Implant-supported versus tooth-implant-supported bridges

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Olika typer av problem har tidigare förutspåtts inträffa i samband med att osseointegrerade implantat förenas med egna tänder vid rehabilitering av partiellt betandade bett, problem som också har belysts i ett flertal experimentella studier. Författarna till denna artikel har utfört jämförande kliniska studier där broarbeten på fristående implantat jämförs med sådana där brostöden utgjorts av både tand och implantat. Efter en uppföljning under fem år av utförda behandlingar har inga nackdelar med broar understödda av både tand och implantat kunnat registreras, vilket även bekräftas av preliminära långtidsresultat.

Oral implants are valuable tools in the prosthetic reconstruction of partially edentulous jaws. These reconstructions may be performed in two principally different ways:
(1) free-standing implant-supported bridges
(2) tooth-implant-supported bridges.

The advantages and drawbacks of splinting teeth and implants have been discussed in the literature. The tooth-implant connections were early questioned as natural teeth – anchored by the periodontium – have a certain mobility, while implants, because of osseointegration, are immobile.

Naert [1] reported favourably on splinting teeth and implants but stated that it should be done only in cases where there was a special reason to do so; the first choice should always be the free-standing bridge. Zarb and Schmitt [2] did not find any advantage in splinting implants to natural teeth and advocated free-standing bridges in all cases. Sullivan [3] discussed the possible inactivity of the periodontal membrane after tooth-implant connection and the risk of disuse atrophy of the periodontal ligament. He also discussed the possibility of implant overload if a rigid connection was used.

The negative influence on the periodontium has been elucidated in two experimental studies. O´Leary et al. [4] designed a study with the aim of evaluating how natural teeth are affected when splinted to implants. They used Beagle dogs and compared teeth splinted to implants with teeth splinted to other teeth. They concluded that a natural tooth with normal mobility may function satisfactorily as an abutment for a fixed partial denture in combination with a screw-type implant. In another experimental study, Biancu et al. [5] demonstrated similar results. No negative influence on natural teeth of splinting to implants could be demonstrated in this study either .

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Figure 1. The "Umeå study" comprised patients with a Kennedy-Applegate Class I dentition in the lower jaw.

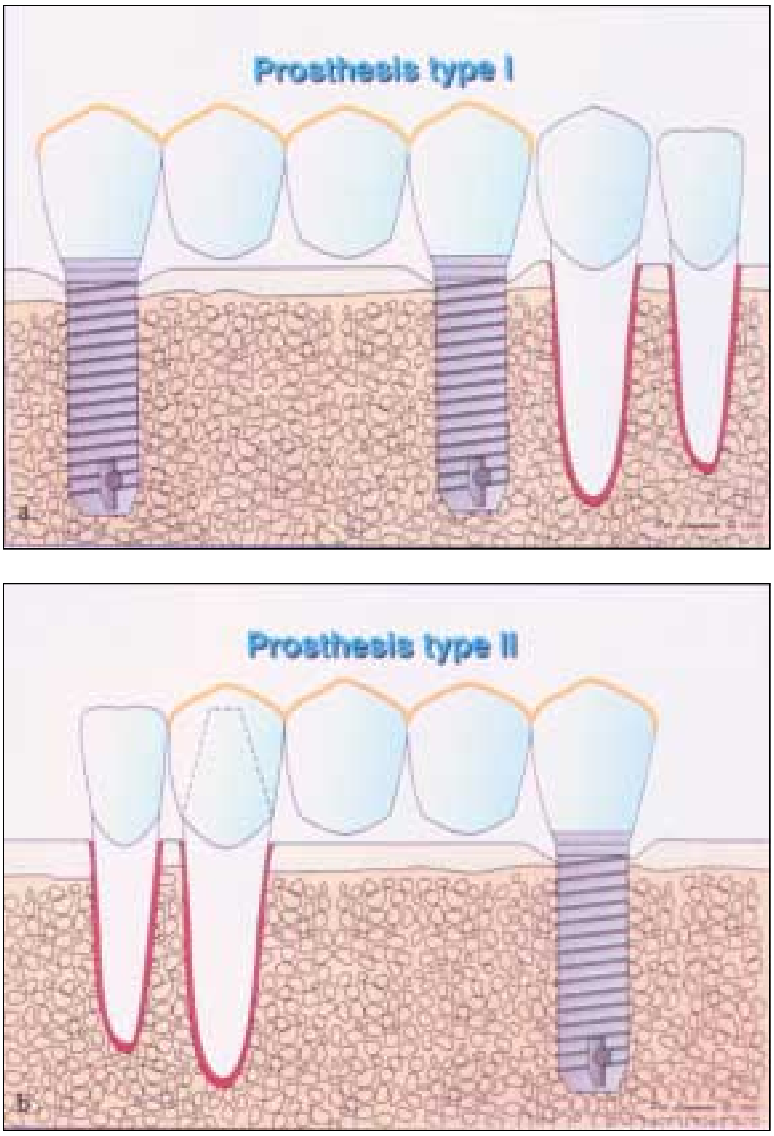

Figure 2. Each patient had two types of bridges; **(a)** *bridge type I* was supported by two implants, **(b)** *bridge type II* was supported by one tooth and one implant.

