The implant-tooth connection: a 10-year perspective

Richard J. Lazzara, Stephan S. Porter and Diego H. Santamarina

Möjligheten att i en fast broersättning koppla samman egna tänder med implantat har länge ifrågasatts och forskning pågår kontinuerligt inom detta område. Intresset har särskilt riktat sig mot skillnaderna i mikrorörelseer hos egna tänder jämfört med implantat då dessa är i funktion. I denna artikel utvärderas kliniska långtidsresultat av oral rehabilitering med fasta broarbeten som understötts av egna tänder och implantat förenade i samma konstruktion. Författarna fokuserar även på risken för komplikationer genom att tand och implantat kopplas samman som brostöd.

As a result of the high levels of success achieved with current implant designs [1, 2], implant therapy has become a highly predictable method of replacing missing teeth. However, there remain several unanswered questions regarding particular restorative options that incorporate dental implants.

In the partially edentulous patient, several factors related to treatment planning are different from those for the totally edentulous patient. Factors such as implant position relative to adjacent teeth, the sequencing of periodontal treatment, implant placement protocols, implant restorative options, including whether to connect to teeth, and occlusal considerations must all be addressed during the treatment of the partially edentulous patient.

One of the most controversial issues related to implant treatment of the partially edentulous patient is whether implants should be connected to adjacent teeth and if so, should the connection be rigid or allow for some movement within the connector. Additionally, it is not known whether there is an ideal ratio of teeth to implants that is necessary for optimum support of a fixed bridge. Several authors have addressed these issues from both the clinical and the theoretical perspective in an attempt to answer a number of questions. However, to date, the connection of implants to teeth remains a highly controversial topic in implant dentistry.

The stability and longevity of connecting an implant, which is rigidly connected to bone, and teeth, which undergo movement during function, is of concern to the clinician. It has been thought that when a tooth is connected to an implant, the tooth acts as a cantilever or "living pontic" that may cause biomechanical problems either within the restoration itself or in the bone supporting the implant and tooth.

Ericsson et al. [3] reviewed clinical cases in which teeth were connected to implants in ten

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partially edentulous patients over a period of up to 30 months and reported good clinical results. In a 2-year longitudinal study, Åstrand et al. [4] did not report any disadvantages of connecting teeth to implants in the same restoration. They did, however, observe a 12% implant failure rate for the 69 implants during the 2-year observation period. A more extensive review by Naert et al. [5] evaluated 509 implants in 146 patients during an observation period of 30 months. Of the 217 bridges evaluated in that study, 49 were rigidly connected to teeth with an average of 2.3 implants per bridge, for a total of 113 implants rigidly connected to teeth. The authors concluded that no periodontal or mechanical problems occured when implants were rigidly connected to teeth during the 30 months of observation. Lindh et al. [6] evaluated three patients in which one implant was rigidly connected to one tooth in the mandibular posterior region of each patient and found no complications during the 3-year follow-up.

The purpose of this retrospective study is to review treatment outcomes in patients who have had implants rigidly connected to teeth for up to 10 years and to report any complications, changes in bone levels and rates of survival for both the implants and teeth.

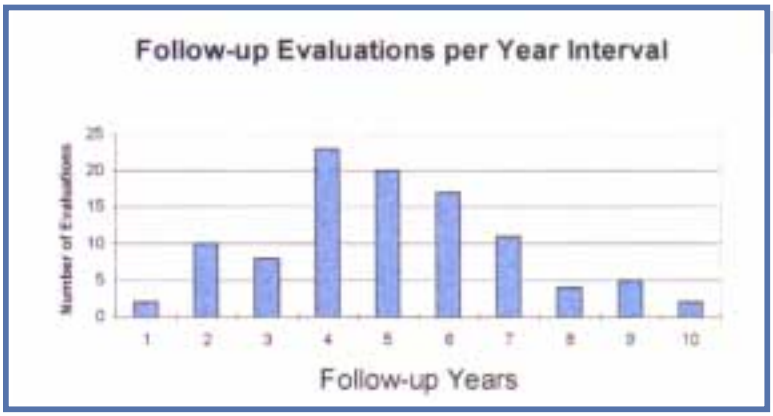

Figure 1. The average period of post-loading evaluation is 5.28 years.

