

Tooth-Implant Connection: A Review

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The aim of this review was to assess the long-term outcomes of restorations supported by implants and natural teeth with regard to complications associated with implants, teeth, and restorations, as well as the influence on these parameters of the connector type used. A net-based search in PubMed was combined with a manual search. Clinical studies, reviews, and biomechanical studies were included. Information on survival rate, complication rate, incidence of tooth intrusion, and, where applicable, type of connector used, was retrieved from the clinical studies. Force distribution and types of connectors used were retrieved from the biomechanical study. A summary of outcomes was retrieved from the reviews. A total of 25 articles were selected for inclusion in this review, including clinical studies (15), biomechanical studies (7), and reviews (3). Implant success rates ranged from 79.5%–100%. Tooth complications occurred in 5.4%–11.8% of cases. Complications in the suprastructure were observed in 5%–90% of cases. Tooth intrusion presented in a total of 0%–66% of all cases, more often in cases with nonrigid connection (0%–66%) than in cases with rigid connection (0%–44%). Biomechanical studies show a large difference in stress distribution and in dependence on the type of connector used, with most studies demonstrating that nonrigid connectors drastically reduce stress on the suprastructure while increasing forces on supporting teeth and implants. Long-term success rates for tooth-implant connections are lower than for solely implant-supported restorations with regard to prognosis for teeth, implants, and suprastructure. Use of rigid connectors leads to more favorable clinical outcomes in terms of long-term stability, occurrence of complications, and tooth intrusion.

Key Words: dental implants, fixed partial dentures

INTRODUCTION

During past decades, implant treatment emerged as a widely accepted treatment modality with a reported long-term success rate greater than 90% for the treatment of both partially and completely edentulous patients.¹ However, the combined use of teeth and implants as anchors for prosthetic restorations remains a controversial issue.

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Although implants become osseointegrated and thus have a rigid connection to supporting bone, teeth are supported by the periodontal ligament, allowing for physiologic mobility that leads to displacement of the crown of 50–200 μ if forces of 0.1 N are applied.² Implants, on the other hand, demonstrate maximum displacement of 10 μ .³ A different behavior for masticatory forces results, leading to excessive load on the restoration, the abutments, and the implant. Complications such as fracture of mechanical parts and a higher incidence of caries at the crown margin and tooth intrusion have been described.⁴ The use of both rigid and nonrigid connectors of

different designs has been suggested to minimize these effects.^{4,5}

Although the literature evaluating long-term treatment outcomes of solely implant-supported suprastructures is abundant, only limited data are available on the combined use of implants and natural teeth. The purpose of this review is to evaluate the long-term success rates of combined implant-tooth-supported fixed partial dentures, as well as the influence of the connector type and the biological force distribution.

MATERIALS AND METHODS

A net-based search on PubMed using the terms “tooth AND implant AND connection,” “tooth AND implant AND connected,” “tooth AND implant,” and “implants AND tooth AND fixed partial denture” was performed and was combined with a manual search, which was based on the references of selected articles. Clinical studies, reviews, and biomechanical studies were included. The review was limited to publications in English.

Information on survival rate, complication rate, incidence of tooth intrusion, and, where applicable, types of connectors used, was retrieved from the clinical studies. Force distribution and types of connector used were retrieved from the biomechanical study. A summary of outcomes was retrieved from the reviews. A meta-analysis was not performed.

RESULTS

A total of 25 articles were selected to be included in this review. Articles were classified as follows: clinical studies (15; Table 1), biomechanical studies (7; Table 2), and reviews (3; Table 3). A subclassification was made according to the use of rigid vs nonrigid connectors and studies in which no differentiation between the 2 was made. Publication dates ranged from 1995–2009, and observation time ranged from 3–10 years.

