark

implant, Nobel Biocare, Göteborg, Sweden) was performed and demonstrated that the conical abutment design has a higher resistance to loading forces than the butt joint interface.[20]

CONCLUSIONS

With the Ankylos implant system, it was possible to replace a molar with only 1 implant. Survival rates comparable to the values found for the same type of implant used in other clinical indications were realized.[21] The reported data seem to be a consequence of both the specific stress distribution, realized by a progressive thread design, and the mechanical strength of the tapered implant-abutment connection.

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