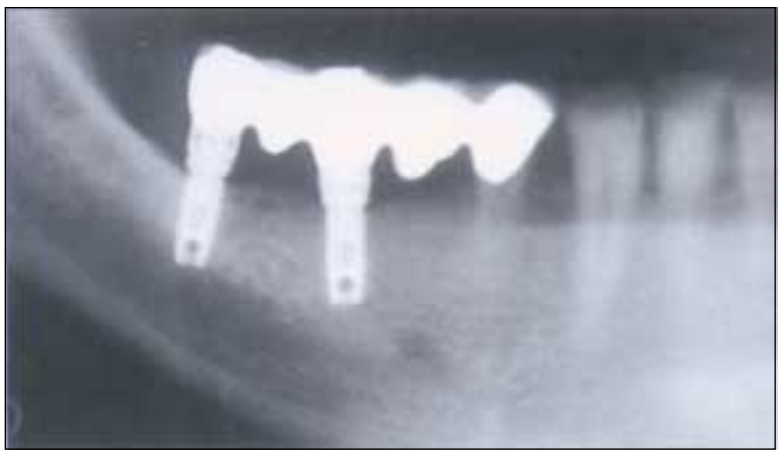

Figure 2. All fixed bridges were fabricated with a one-piece metal framework and either cement or screw retained to the implant abutment or screw retained directly to the implant.

Material and methods

A total of 45 patients from one private periodontal practice who had been consecutively restored with fixed bridges rigidly connecting both implants and teeth were reviewed. The length of time the fixed bridges were in function ranged from 2.5 to 10 years, with an average time in function of 5.28 years (Fig. 1).

A conventional two-stage implant placement protocol was followed for all patients, 4 months of healing was allowed for implants in the mandibular arch and 6 months for implants in the maxillary arch. Final restorations were placed approximately 10 to 14 weeks after stage-two surgery. Patients followed a 6-month recall programme which included an evaluation of periodontal tissues, the stability of the fixed bridge and the bone levels around both the implants and the connected teeth.

For this study, radiographic measurements of crestal bone levels were obtained from radiographs taken at the first evaluation appointment following initial placement of the fixed bridge and again at the most recent evaluation appointment. Bone level measurements were made on the mesial and distal aspect of each implant using the implant platform as the measuring point of reference. Mesial and distal bone level measurements were also made on the teeth included in each fixed restoration. For tooth measurements, the mesial and distal crown margins were used as the reference point for the mesial and distal bone level measurements. Bone level measurements were obtained from parallel periapical radiographs, which utilised the long cone technique and a radiographic film holder (Rinn XCP, Rinn Corp., IL, USA), as well as from panoramic radiographs. When panoramic radiographs were used, the measurements were adjusted for the calibrated magnification on the panoramic film.

Patient records were reviewed for complications, including caries, tooth intrusion, implant fracture and for prosthetic complications requiring alteration or remake of the fixed bridge. The fixed bridges evaluated in this study were all fabricated as a one-piece metal framework without the use of precision attachments, screw connections or other types of interlocking mechanisms (Fig. 2).

Some teeth had cemented copings placed on them before placement of the fixed bridge. All

fixed bridges were cemented to teeth using a permanent cement, but either cement or screw retained to the implant abutment or screw retained directly to the implant.

Results

Of the 45 patients included in this study, there were 25 females and 20 males ranging in age from 40 to 84 years with a mean age of 67.7 years. The 45 patients were restored with 55 fixed bridges supported by 136 teeth and 110 implants (*3i*®, Palm Beach Gardens, FL, USA). The 110 implants included 82 screw-type and 28 cylinder implants. Implant diameters ranged from 3.3 mm to 6.0 mm and lengths from 6 mm to 18 mm (Table 1).

Sixty-two implants (56.4%) were placed in the maxillary arch while 48 (43.6%) were placed in the mandibular arch (Figs. 3 and 4). Twenty-six (47.3%) of the fixed bridges were in the maxilla, and 29 (52.7%) of the fixed bridges were placed in the mandibular arch. There was an average of 2.00 implants and 2.47 teeth included per fixed bridge.

During this study, one of the 110 implants was lost due to fracture. The fractured implant was the distal abutment of a maxillary fixed bridge. The post-loading implant survival rate was 99.1%. Four of 136 teeth, one maxillary and three mandibular, were lost during the study period. One was removed because of severe caries involvement, one due to advanced periodontal bone loss, one for endodontic complications and one as a result of intrusion (Fig. 5).