Survival or success rates of implants ranged from 79.5%–100%. Tooth complications, including tooth fracture, caries, endodontic and periodontal problems, and other complications, occurred in 5.4%–11.8% of cases. Complications of the suprastructure, such as fracture, abfraction of veneers, and so forth, were observed in 5%–90% of cases. Intrusion was present in a total of 0%–66% of all cases and was more frequent in cases with nonrigid connection (0%–66%) vs cases with rigid connection (0%–44%).

Most biomechanical studies show that the use of nonrigid connectors drastically reduces stress on the suprastructure but increases forces on supporting teeth and implants. The use of rigid connectors drastically increases the forces on bone surrounding teeth and implants.

DISCUSSION

Although the combined use of teeth and implants to support prosthetic restorations has been repeatedly suggested for many years, only limited data are available on the long-term success of this treatment approach. A wide range of success rates has been reported.

An argument has been made that different reactions to forces between implants and natural teeth may have a negative impact on treatment outcomes, and the use of nonrigid connectors has been suggested.⁶ However, biomechanical studies demonstrate that a shift of force distribution from the suprastructure to the supporting teeth occurs when nonrigid connectors are used.^{7–12} Although clinical data suggest a lower incidence rate of complications involving the suprastructure and implants, a higher incidence of tooth intrusion is observed when nonrigid connectors are used. This seems to be independent of the specific design of the nonrigid connector.^{13–15} The

TABLE 1

Clinical studies*

Author	Study Type	Follow-up Time, y	Connector Type	Implant Survival Rate, %	Restoration: Complications	Tooth Intrusion	Tooth Complications
Nickenig et al ¹⁸ Cordaro et al ¹⁵	Retrospective clinical study Retrospective clinical study	4.7 (mean) 24–94 months	Rigid and nonrigid Rigid and nonrigid	100 99	10%: nonrigid NA	NA 5.6%: nonrigid connectors 66%: nonrigid connectors 44%: rigid connectors	8% NA
Block et al ¹⁴	Prospective, randomized clinical study	5	Rigid and nonrigid	98.6			Fracture in 5 of 66 teeth
Mau et al ¹⁹	Prospective clinical study (multicenter)	5		79.5	NA	NA	NA
Kindberg et al ²⁰ Naert et al ¹⁶ Naert et al ¹⁷	Retrospective clinical study Retrospective clinical study Retrospective clinical study (radiographic evaluation)	5 (mean) 6.5 (mean)	Rigid and nonrigid Rigid and nonrigid	89.8 95.4	5%	NA	5.4%
Lindh et al ²¹	Retrospective clinical study (multicenter)	≤3	Rigid and nonrigid	95.4		5% (exclusively with nonrigid connectors)	11.8% (2.8% caries, 4.9% endodontic, 4.1% periodontitis) Splinting teeth to implants did not affect the long-term outcome
Brägger et al ²²	Prospective clinical study	5		94.8			
Hosny et al ²³	Retrospective clinical study	6.5	Rigid and nonrigid	97.5			

TABLE 1
Continued

Author	Study Type	Follow-up Time, y	Connector Type	Implant Survival Rate, %	Restoration: Complications	Tooth Intrusion	Tooth Complications
Gunne et al ²⁴	Prospective, randomized clinical study	10		89.8			
Garcia & Oesterle ²⁵	Retrospective clinical study		Rigid and nonrigid			3.5; no difference between connector types	
Fartash & Arvidson ²⁶	Prospective clinical study	10	Rigid	100	NA	NA	NA
Steflik et al ²⁷	Prospective clinical study	10		64.7			

*NA indicates not applicable.

