

Occlusion for implant-supported fixed dental prostheses in partially edentulous patients: a literature review and current concepts

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Implant treatment has become the treatment of choice to replace missing teeth in partially edentulous areas. Dental implants present different biological and biomechanical characteristics than natural teeth. Occlusion is considered to be one of the most important factors contributing to implant success. Most literature on implant occlusal concepts is based on expert opinion, anecdotal experiences, *in vitro* and animal studies, and only limited clinical research. Furthermore, scientific literature regarding implant occlusion, particularly in implant-supported fixed dental prostheses remains controversial. In this study, the current status of implant occlusion was reviewed and discussed. Further randomized clinical research to investigate the correlation between implant occlusion, the implant success rate, and its risk factors is warranted to determine best clinical practices.

Keywords: Dental implants, Dental occlusion, Fixed partial denture, Implant-supported dental prosthesis, Review

INTRODUCTION

Implant-supported fixed dental prostheses (ISFDPs) have become a desirable treatment option for replacing missing teeth in partially edentulous patients due to their high predictability and success rates [1-4]. The goal of the ISFDP is to restore esthetics, form, and function. Occlusion plays a role in the functional and biological aspects of the implant supported prosthesis. A well-controlled and maintained occlusion could reduce mechanical and biological complications, thus increasing the longevity of the prosthesis [5].

The occlusal concepts of the ISFDP seem to be extrapolated from the natural dentition and complete denture occlusions with some modifications [6]. However, compared to natural teeth, dental implants present different biological and biomechanical characteristics [7,8]. Dental implants lack a peri-

odontal ligament (PDL) and are more susceptible to bending loads compared to the natural dentition [7,8]. Several risk factors have been associated with the occlusal overloading of ISFDPs, such as occlusal morphology and scheme [7,9-13], nonaxial loading, prostheses with cantilever extensions [1,14-20], an unfavorable crown-to-implant (C/I) ratio [7,21-25], occlusal materials [26-30], and the parafunctional activity of the patient [31-47]. These factors may lead to more biological, technical, or mechanical complications for the ISFDP [7,16,41,42,48,49], or may lead to unfavorable loading of the dental implant. Therefore, ISFDP occlusion should be carefully controlled to increase clinical success rates [7,12,50,51].

Most literature on implant occlusal concepts is based on expert opinion, anecdotal experiences, and *in vitro* and animal studies [52]. Well-performed longitudinal clinical studies on ISFDP are insufficient [53,54]. In addition, little evidence

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supports specific occlusal concepts for implant-supported prostheses [52,55]. However, cautionary approaches lead by experts in the field have been practiced with clinically acceptable outcomes [56]. Therefore, the purpose of this article is to review the occlusal concepts of ISFDPs in the available literature and their current clinical applications.

LOADING ON TEETH VERSUS IMPLANTS

The biological differences between teeth and dental implants are clear. The natural tooth is suspended by the PDL whereas the dental implant is in direct contact with the bone [57]. Under loading, the resilient PDL provides a shock-absorbing feature for the teeth. On the other hand, for implants, a high stress concentration occurs at the crestal bone when loaded, due to the lack of a PDL [58]. The mean value for axial mobility of the teeth is 25 to 100 μm , whereas the axial displacement of osseointegrated implants is 3 to 5 μm [8,15,58]. During lateral loading, the tooth moves at the apical third of the root [59], and the force is instantly dissipated from the crest of the bone along the root [60]. Conversely, the implant moves at 10–50 μm laterally; and the concentration of forces is at the crestal bone [58]. Clinical signs of occlusal overloading of teeth include widening of the PDL, fremitus, and mobility of the tooth [15]. On the other hand, signs of inflammation [61] and crater-like bone defects [62] have been associated with the overloading of implants. Occlusal overloading of implants may also lead to mechanical complications of the supported prostheses, such as screw loosening or fracture, abutment or prosthesis fracture, or even implant fracture [63].