The post-loading tooth survival rate was 97.1%. Two of the fixed bridges were remade due to the position of the removed carious tooth and the fractured implant.

Radiographic analysis

A digital caliper (Digimatic, Mitutoyo Corp., Japan) calibrated in 0.01 mm increments was used to measure bone crest levels using the previously defined reference points. A comparison of measurements taken from the initial and most recent radiographs revealed an average post-loading bone loss of 0.06 mm for the teeth and 0.16 mm around the implants.

When comparing the mesial and distal crestal bone measurements for teeth, an average bone loss of 0.09 mm was measured on the mesial

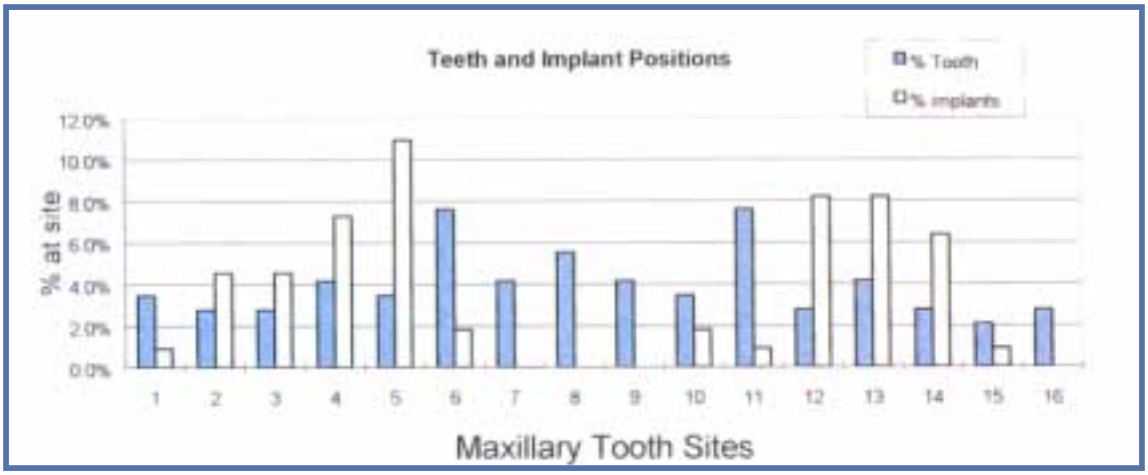

Figure 3. Percentage and location of teeth and implants supporting fixed bridges in the maxillary arch.

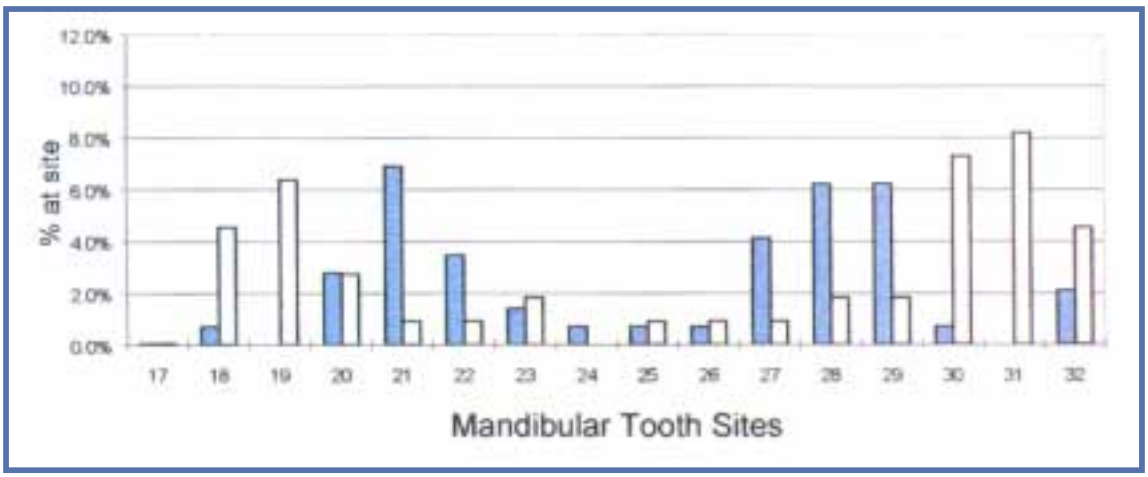

Figure 4. Percentage and location of teeth and implants supporting fixed bridges in the mandubular arch.

surfaces and 0.03 mm on the distal surfaces. The implants had an average bone loss of 0.14 mm on the mesial surfaces and 0.18 mm on the distal surfaces.