TABLE 2
Reviews

Author	Study Type	Number of Articles Reviewed	Connector Type	Implant Survival Rate	Restoration: Complications	Tooth Intrusion	Tooth Complications
Hita-Carrillo et al ²⁸	Review	20		84.4%–100%	80%–90%	0%–5.6% (mainly with nonrigid connectors)	
Lang et al ^{4,5}	Review	13 (meta-analyses)		90.1%: 5 years; 82.1%: 10 years	77.8% (10 years)	5.2% (almost exclusively with nonrigid connectors)	3.2%, loss at 5 years; 10.6%, loss at 10 years
Lindh ²⁹	Review						

TABLE 3

Biomechanical studies

Author	Study Type	Stress Distribution
Lin et al ¹¹	Biomechanical model	Prosthesis stress was 3.4 times higher for nonrigid connectors than for rigid connectors. Tooth-to-implant displacement was larger with nonrigid connection.
Maezawa et al ³⁰	Biomechanical model (4 prosthetic designs: a tooth-implant-retained 1-piece suprastructure, 3-piece suprastructures with an anterior and 2 posterior segments with unconnected teeth, 3-piece suprastructures with the teeth connected to the posterior segments, and 3-piece suprastructures with the teeth connected to the anterior segment)	Maximum stresses in peri-implant regions of the bone were lower for the 1-piece suprastructures. When the suprastructure was connected to either the anterior segment or posterior segment the maximum stress in the periodontal ligament was lower than in the cases with unconnected suprastructures.
da Silva et al ¹²	Biomechanical model	Less stress with rigid connection and external hexagon
Lin et al ⁹	Biomechanical model	Stress on implants increases with the use of nonrigid connectors and with decreasing periodontal support around the teeth.
Lin et al ¹⁰	Biomechanical model	Higher stresses with the use of nonrigid connectors
Ormianer et al ⁸	Biomechanical model in vivo	Horizontal strains (leading to deformations)
Nishimura et al ⁷	Biomechanical model	Use of rigid connectors leads to slightly higher stress in the supporting structures

use of rigid connectors increases the amount of bone loss observed around implants, although no major differences in implant survival rates have been noted.^{16,17}

The wide variety of outcomes may be due to the fact that the incidence of tooth intrusion and other complications increases over time, with more complications presenting after the 3 year time point. Therefore, studies of shorter duration demonstrate better clinical outcomes.

A prospective evaluation revealed an incidence of intrusion of 66% in the nonrigid group vs 44% in the rigid group over 5 years.¹⁴ These numbers are significantly higher than those reported in other studies, possibly because the design of the study allowed evaluation of even minor levels of intrusion. In the same study, tooth loss due to root fracture was reported with the use of both rigid and nonrigid connectors. An

overall higher rate of complications was reported in the nonrigid group.

Nickening et al¹⁸ reported a higher incidence of technical complications when nonrigid connectors were used. This contrasts with the findings of other clinical studies and with the findings of biomechanical studies indicating higher stresses on the suprastructure when rigid connectors are used.

A factor that should be taken into consideration is the amount of periodontal support provided for abutment teeth. Decreased periodontal support on the abutment teeth increases forces on the remaining supporting bone and on the implant.⁹ In the same study, it was demonstrated that the use of a rigid connector increases forces on the restoration and on the implant but decreases forces on the bone.

In most clinical studies, a slightly greater amount of bone loss was observed around

implants in implant-tooth-supported restorations as compared with those that were entirely implant supported. However, no influence of this finding on short-term implant survival rate was reported. Use of an internal hexagon implant abutment connection increases denture stability while increasing stresses in the abutment; this suggests that the use of an external abutment is favorable in these cases.¹²

The combination of teeth and implants to support restorations yields a lower long-term success rate than the use of implants alone. If use of this combination cannot be avoided, then the use of rigid connectors with only periodontally nonimpaired teeth yields higher success rates.

CONCLUSIONS

- Only limited long-term clinical data exist.
- Biomechanical models have their limitations with regard to the clinical application of retrieved findings.
- Tooth-implant connections have higher failure and complication rates compared with tooth-tooth/implant-implant-supported restorations.
- Despite the more favorable force distribution of nonrigid connectors observed in biomechanical models, rigid connections achieve better outcomes with regard to long-term stability, complications, and tooth intrusion. However, greater marginal bone loss around implants is observed when this type of connector is used.
- The combination of teeth and implants to support restorations yields a lower long-term success rate than the use of implants alone.

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