OCCUSAL SCHEME AND MORPHOLOGY

There is little evidence to suggest that a specific occlusal scheme for ISFDPs is superior, since changes in occlusion may be easily adopted by the complex neurophysiological mechanism in the jaw muscle system [56]. In addition, occlusal scheme design has minor or no importance to marginal bone loss of implant-supported prostheses [64]. General recommendations for occlusal morphology include flat fossa and grooves for wide freedom in centric [11], shallow occlusal anatomy, a narrow occlusal table, and reduced cuspal inclination [15]. It is recommended that the size of the occlusal table be 30% to 40% smaller for molars [7,12,13]. Widths greater than the implant diameters may generate cantilever effects and some bending movement in single unit implant-supported prostheses [7,12,13]. A narrow occlusal table may increase axial loading and decrease nonaxial loading for the implants [7,65]. The reduced cuspal inclination can decrease the bending moment, increase the axial loading force of im-

plants, and reduce stress on the implant and the implant/abutment interface [9-11].

The correlation between occlusal overloading and peri-implantitis, which consequently results in implant failure, has been controversial [66-76]. Supra-occlusal axial and lateral loading has been shown to create some crater-like bone defects lateral to the implants and loss of osseointegration [68,69,74]. However, it should be noted that the loss of osseointegration observed in those studies could have been attributed to the use of short and narrow implants, impractically high-occlusion, or excessive lateral overload [68,69,74]. Furthermore, it could be that the implants evaluated were smooth surface implants instead of rough surface implants that have a more favorable success and survival rates [77-81]. On the other hand, some studies have indicated that axial and lateral occlusal overload leads to no differences from nonloaded sites according to clinical, radiographic, and histologic observations [73,82]. No crestal bone loss was observed. Occlusal forces are hardly in the vertical direction; mastication involves side-to-side action as well [52]. Evidence does not support that nonaxial loading has a detrimental effect on osseointegrated implants [83,84]. However, occlusal overload may consequently lead to mechanical complications [51,83,85], such as loss of veneering acrylic and porcelain fractures [5]. This may consequently result in failure of the implant and its supported prosthesis [85]. Therefore, ongoing maintenance and periodic evaluation of an ISFDP are important in order to monitor any changes and manage potential mechanical complications [7,86].

Besides bilateral balanced occlusion for complete denture fabrication [87], group-function occlusion, and mutually protected occlusion for the natural dentition with and without fixed prostheses [88,89], implant-protected occlusion has been suggested for implant-supported prostheses [90]. The implant-protected occlusion concept aims at protecting the implants by reducing occlusal force on implant prostheses [90]. Some other occlusal scheme designs for ISFDPs have been adopted and modified from existing concepts. The guidelines are summarized in Table 1 [15,20,56,91-93]. Prescription of a night guard after delivery of an ISFDP is recommended, especially for those diagnosed with parafunctional activities [20].

PROSTHESES WITH EXTENSION UNITS

The beliefs and recommendations regarding cantilever extensions of ISFDPs have been inconsistent [1,16-18]. The major limitations of prostheses with extensions include possible complications such as prosthesis debonding [16], potential overload of the supporting implants [14,51], and higher stress

concentrations around the adjacent implants with extensions [19]. A minimal cantilever for single unit ISFDPs and avoidance of mesial and distal extensions in posterior ISFDPs have been recommended [20]. When an extension is utilized in a posterior ISFDP, mesial placement of the extension has been suggested in order to reduce biomechanical complications [20]. In contrast, a recent systematic review assessed the survival rates and the incidence of technical and biological complications of ISFDPs with a cantilever [1]. The review demonstrated that the high survival rate of ISFDPs with extensions was comparable to those prostheses without extensions. In addition, no major detrimental effects, such as marginal bone loss, were observed [1,21]. The most common complications noted were veneer fracture and screw loosening. Moreover, the position or length of the extension did not influence the marginal bone [18]. Therefore, the findings supported that extensions of ISFDP can be a viable treatment option [1,18].

C/I RATIO

An optimum crown-to-root ratio (0.5:1) has been proposed for a natural tooth that serves as a fixed dental prosthesis abutment [94]. As for ISFDPs, the definition of the C/I ratio has been proposed to be the length from the anatomical crown (the fulcrum of the lever arm at the implant shoulder) to the implant, or that from the clinical crown (the fulcrum of the lever at the bone crest) to the implant [21]. An unfavorable C/I ratio, perceived as a form of nonaxial loading, contributes to an increase in stress to the implant and bone [7]. However, ISFDPs with anatomical and clinical C/I ratios of 2–3 have demonstrated high survival and success rates compared to those with low C/I ratios [21]. The C/I ratio was found to have no significant influence on the technical and biological complications and marginal bone loss of ISFDP [24]. Therefore, the concept of the crown-to-root ratio and its guidelines for natural tooth abutment prognosis should not be applied to ISFDPs [25].