When comparing the average amount of bone loss around both teeth and implants, the implants had more bone loss occurring on the combined mesial and distal surfaces than the teeth. When comparing the mesial and distal surfaces of both the teeth and implants, more bone loss occurred on the distal surfaces of the implants and mesial surfaces of teeth. The average bone loss on the mesial surface of teeth was 0.09 mm, while the implants had an average bone loss of 0.14 mm on the mesial surfaces. The distal surfaces of teeth had an average bone loss of 0.03 mm, while the implants had 0.18 mm of bone loss on distal surfaces. Thus, there was on average 1.6 times more bone loss on the mesial surfaces of the implants when compared to the mesial surfaces of the teeth and 6 times more bone loss on the distal surfaces of the implants than on the distal surfaces of the teeth.

Table 1. The distribution of implant types, diameters and lengths

Cylinder implants			Threaded implants		
Diameter (mm)	Length (mm)	Number	Diameter (mm)	Length (mm)	Number
3.3	10	1	2.9	10	1
3.3	13	4	2.9	13	3
3.3	15	2	3.25	18	1
4.0	11	5	3.75	10	39
4.0	13	7	3.75	13	18
4.0	15	1	3.75	15	5
4.0	17	1	3.75	7	8
4.0	8	2	4.0	10	2
5.0	10	1	4.0	7	1
3.3	13	2	5.0	10	1
3.3	8	1	5.0	7	1
3.3	10	1	6.0	6	1
4.0	8	1			
Total		29	Total		81

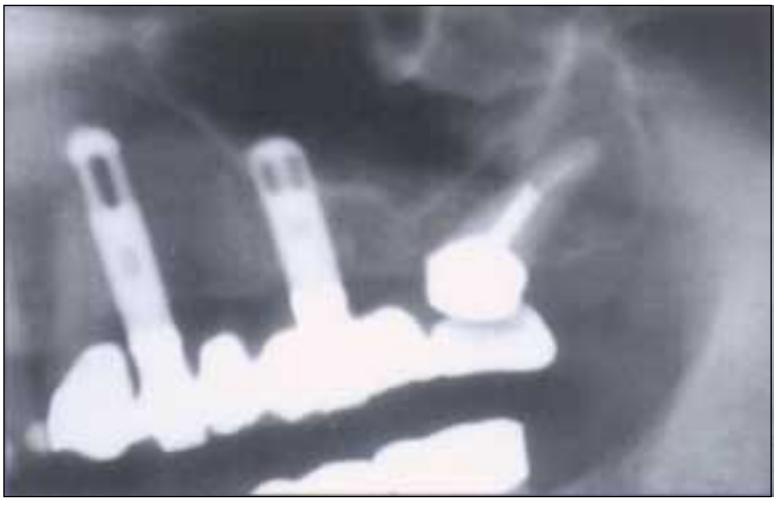

Figure 5. Panoramic radiograph showing the one incidence of tooth intrusion encountered in this study. Tooth intrusion occurred following 4 years of function.

Discussion

In spite of the success of rigidly connected implant and tooth-supported bridges reported in numerous studies [3–6] there continues to be significant controversy and uncertainty about the long-term stability and health of the implants and teeth when supporting a fixed bridge. This retrospective study evaluated fixed bridges that have been in function for up to 10 years and confines the patient population to those who have implants that are rigidly splinted to teeth with one-piece fixed bridges. By confining our observations to fixed bridges that do not incorporate screw-type connections or other types of interlocking mechanisms, we eliminate the influence of different attachment types and the inherent variation in the mobility each attachment type possesses.

As often mentioned, the surgical and restorative implant protocols developed for fully edentulous patients cannot be automatically applied to the partially edentulous implant patient. Therefore, in treatment planning for the partially edentulous patient, the influence of adjacent teeth must be considered with regard to implant position, treatment sequencing and treatment planning for prosthetic support.

