The prosthetic management of a poor implant treatment is presented in this case report. The recommended occlusion concepts for implant-supported prostheses were applied for the resolution of the case. The rehabilitation of the posterior segments provided a mutually protected occlusion with adequate distribution of the axial and lateral bite forces with stable posterior occlusion. The clinical exam indicated the need for modification in the vertical dimension of occlusion. Sufficient interocclusal rest space was present to test the alteration in the vertical dimension. The aim was to achieve an occlusion scheme that followed four specific criteria: (1) centric contacts and centric relation of the jaw-to-jaw position; (2) anterior guidance only; (3) shallow anterior angle of tooth contact; and (4) vertical dimension of occlusion with acceptable tooth form and guidance. The success of an oral rehabilitation relies in following the aforementioned criteria, appropriate interaction between the dental laboratory technician and the clinician, careful elaboration of the provisional rehabilitation with all the desired details to be reproduced in the final prosthetic restoration and sufficient follow-up time of the provisional prostheses before placing the final restoration.

Key Words: implants, prosthesis, occlusion, mutually protected occlusion, canine guidance

INTRODUCTION

The importance of teeth occlusion was not fully understood in the early days of dentistry. Some authors suggested that food grinding was related with the masticatory surfaces of the opposing teeth. The concept of an optimal occlusal relationship was based on a bilateral muscle balance that provided adequate control of strength and pressure between the dental arches, according to the mandibular movements guided by the condyle path and by the occlusal surfaces of the opposing teeth. In the early 20th century, clinicians began to apply the occlusal concepts based on the knowledge of the physiology of the masticatory system and its functional geometry and to recognize dysfunctional adaptations of occlusion.

Understanding the principles of the mandibular movements, the transverse horizontal axis and the maxillomandibular relationships associated with the development of devices to record and transfer the maxillomandibular relationship to the dental laboratory has led to the rehabilitation of patients and to the recovery/maintenance of the good health of the stomatognathic system. However, the evolution of the occlusion principles has gone through different concepts among the following: bilateral balanced articulation; the concept of long centric articulation; the Bennett movement; the absence of contacts on the nonworking side; and the importance of establishing an anterior guidance at the beginning of an oral rehabilitation; the importance
of the canine guidance; and the development of the New Scandinavian Gnathology School with the intent to further understand the mutually protected occlusion.6

An impaired dental occlusion affects the mandible movements, the masticatory function and the esthetic appearance of the patient, and may also lead to social and psychological disorders.7 Dental occlusion and different occlusion schemes have been discussed in literature. Some of the methods to correct and to restore function to damaged teeth have no scientific support. The earliest reports were predicated upon years of successful clinical observations or subjective experiences,3 not based on scientific evidence.

The study of the relationship between neurophysiology and the stomatognathic system led to understanding the relationship between dental occlusion, the temporomandibular joint, the muscles and the associated functional patterns of the jaw movements.8 The importance of considering such factors when performing an oral rehabilitation was then demonstrated.9 Despite understanding this relationship and the growing research in this area, studies have reported that some clinicians are still not careful with the occlusion characteristics of the rehabilitation.10

The introduction of the osseointegrated implants has further complicated this situation.11 Current scientific studies have discussed whether the principles of occlusion for the natural dentition could be directly applied to implant-supported restorations.11 Although this may be successful, this rationale may result in overly complex or simplified treatment protocols.11 The mechanisms of load perception and modulation are different between teeth and implants, thus resulting in different stress distribution between both because of the absent periodontal ligament in the latter and the resulting decreased capability of impact absorption and resilience.12 Implants may absorb all heavy biting force because of the non-significant implant mobility (3–5 mm) while teeth can be intruded (25–50 mm) with any occlusal force.13

Occlusal adjustments have been proposed to eliminate the differences in mobility between teeth and implants, aiming to uniform distribution of the loads.13,14 Some authors have recommended a clearance of 30 μm between implants and opposing teeth.15,16 Consequently, the implant is not subject-
ed to load during light or moderate dental contact. During high-intensity contacts, the implants and teeth will contact simultaneously.16 Positional changes of teeth may intensify the occlusal stress on implants.13 Re-evaluation and periodic occlusal adjustments are needed to prevent the potential overloading of the implants from the positional changes.13,14,17,18