Another term, crown height space (CHS), defined as the space between the occlusal/incisal plane to the crest bone [22], has been suggested for evaluating the interarch space for implant supported prostheses. The ideal CHS for an ISFDP is 8 to 12 mm to accommodate the biologic width, abutment height, and occlusal materials of the crown [22]. A comparison between the C/I ratio and CHS showed that the CHS is a more significant factor for measuring biomechanically-related complications [23].

OCCLUSAL MATERIAL

The original recommendation for occlusal materials of im-

plant-supported prostheses was acrylic resin with a gold alloy framework [30,54,95]. The purpose was to provide a shock-absorbing mechanism instead of transmitting the force to the bone, leading to a reduction in possible implant failure [30,54,95]. In clinical practice, porcelain has become the material of choice for ISFDPs due to its esthetics and wear-resistance [64]. Therefore, the mechanical and physical effects of different restorative materials, such as metal ceramic crowns and all-ceramic crowns, on implant and supporting bone have been evaluated. It was found that the use of more rigid material directed greater stress concentrations onto the abutment [29]. Conversely, the use of different occlusal materials did not affect the masticatory force load rate [96], force absorption quotient [27], or stress distribution/stress values in the supporting bones [26,29]. When comparing metal-ceramic to all-ceramic occlusal material, both were able to withstand loads. However, metal-ceramic withstood higher strength loads [28]. The authors recommended the use of occlusal materials with a high elasticity modulus [26,29].

PARAFUNCTIONAL ACTIVITY

Parafunctional activities, such as bruxism and clenching, have been suggested to have biological, technical, and mechanical impacts on implant-supported prostheses [31,33,35,

Table 1. Occlusal scheme guidelines for Implant-supported fixed dental prosthesis.

General occlusal scheme
Centered contacts in maximum intercuspation (point centric or freedom in centric with 1–1.5 mm)
Light contact on firm occlusion with shim stock (8–30 μm) passing through
Anterior guidance with natural dentition
No centric relation-maximum intercuspation discrepancy, no working, nonworking, or protrusive interference contacts
Implant-supported fixed dental prosthesis (single unit)
Avoid excursive guidance
Increased proximal contact
Implant-supported fixed dental prosthesis (multiple unit)
Anterior section
Light contact in maximum intercuspation (30 μm)
Flatten vertical and horizontal overlap and protrusive guidance to reduce lateral forces
Selective excursive guidance for best biomechanical abutment distribution
Posterior section
Excursive guidance on well-supported anterior natural teeth with posterior teeth disclusion in eccentric movements
Canine protected or mutually protected occlusion if canine present
Group function occlusal scheme if canine absent/prosthesis replacing bilateral distal extension
Optimum abutment support for working guidance

41,42,48,49,70]. Regarding the biological effects, some studies have advocated that parafunctional activities are associated with marginal bone loss around implants and loss of osseointegration [31,33,35,47,70] due to overloading of the implants [31]. However, the clear role of parafunctional activities on implant overloading and loss of osseointegration is not evident, and various results have been reported [36,37,39,40,43-46]. It has not been possible to establish a cause-and-effect relationship between parafunctional activity and implant survival [36-40]. Conversely, parafunctional activities have been attributed to technical and mechanical complications, such as veneering porcelain chipping/fracture or screw loosening [34,35,41,42,48,49]. Therefore, occlusal night guard prescription for patients diagnosed with parafunctional activity are highly indicated [38,39]. More long-term randomized controlled studies are advocated to investigate the relationship between parafunctional activities and implant failure to support the treatment modality [38].

CONCLUSION

Evidence-based consensus for managing occlusion for ISFDPs is still lacking. Most of the available clinical data are controversial. Current clinical practices rely heavily on principles extrapolated from the natural dentition or removable dental prostheses on complete edentulous patients and on expert opinions. More clinical trials investigating occlusion for ISFDPs and its relationship with risk factors are warranted to determine best practices for our patients.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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