# A literature review on the clinical performance of fixed prostheses with tooth-implant connection

**Abstract:** *Dental implants are widely accepted in the Dentistry field. New restorative procedures, employed in edentulous patients with no prospect of satisfactory treatment, have been established on the basis of Implantodontics. Thus, not only patients, but also specialists have gained the benefits of the new procedures for oral rehabilitation. However, fixed prostheses in which natural teeth connect with osseointegrated implants are still an issue. Thus, this paper aimed at conducting a literature review on implant/tooth-supported fixed prostheses, taking into account the new procedures established for restoration of partially edentulous patients.*
**Keywords:** *Dental prosthesis. Dental implant. Treatment.*

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## INTRODUCTION

In 1986, Sullivan[10] discussed about the prosthetic considerations associated with the use of osseointegrated implants attached to natural teeth in fixed partial denture. Tooth immobility caused by the use of rigid connections was highlighted as a major concern, as it may lead to atrophic changes in the periodontal ligament, increased medullary spaces adjacent to the tooth and greater susceptibility to periodontal inflammation.

Weinberg and Kruger[11] analyzed the distribution of forces in tooth-supported as well as implant-supported prostheses and found significant differences between them. The authors suggest the use of non-rigid connections for combined implant/tooth-supported prostheses.

Fugazzotto et al[8] analyzed the results yielded with 843 patients treated with 1,206 implant/tooth-supported prostheses using 3,096 screw-fixed connections. According to the authors, several problems occur after different treatment approaches are employed to attach natural teeth to implants beneath fixed prostheses. After 3 to 14 years in function, only nine cases of intrusion were noted. All problems were associated with fractured or lost screws. This study demonstrates the efficacy of this treatment approach when tooth/implant-supported fixed prostheses are used. It revealed that the incidence and severity of natural teeth intrusion after fractured or lost screws relies on the variable of time. Whenever fractured or lost screws were observed within 3 months, tooth intrusion did not occur.

Brägger et al[12] compared the frequency of technical as well as biological complications between implant-supported fixed partial denture (FPD), tooth-supported fixed partial denture (tooth FPD) and implant/tooth-supported fixed partial denture (tooth-implant PPF) over 4 to 5 years of function. Group I (implant FPD) included 33 patients with 40 FPDs; group II (tooth FPD) included 40 patients with 58 FPDs; and group III (tooth-implant FPD) included 15 patients with 18 FPDs. Of the bridge abutments, 144 used teeth as abutment, while 105 used implants. The mean number of units replaced by FPD was three. Complete failure resulted in one FPD loss in each group. Two implants were lost due to fracture caused by bone defect. One tooth underwent vertical fracture and one was lost due to periodontitis. Biological complications (peri-implantitis) occurred in 9.6% of the implants.

Biological complications also occurred in 11.8% of teeth used as abutment: 2.8% had secondary caries; 4.9% had endodontic issues and 4.1% of teeth had periodontitis. Technical complications were associated with bruxism. The authors found favorable clinical conditions for implants and teeth used as abutments after 4 to 5 years of function. Within this period, FPD loss occurred at a similar rate with implant-supported, tooth-supported and implant/tooth-supported prostheses. More fractures were found in implant-supported FPD. Impaired general health status was not significantly associated with major biological failures; however, bruxism and prosthesis extensions were associated with major technical failures.

Lindh et al[13] conducted a longitudinal comparative study with 26 patients with residual anterior dentition who were bilaterally treated with two different designs of partial denture fixed in the posterior maxilla. On one side, the reconstruction was implant-supported, whereas on the opposite side, implant/tooth-supported prostheses were used. Patients were monitored for 3, 6, 12 and 25 months after implant loading. Ninety-five implants were installed, eleven of which were not loaded. A total of ten implants failed, seven prior to loading and three within the first 3 months of function. The authors found no differences in failure rate for implants with two different prosthesis designs. The total mean loss of bone height near the implants was within acceptable standards, however, it was more severe for implants that were not combined with teeth. Results revealed a correlation between prosthesis design and marginal bone loss.