The problem of possible overload has been studied by Rangert et al. [6]. They made an *in vitro* study of the elasticity of the screw joint. The vertical movement of a loaded tooth has been found to vary between 50 and 100 microns. In this study, they found that with a 16-mm extension, a vertical movement of 200 microns (corresponding to a bending moment of 60 Ncm) can be applied before the screw joint opens. With a movement of only 50 microns, the safety margin is good, and with a prosthesis supported by one Brånemark implant and a natural tooth with normal mobility, the risk of mechanically overloading the implant is non-existent. A consequence of this limited mechanical loading is that the stress on the bone is limited to the values normally encountered in clinical practice.

McGlumphy et al. [7] found that they could change the elastic intra-mobile element of an IMZ-implant to an element made of titanium without changing the peri-implant stress distribution, observed by a photo-elastic method. This observation supports that the screw joint itself has a considerable elasticity.

Rieder and Parel [8] recommended free-standing bridges to avoid that the natural tooth abutment becomes intruded. Many hypotheses have been put forward to explain this phenomenon. One is that when the tooth is loaded and undergoes a vertical movement, the tooth cannot entirely resume its earlier position due to friction in the attachment. After repeated loading, the tooth becomes intruded. However, the use of a rigid connection and a locking pin or locking screw may prevent this complication.

A comparative intra-individual study of bridges supported by a combination of teeth and implants versus bridges supported by implants only was begun at Umeå University in 1984. Reports from this study of tooth-implant-connected bridges compared to free-standing implant-supported bridges have been published after 2-, 3-, and 5-year observation periods [for details of materials and methods, see 9–11].

Material and methods

The "Umeå study" started in 1984 and was performed on 23 patients with Kennedy-Applegate Class I dentitions in the lower jaw (Fig. 1) and a complete upper denture. They had a mean age of 57.7 years at the start of the study (range 45–68 years).

The patients were provided with two implants *ad modum* Brånemark in each mandibular quadrant. At the second operation only three of the four fixtures in each patient were provided with abutments. The fourth fixture, the anterior one of one of the sides, was left as “a sleeping implant”. Standard abutments were used and connection to the fixtures took place after a healing period of 3–4 months.

At the prosthetic procedure, each patient was provided with two types of bridges. *Bridge type I* was supported by two implants and *bridge type II* was supported by one implant and the distal tooth in the residual dentition (Fig. 2). The choice of side for the two types of bridges was randomized.

The framework of bridges type II was constructed in two parts and connected with a precision attachment, which was locked with a horizontal gold screw. This construction was used to permit removal of the implant-supported part of the bridges for examination of tooth mobility and implant stability.

The patients were examined at the time of bridge insertion and at the 1-, 2-, 3-, and 5-year follow-ups. Clinical parameters, including bridge stability and individual implant stability, were recorded, as were marginal tissue reactions. Intraoral radiographic examinations were performed after 1, 2, and 5 years.

Results

The patients were followed for 5 years. During this period, there was only one drop-out: the patient had died.

Implant failures. Of the 69 primarily installed and loaded implants (3 implants were used in each of the 23 patients), 8 were lost. One fixture was removed at the abutment connection. Four implants were lost within 6 months after loading and 3 were lost later on (Table 1). Five implants out of 46 were lost among the *bridge type I* implants and 2 out of 23 among the *bridge type II* implants.

Implant success rate. The success rate was calculated using the criteria of Albrektsson et al. [12]. Implant stability was evaluated with the bridges removed. All remaining implants were stable. None of the implants gave rise to any symptoms, the radiographs displayed no pathological changes, and the mean annual bone loss after the first year in function was less than 0.2 mm.

The difference in success rate between the two groups was insignificant: 89.1% for *bridge type I* implants and 91.5% for *bridge type II* implants.

Tooth mobility. Twenty-one of the abutment teeth had only physiological mobility; in two cases the mobility was slightly increased.

Peri-implant tissue reactions. At the clinical examinations, traditional periodontal records were used regarding both implants and teeth. To-day, the value of such registrations made for implants has been questioned. However, changes in the *plaque and gingival indices* as well as in *probing pocket depth* at implants connected to *bridge types I* and *II* did not differ.

Marginal bone level. The changes in marginal bone level were small during the 5-year follow-up period. During the first year of function, the marginal bone loss was about 0.4 mm in both groups (Fig. 3). Should the connection of implants to teeth have given a risk of overload of the implants, a greater bone loss in connection with these implants might have been expected. On the contrary, the difference at the 2-year follow-up between the two types of bridges was in favour of the implants connected to teeth.

After the second year, no further bone loss was observed; instead a mean gain in the bone crest region was seen. At the end of the observation period, the mean bone loss, compared with the baseline, was only 0.2 mm. At the 5-year examination, no difference between changes in implant bone level at *bridges type I* and *type II* could be demonstrated.