The results of this 10-year clinical study indicate that the rigid connection of implants to teeth does not lead to increased failure rates of either the tooth, the implant or the prosthesis. In fact, when taking into account the 99.1% survival rate of the 3i implants evaluated in this study and the 88.4% survival rate reported by Åstrand et al. [4] using Brånemark implants during a 2-year observation, we see a high survival rate for splinted implants. In a 30-month study by Naert, using Brånemark implants, he reported a 96.5% success rate in the maxilla and 96.3% in the mandible [5]. Thus, the 99.1% success rate for implants evaluated in this study during an average of 5.28 years seems quite acceptable.

Bone level changes around the majority of implants in this study conform to the criteria for success previously quoted by Albrektsson et al. [7] and are similar to rates of bone loss reported

around implants splinted to teeth in previously published studies. The calculated annual bone loss of 0.03 mm for implants and 0.01 mm for teeth as measured in this study compares favourably to previous works on this subject. Ericsson et al. [3] provided minimal detail on their radiographic findings, but indicated that most of the implants lost less than 1 mm of bone during their 6 to 30-month evaluation period. However, only three of the ten patients were followed for 30 months, with four patients being evaluated for only 6 months. During that time, three of the 41 implants placed had more than 1 mm of bone loss, with one implant having 3 mm of bone loss.

In the study by Naert et al. [5], they found up to 2 mm of bone loss during the average 30 months of loading. They observed 0.77 mm of bone loss around the maxillary implants and 0.96 mm of bone loss around mandibular implants during the first year. They reported that in the maxilla an additional 0.1 mm of bone loss occurred during the following years. None of the previously quoted studies however, measured the bone loss around the teeth attached to implants in the fixed bridges. The present study showed an average bone loss of 0.06 mm around the splinted teeth during the 10-year observation period. Therefore, the data obtained from this study seem to indicate that teeth and implants rigidly splinted in the same bridge function successfully without any deleterious effect on either the bone or the restoration.

Tooth intrusion has been reported as a possible complication when implants are connected to teeth [8–13] and several theories have been developed to explain this phenomenon. In only one of the fixed bridges in this study, and only after 4 years of loading, did one of the two teeth supporting a fixed bridge intrude (Fig. 5). The one intruded tooth was the posterior abutment in a two-tooth, 2-implant, 4-unit maxillary fixed bridge. The remaining tooth in this bridge has remained healthy and functioned successfully for an additional 4 years. Since only one of the 136 teeth included in this study underwent intrusion (0.99%), this is not considered a significant complication of rigidly connecting teeth and implants. It is unknown whether intrusion is more of a problem when teeth and implants are connected by some type of non-rigid attachment. However, in a survey of practitioners who reported tooth intrusion, an approximately equal number reported intrusions with rigid connections versus non-rigid connections, 37 and 41, respectively [8]. Future similar studies may determine the potential significance of having more teeth than implants in a fixed bridge or vice versa with regard to the overall stability of an implant and tooth supported fixed bridge.

In conclusion, the data provided by this study indicate that the rigid connection of implants and teeth does not accelerate bone loss around either the implant or the tooth, that the implant and tooth survival is high and that complications with this type of prosthesis are minimal.

Summary

The implant-tooth connection: a 10-year perspective

The rigid and non-rigid connection of teeth and dental implants remains one of the most controversial methods of restoring implants in the partially edentulous patient. The purpose of this retrospective study is to review treatment outcomes in patients who had implants rigidly connected to teeth for up to 10 years (average 5.28 years). A total of 45 patients, consecutively restored with fixed bridges rigidly connecting both implants and teeth are reviewed. The 45 patients are restored with 55 fixed bridges supported by 136 teeth and 110 implants. Twenty-six (47.3%) of the fixed restorations are in the maxilla and 29 (52.7%) in the mandible. There is an average of 2.00 implants and 2.47 teeth included per fixed bridge. The results show a post-loading implant survival rate of 99.1% and 97.1% for teeth. Four of 136 teeth, one maxillary and three mandibular, were lost during the study period. One was removed because of severe caries, one due to severe bone loss, one for endodontic complications and one as a result of intrusion. A comparison of measurements taken from the initial post-loading and most recent post-loading radiographs reveal an average bone loss of 0.06 mm around teeth and 0.16 mm around implants. From the data provided by this study, it appears that the rigid connection of implants and teeth does not accelerate bone loss around either the implant or the tooth.

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