Naert et al[2] conducted a study with 123 patients in which 339 implants were connected to 313 teeth by means of fixed partial denture (experimental group) and monitored for 1.5 to 15 years; and with 123 patients in which 329 freestanding implant-supported prostheses were installed (control group) and monitored for 1.3 to 14.5 years. Their study aimed at comparing the treatment methods performed with implants. To this end, they assessed the implant, the tooth and the prosthesis-related complications. Implant success was assessed with respect to immobility and/or absence of fracture after loading. In the experimental and control group, it reached 95 and 98.5%, respectively. According to the authors, implant/tooth supported prostheses are more likely to present implant failure (immobility and fracture) and prosthetic complications. For this reason, the use of freestanding prosthesis is a primary option that should be considered. In order to prevent intrusion of the abutment tooth, the connection must be completely rigid.

Lindh et al[24] conducted a retrospective study about implants attached to natural teeth. They aimed at assessing implant survival rate, marginal bone loss and the indications of this treatment approach. Their study comprised 111 patients selected at different clinics in Sweden who received 185 implants.

The authors found out that the implant survival rate was 95.4% after a three-year follow-up. All cases revealed intrusion for restorations with non-rigid connections between implants and teeth.

Block et al[14] conducted a clinical prospective study and assessed the effect of rigid and/or non-rigid connections over teeth and implants in a cross-arch model. Thirty patients received two implants, one on each side of the mandibular arch, and underwent restorative treatment with three fixed partial dentures connected with rigid or non-rigid abutment tooth. Repeated-measures analysis did not reveal significant differences in bone loss for implants (rigid versus non-rigid). The percentage of patients who presented measurable intrusion was 66% for the non-rigid group and 44% for the rigid group; 25% of non-rigid teeth presented intrusion greater than 0.5 mm, in comparison to 12.5% for the rigid group. The authors concluded that the high incidence of intrusion and non-scheduled patient visits suggest that alternative treatments without implant/tooth connections may be indicated.

Zhiyong et al[15] highlighted the influence of prosthesis design and loading condition over stress distribution on implant/tooth-supported prostheses. Six 2D finite element models, two reference models and four experimental models were digitized with a view to simulating different prosthesis designs. Six different loadings conditions were applied to assess the stress distribution on teeth and implants. This study revealed that the loading on implant/tooth-supported prostheses was mainly supported by the implant. Minimizing the loading on the tooth decreased the stress exerted over the tooth and the implant. Using implants as abutment was more effective in minimizing the stress than using teeth as abutment in implant/tooth-supported prostheses.

Lin, Wang and Kuo[9] assessed the biomechanics in an implant/tooth-supported system submitted to different occlusal forces, with rigid and non-rigid connections by adopting a non-linear 3D finite element approach. The authors concluded that: (I) Contact elements may be carried out to simulate the realistic interface condition within the implant system and the sliding keyway function; (II) Both occlusal contact force and contact position affect the distribution of stress in a splinting system with different connection designs; (III) The stress-breaker function is only clear when occlusal forces act on natural teeth; (IV) Occlusal adjustment procedures can reduce the effect produced by the cantilever and redistribute stress in the maximal intercuspation or lateral working position for implant/tooth supported prostheses.

Ormianer et al[16] conducted an *in vivo* study to measure strains involved in connecting implants to a natural tooth and compared rigid and nonrigid tooth/implant connections.

Strain gauges were cemented to the experimental restoration, and recordings were obtained from the restorations while the patient bit on a wooden stick on the day of placement and after 2 weeks in function, using both rigid and non-rigid attachment connections.

According to the authors, and within the limitations of this study, combined implant/tooth-supported restorations could be a potential complication and could cause intrusion of natural teeth, regardless of the type of connection.

Lin et al,[25] using a non-linear finite element approach, investigated the mechanical interactions established between combined implant/tooth systems with different periodontal support and number of teeth connected to rigid and non-rigid connectors. The authors concluded that the finite element analysis suggests that non-rigid connectors be carefully used, as they break stress transference and increase unfavorable stress values in the implant system. The implant/tooth—supported system with additional splinting exerts its function in a more efficient way with impaired periodontal support.

Nickenig, Schäfer and Spiekermann[17] reviewed the incidence of biological and technical complications in cases of implant/tooth—supported fixed partial dentures (FPD) treatments. Based on the treatment documentations of a Bundeswehr dental clinic (Cologne-Wahn German Air Force Garrison), the medical records of 83 patients with implant/tooth—supported prostheses were recorded. The median follow-up time was 4.73 years. According to the authors, technical complications of implant-supported FPD depend on the different prosthesis configurations. The use of rigid functional connections yields similar favorable values as in case of solely implant-supported FPDs.