Additional factors regarding the different biomechanical behavior between teeth and implants have been discussed: The different bone densities when planning implant-supported prostheses need to be studied and understood,13,19 different responses to bite forces during mastication,20 higher stress concentration surrounding the implants when submitted to occlusion overload,12 and lesser tolerance of the implants to oblique forces.11,21 The different biomechanics between teeth and implants hence complicate the planning of an implant-supported oral rehabilitation and the establishment of the prosthesis design and the occlusal contacts.

Factors affecting load distribution in dental implants include geometry, number, length, diameter and angle of the implants, implant location in the arch, type and geometry of the prosthesis, prosthesis material, acceptable framework design, location, direction and magnitude of load application on the prosthesis, condition of the opposing arch, mandibular deformities, bone density, gender and age of the patient, food consistency, and bite size.

This study used the occlusion concepts recommended in literature for acceptable prosthetic design and the recommended occlusion contacts for implant-supported prostheses in the resolution of a poor implant treatment.

**CASE REPORT**

A 32-year-old woman presented to the ILAPEO (Instituto Latino Americano de Pesquisa e Ensino Odontológico - Latin American Institute of Dental Research and Education) with a complaint of repeated fractures of the anterior teeth. Table 1 presents the treatment steps that were taken throughout the patient treatment. The following methods for the diagnosis of the patient were used: anamnesis, clinical examination, panoramic radiography (Figure 1) and profile teleradiography (Figure 2).
The clinical examination found a mandibular prognathism associated with Angle Class III molar relationship. Infra-occlusion of the posterior teeth was present with occlusal contacts on the anterior teeth #9, #10, and #11. Teeth #21 and #27 were rotated (Figures 3a, 3b, 3c).

The implant-supported prostheses had the same crown orientation as of natural teeth #4 and #13 and presented a bilateral cross-bite in the posterior segments (Figure 3a). The previous rehabilitation presented posterior bilateral cross-bite disregarding the compensating curves. The patient presented constant fractures of the incisal edge of tooth #7 and reported a history of repeated fractures in the other maxillary incisors (teeth #8, #9, and #10), which required esthetic restorations.

It was concluded that the recommended occlusion concept that provided a mutually protected occlusion had not been applied in the initial rehabilitation. The posterior teeth had no contact with the antagonists in centric relation (CR) and in maximum intercuspation (MIC). Occlusal contacts were established by the anterior teeth (Figures 3b and 3c). Additionally, disclusion of anterior teeth was made by the posterior teeth during the mandibular excursive movements. The patient had no complaints of muscle pain or joint discomfort and her main complaint were the constant fractures in the esthetic restorations of the anterior teeth.

<table>
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<td>1</td>
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Table

Figures 1 and 2. Figure 1. Initial panoramic radiography. Figure 2. Initial profile teleradiography (note the maxillomandibular relationship).
The maxillomandibular relationship was evaluated. The rest vertical dimension (RVD) compared with the vertical dimension of occlusion (VDO) showed a difference of 5 to 6 mm between the two, allowing the re-establishment of 2 mm to the VDO. The increase in the VDO enabled the relief of the contacts in the anterior teeth. A Lucia jig was obtained with acrylic resin (Duralay, Polidental, São Paulo, Brazil) to transfer the mandibular position after the reestablishment of the vertical dimension by 2 mm and with the mandible guided into CR (Figure 4). After checking the reliability of the Lucia jig, a wax (Asfer, São Caetano do Sul, São Paulo, Brazil) occlusal rim was used to transfer the maxillomandibular relation record to the semi-adjustable articulator (Bio Art, São Carlos, São Paulo, Brazil).