Table 1. Number of implants lost during the course of the study

Course of the study	Lost implants
Before loading	1
0–6 months after loading	4
6–18 months after loading	3
>18 months after loading	0
Total	8

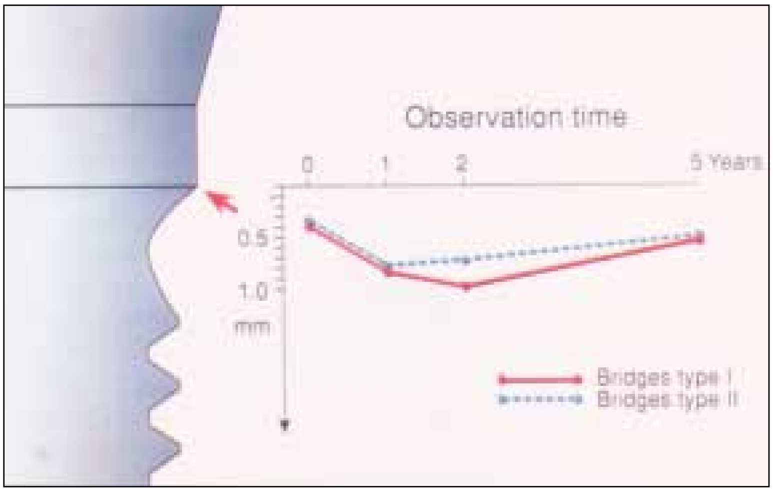

Figure 3. Mean marginal bone levels for free-standing implants (bridges type I) and tooth-connected implants (bridges type II) at different times of the first 5-year observation period.

Technical complications. Few technical complications occurred. One horizontal gold screw was fractured and one gold screw was loose. The occlusal material fractured in one patient and in another composite fillings had to be remade.

Discussion

This review of the results of the "Umeå study" shows that the connection between an implant and a tooth with normal periodontium does not have any detectable negative influence on either implant or tooth. This conclusive remark may be supported by the following aspects of oral rehabilitation.

Type of splinting

Several different possibilities for splinting implants and teeth have been suggested in the literature. A *rigid connection* means either that the bridge is made in one piece or that it is made in two pieces connected by a precision attachment with some kind of locking device. A rigid connection has been proposed by, for example Weinberg [13] and Gunne et al. [10].

In a *non-rigid connection,* the bridge is made in two pieces and vertical movement between them is possible, as has been suggested by Sullivan [3]. In a *resilient connection,* the freedom of movement between the two parts of the bridges is greater than one degree. Such a connection has been advocated by, for example Kay [14] and Richter et al. [15]. There seems to be no consensus regarding which type of splinting is most suitable. In a recent paper, however, Gross and Laufer [16] stated that there is "an increasing body of information favouring rigid connections".

Load distribution

It seems that it is possible to use both teeth and implants together in the support of a bridge, despite their differences in mobility and warnings for possible biomechanical problems. The most probable explanation for this is the flexibility of the screw joint [6]. This flexibility allows the tooth to move in an apical direction without overloading the implant or causing the screw joint to open excessively.

To further investigate the distribution of the load between the tooth and the implant, a functional study was made on five of the patients of the "Umeå study" [17]. In this study, the tooth-implant-connected bridges of five patients were removed and the original abutments were replaced by previously strain-gauged and calibrated abutments. After that the bridges were replaced. A bite fork was used in different positions and the maximum bite force measured. The results demonstrated that if the fork was placed over the tooth, most of the force was distributed to the tooth and just a little to the implant. If the bite fork was placed over the implant, the implant took almost all the load. When the bite fork was placed in between, the load was divided between the tooth and the implant. The conclusion from this study was that when one tooth is connected with one implant using a rigid connection, the occlusal load is distributed between the tooth and the implant.

Preliminary 10-year results

Recently, a 10-year follow-up of the "Umeå study" was performed. There were two more drop-outs at this examination; one patient had died and another was not able to take part in the investigation due to the long travel distance. The following preliminary observations were made:

No more implant losses occurred during the second 5-year period. A life-table analysis gave a *success rate* after 10 years of 88.4%. *The marginal bone level* dropped 0.5 mm at *bridges type I* and 0.3 mm at *bridges type II* during the last 5 years. This difference between the tooth-connected and the free-standing implants, however, was not clinically significant.

Conclusive remarks

Several studies have been published demonstrating good results of treatments where implants and teeth have been connected in the same bridge [18–22]. Negative reactions have been found in only one study [23].

Tooth-implant connections are used in three different situations:

- One implant connected to one tooth or a block of teeth
- Multiple implants connected to one or more teeth
- Teeth interspersed in an implant-supported bridge.

The use of teeth and multiple implants or teeth interspersed among implants are complex situations with regard to loading conditions, and these types of situations are insufficiently documented.

With one implant connected to one tooth we have a simpler and more widely documented situation. Our present knowledge indicates that one implant connected to one tooth or to a block of teeth with a rigid connection is an efficient and reliable treatment.

Summary

Different kinds of problems have been anticipated if osseointegrated implants are connected to natural teeth. These problems have been elucidated in several experimental studies. The authors have performed a comparative clinical study between free-standing implant-supported bridges and tooth-implant-supported bridges. After a long-term longitudinal follow-up, no disadvantages of tooth-implant connections can be observed.

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