Krennmair et al[18] conducted a retrospective study to assess the results of implants and natural teeth used as combined abutments to support maxillary telescopic prostheses. Between 1997 and 2004, 22 patients with residual maxillary teeth underwent prosthetic rehabilitation with supplementary placement of implant/tooth-supported telescopic prostheses. A total of 60 supplementary implants were placed in strategic position and connected with 48 natural abutment teeth using telescopic crowns. The follow-up registration included implant and natural tooth survival rates as well as peri-implant and periodontal parameters, along with prosthetic maintenance. Natural tooth abutments were additionally followed to compare their periodontal parameters at baseline and follow-up examination. Based on the retrospective clinical review, the authors concluded that: (I) successful function over a prolonged period and with a minor complication rate of implant/tooth-supported telescopic maxillary dentures may be anticipated; (II) there is a great variety of treatment modalities offered by the use of tooth/implant-supported telescopic prostheses in elderly patients.

Lindh[19] arose a controversial question, which still remains after three decades of debate, regarding tooth/implant-supported prostheses. The author assessed what support could be found in the literature to explain tooth extraction in favor of implant placement, and to elucidate whether tooth/implant-supported prostheses were inferior to solely implant supported constructions in terms of survival and complications. According to the author, the results showed that there was no support for extracting teeth in favor of implant placement. On the contrary, healthy teeth presented greater survival rates. The use of implant/tooth-supported prostheses is also endorsed in certain situations with solid, but limited scientific support. In a wider sense, such prostheses could be used as a reliable therapy in all regions of the mandibular arch. However the status of the abutment teeth in terms of periodontal support, pulpal status and risk of carious lesions and biomechanical complications should always be considered in relation to the long-term prognosis of the prosthesis.

Lin, Wang and Chang[20] investigated, by means of a three-dimensional non-linear finite element approach, the biomechanical interactions in tooth/implant-supported fixed partial dentures under several loading conditions with different numbers of splinted teeth and connector types (rigid and non-rigid). The authors concluded that the loading condition is the main factor affecting stress distribution in different components (bone, prosthesis and implant) of implant/tooth-supported FPD. Minimizing the occlusal loading force on the pontic area by means of selective wearing procedures could reduce the stress values. A non-rigid connector may more efficiently compensate for the dissimilar mobility between the implant and natural teeth under axial loading forces but with the risk of increasing unfavorable stresses in the prosthesis.

Nickenig et al[21] assessed and compared the clinical outcomes of implant/tooth—supported fixed and removable partial dentures in a group of partially edentulous patients. Biological and technical complications were recorded and reviewed. A retrospective analysis of the dental records of 224 patients with a mean age of 51.3 years was carried out. The assessment included details regarding the biological and technical complications of the prescribed prostheses, and complications associated with both types of abutments used.

According to the authors, the survival data for both types of prosthesis were comparable to prostheses supported solely by implants. There was no difference in the complication rate between primary splinting (fixed) and secondary splinting with telescopic systems (removable). A greater risk of biological complications was recorded for endodontically treated abutments or teeth with a reduced attachment level.

## DISCUSSION

Fixed prostheses in which natural teeth connect with osseoitnegrated implants are still a controversial issue. The advent of implants brought new possibilities to the rehabilitation of total or partially edentulous patients. Nevertheless, since it is a relatively new and scientifically supported science, it does not have well-established clinical protocols that ensure its use in a safe and proper manner. In this context, it is necessary to establish, on the basis of scientific literature, concepts that allow the clinician to carry out treatment with tooth/implant-supported prostheses, making it a feasible treatment option that contemplates new restorative therapeutic possibilities.

Sullivan,[10] in 1986, already discussed the effects of osseointegrated implants attached to natural teeth in partially edentulous arches with rigid connections. In this context, decreased tooth mobility provided by periodontal ligaments could cause alterations in the long run. Such alterations result from hypofunction. They cause periodontal ligament thinning and increase the medullary spaces of adjacent bone, thus causing the tooth to become more susceptible to periodontal inflammation. Nevertheless, it is worth noting that complete immobility does not occur due to the flexibility inherent to prosthetic segments which are usually made of metal. Furthermore, bone and titanium have elasticity standards that, when in combination, have values between 100 and 200 mm, similarly to periodontal ligament resilience values.