The anteroposterior curves of the patient were evaluated after prosthesis removal (Figures 5a and 5b). Both superior and inferior arches were molded after prosthesis removal and the diagnostic casts were assembled in a semi-adjustable articulator (Bio Art, São Carlos, São Paulo, Brazil) using a facebow (Bio Art, São Carlos, São Paulo, Brazil) to transfer the spatial relationship of the maxillary arch to the articulator and an interocclusal record to transfer the maxillomandibular relationship.

A diagnostic waxing of the planned prosthesis was performed to evaluate the outcome of the rehabilitation (Figure 6). Acrylic provisional restorations were fabricated with the new planned interocclusal space using the diagnostic waxing of the crowns. After the installation of the provisional maxillary and mandibular crowns, an occlusal adjustment was carefully performed and adjusted with double-sided occlusal marking film (AccuFilm II, Parkell, Edgewood, NY, USA). A mutually protected occlusion with simultaneous bilateral posterior contacts in maximum intercuspation and disengagement of the posterior teeth by the anterior teeth in all mandibular excursive movements was achieved. The aim was to obtain an implant-supported oral rehabilitation with axially directed occlusion forces to avoid overloading the implants.
during the mandibular excursive movements (Figure 7a, 7b, and 7c).

Phonetic test was performed to verify the established VDO and to evaluate the presence of adequate speaking centric space. The freeway space was verified by performing tests with the VDO and RVD, visual analysis and with the aid of a Willis gauge (Jon Dental Products, São Paulo, SP, Brazil).

After the installation of the provisional crowns, the patient returned to follow-up sessions to evaluate phonetics and presence of muscle pain and temporomandibular joint (TMJ) discomfort. No symptoms of abnormal muscle activity were found and the phonetic test found normal characteristics. The patient then received a removable orthodontic appliance with tension coil springs to correct the cross-bite of teeth #10 and #11 (Figure 8a and 8b). During the period of orthodontic treatment, the endodontic treatment of teeth #20 and #29 was performed to allow for the preparation of the prosthetic crowns in a more lingualized occlusion.

The final rehabilitation was performed after completion of the orthodontic treatment and finishing of the needed endodontic treatments. This happened one year after the installation of the provisional restoration. All posterior teeth were restored with metal-ceramic complete crowns. Ceramic veneers were placed in all anterior teeth (with the exception of tooth #9, which received a complete ceramic crown with a zirconia-based crown coping). To compensate for the vestibular inclination of tooth #21 replacing implant (Figure 9), a customized zirconia abutment was fabricated (Neoshape, Neodent, Curitiba, PR, Brazil) and a complete ceramic crown with zirconia-based crown coping was cemented on the abutment. This
allowed an increase in porcelain thickness and provided better esthetics to the crown (Figure 10).

The same occlusal scheme that was established in the provisional rehabilitation was followed in the final prosthetic restoration. Bilateral contacts were designed to occur simultaneously and coinciding with the condylar position in CR (Figure 11a, 11b, and 11c). Anterior guidance was established on the anterior teeth to disengage the posterior teeth during excursive movements. Protrusion contacts only occurred in the incisors and the canine guidance was present during lateral excursive movements (Figure 12a and 12b).

No fractures were observed in the maxillary anterior ceramic crowns and veneers at the one-year follow-up of the final restorations. The masticatory muscles and the TMJ were evaluated for pain and discomfort. The patient was found to be asymptomatic and comfortable during the one-year period. The final view of the installed prosthetic rehabilitation showed a significant change of the esthetic and functional aspects (Figure 13a, 13b, and 13c). The final occlusal scheme can also be seen in the profile teleradiography (Figure 14).

**DISCUSSION**

The controversy found in literature may confuse clinicians when establishing the occlusal aspects of an implant-supported rehabilitation with opposing teeth and implants, possibly resulting in implant prosthesis without any effective occlusal contacts, such as the one presented in this case study. The occlusal schemes recommended for the occlusal rehabilitation clearly emphasize the following aspects.
points: presence of a mutually protected occlusion with simultaneous bilateral contact of the posterior teeth protecting the anterior teeth and maintaining stability in the posterior occlusion, reestablishment of the anatomic curves and oriented anterior guidance, decreased cuspal interference on the nonworking side associated with a shallow anterior guidance to minimize the antagonist forces during the disengagement of the posterior teeth, centralized forces on the long axis of the implants, and minimized lateral forces.

However, histological findings in monkeys showed no bone abnormalities when implant-supported prostheses were overloaded. The teeth gradually intruded and the supporting bone was able to bear the load after thickening and remodeling of the surrounding bone. Conversely, occlusal overload was previously reported as the main factor for the loss of osseointegration of osseointegrated implants and increased marginal bone loss. Occlusal overload and off-axis torsional loads can also lead to loosening of the abutments and of the prosthetic screws and to fractured implants and prosthesis.

Decreased occlusal stress of the implant-supported prosthesis is most often the factor related to marginal bone loss that can be directly impacted by the restorative dentist, however, the remaining factors related to marginal bone loss should not be overlooked in favor of the concept of occlusal overload.

To achieve an optimal occlusal design, the clinical examination in the presented case study indicated the need to modify the occlusal vertical dimension. Sufficient interocclusal rest space was present to test this modification. In agreement with previous studies, the rehabilitation of this clinical case was planned aiming to achieve a harmonious occlusal scheme according to four restorative criteria as follows: (1) Centric contacts and centric relation of the jaw-to-jaw position—even distribution with the occlusal contacts small and centered over the implants; (2) eccentric contacts—anterior guidance only, distributed over multiple teeth; (3) angle of tooth contact—shallow as possible to minimize shear forces but still disclude posterior teeth; and (4) Vertical Dimension of Occlusion (VDO)—alter if necessary to create proper tooth form and guidance. Alteration of the present VDO might be needed to achieve an adequate orientation of the occlusal forces, thus optimizing the stresses surrounding the implants. VDO alterations should be thoughtful to avoid increased muscle activity and temporomandibular joint overload and pain.

The temporomandibular joint may be protected with the correct establishment of the posterior teeth contacts. A more posterior occlusal contact of the teeth will lead to a greater bite force, thus reducing the joint load. With more contact of the anterior teeth, a lower bite force is present with increased joint load. The alterations made to the occlusal scheme and to the VDO of the patient were carefully evaluated and the following parameters were considered: evaluation of the available freeway space with an interposed anterior jig, facial measurements and phonetic test with specifically sibilant or “S” sounds. The alterations in the VDO of the patient were tested in the stage of the provisional prosthesis, before the final rehabilitation. After completion of the orthodontic treatment, one year after the installation of the provisional restorations, the modification of the VDO was found to be adequate to the patient and was used in the final rehabilitation. The provisional stage was therefore used as the testing ground for the occlusal hypothesis. Adequate care with alterations in the VDO is in agreement with previous studies that recommended the testing of any modification to the VDO at the provisional stage of the rehabilitation.

The abutment selection should compensate for minor irregularities in implant angulation to aid in the compensation of the occlusal factors. Severe angulation problems may be a contraindication for fixed implant-supported prosthesis. For resolution of the present clinical case, the abutment used in tooth #9 replacing implant was customized to allow a more lingual position to the crown. Zirconia was used as core material for this restoration because of favorable esthetics by eliminating the gray effect present in implant prostheses with metal alloy substructures.

The oral rehabilitation presented in this clinical report has shown the importance of understanding and applying the recommended occlusal schemes for the rehabilitation of a partially edentulous patient. Numerous studies have reported the main aspects to be considered in the rehabilitation of multiple edentulous segments. It is unacceptable to
rehabilitate a patient disregarding the recommended occlusal aspects and criteria.

Optimum interaction between the clinician and the dental laboratory is required. The provisional restoration should contain the occlusal scheme intended for the final restoration, aiming to provide sufficient follow-up of the patient bearer of the temporary crowns before the installation of the final rehabilitation, thus ensuring the long-term success of the implant-supported prosthetic restoration.

**ABBREVIATIONS**

CR: centric relation
MIC: maximum intercuspation
RVD: rest vertical dimension
TMJ: temporomandibular joint
VDO: vertical dimension of occlusion

**REFERENCES**