According to Jemt et al,[22] implant/tooth—supported prosthesis may be used in specific cases due to economical and/or mechanical reasons. In these cases, an abutment tooth tends to function as a bridge in relation to the implants, which implies in a concentration of forces in the area between the tooth and the implant. Therefore, this treatment approach must be cautiously addressed, especially in the maxillary arch.

Since tooth and implant are elements of different nature, movement of prosthetic abutments is a major restorative challenge, especially if immobility of rigid connections is considered. Natural teeth have a degree of movement ten times greater than osseointegrated implants. Whenever natural teeth are connected with implants by means of a rigid fixed prosthesis, the total load is supported by each element in proportion to their hardness, which increases the additional overload exerted on the implant bone interface. Thus, non-rigid connections have been used to compensate for the differences in stiffness, acting as stress-breakers.[2] Skalak[5] proposed the need for resilient elements, possibly ring-shaped, that should be inserted between the implant and the prosthesis so as to mimic natural teeth displacement and, as a result, minimize the differences in displacement and equally distribute the load applied to the abutments.

Weinberg and Kruger[11] classified tooth and implant movement into three types: (I) macromovement (0.5 to 1 mm) for teeth with deficient periodontal support; (II) micromovement (0.1 to 0.5 mm) for teeth with periodontal support; and (III) micromovement (> 0.1 mm) for osseointegrated implants. As far as we can see, there is a clear difference in mobility between teeth and implants. Natural teeth have periodontal ligaments with proprioceptors that sense pressure and pain. Periodontal fibers are disposed and originated in such a way that allows them to effectively act against occlusal forces — they are real elastic cushions! Conversely, implants do not have a periodontal ligament, but are biomechanically attached to material such as titanium and bone that effectively act. Nevertheless, the dissipation and action of forces exerted over implants is a critical issue, since implants cannot support intense lateral or transverse forces, but can only support forces in their long axis.

The use of rigid and non-rigid connections remains controversial,[20] with minor or insignificant differences between these options. Nevertheless, long-term radiographic examinations of implant/tooth—supported prostheses reveal more bone loss around implants with rigid connections in comparison to non-rigid ones.[2] Thus, the literature does not reach a consensus regarding the most appropriate connector design for implant/tooth—supported systems.

Mobility of teeth with healthy periodontal ligament may vary between 50 and 200 mm, whereas mobility of osseointegrated implants is not greater than 10 mm. This fact suggests that the physiological movement of the teeth may cause the prosthesis to act as a cantilever, which results in overload that, in turn, may cause peri-implant marginal bone resorption and potential failure in osseointegration. For this reason, non-rigid connectors have been recommended. However, the use of non-rigid connections is associated with intrusion of abutment teeth.[16]

With regard to potential complications, Albrektsson et al[23] suggested some criteria that determine implant success, namely: signs of infection, pain, neuropathies, paresthesia, abutment mobility or increased bone loss — less than 0.2 mm within the first year in function — and absence of peri-implant radiolucency. Furthermore, success rates of 85% 5 years after placement and 80% ten years after placement are minimal criteria to determine implant success.[13]

Thus, attaching a tooth to an implant using a rigid connection restrains tooth movement, which may cause atrophic changes in the periodontal ligament. Furthermore, it is worth noting that the incidence of forces may cause complications such as intrusion of natural teeth,[8] abutment screw loosening,[9] peri-implant bone resorption or even loss of osseointegration.[9,15] In addition to the problems caused by the difference in mobility between prosthetic abutments, material of low flexural resistance are more likely to fracture. Therefore, choosing the most appropriate material, their properties and connection, as well as the financial aspects related to treatment must be considered.

This literature review leads us to conclude that proper planning is highly necessary. It must include mechanical, biological, economical and personal aspects in order to provide patients with feasible treatment options with greater survival rates.

## CONCLUSION

Based on the results of this study it is reasonable to conclude that:

1) Implant/tooth—supported prostheses are a feasible treatment approach that meets the needs of partially edentulous patients.

2) Correct planning is key to success and survival of treatment carried out with implant/tooth—supported partial prostheses.

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