Denture-Related Biomechanical Factors for Fixed Partial Dentures Retained on Short Dental Implants

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Prosthodontically driven biomechanical considerations are essential for long-term successful outcomes in dental implant therapy. Correct protocols seek to preclude potential consequences associated with functional and parafunctional occlusal overload such as screw loosening, component fracture, compromised marginal bone maintenance, and the integrity of the induced osseointegration response. Other concerns also need to be addressed, more especially when other implants are selected, for example: bridge insertion torque (BIT) in cases of immediate loading, cantilever length–anteroposterior spread ratio (CL–AP), overall crown-to-implant ratio (oCIR), total bone-to-implant surface area (tBICA), and the status of the opposing dentition. In spite of promising clinical results, evidence-based clinical protocols demand that such biomechanical limits still need to be determined. *Int J Prosthodont 2015;28:412–414. doi: 10.11607/ijp.4238*

Inadequate emphasis on biomechanical treatment-planning protocols may result in a range of prosthesis maintenance requirements, including occasional remakes. The current recruitment of short dental implants (generally defined as lengths shorter than 8 to 10 mm) for minimally invasive rehabilitation of atrophic jaw regions is essentially based on efforts to avoid bone augmentation surgery. However, their use challenges established principles of routinely employed fixed prosthodontic protocols given the associated significant reduction in resultant bone-to-implant contact. This demands critical consideration of at least five relevant biomechanical determinants when prescribing fixed prostheses supported by short implants.

Bridge Insertion Torque

Bridge insertion torque (BIT) is exclusively relevant to prosthetic concepts of immediate or early loading. As originally defined by Neugebauer et al,[1] BITs are calculated as the mean value of individual implant insertion torques within a multi-unit reconstruction. In their study, four to six implants were placed in the posterior maxilla and mandible of seven minipigs. When subjected to immediate loading, all implants failed when the BIT was less than 35 Ncm (only occuring in the maxilla), compared to an implant success rate of 96% with BITs greater than 35 Ncm. In spite of this study's inherent scientific shortcomings—questionable external validity, lack of statistical power, jaw and implant number differences—the surgical community has embraced a general guide that precludes immediate loading if a BIT of 35 Ncm cannot be reached. Consideration of BITs may also be of particular importance when immediate loading is applied to short implants.

Cantilever Length–Anteroposterior Spread Ratio

Cantilever length (CL) is understood as the fraction of superstructure projecting beyond the most distal implant, while anteroposterior spread (AP) refers to the distance between the line connecting the two most distal implants (at their distal edge) and the center of the most distant implant, thus providing a rough measure of geometric implant distribution.[2] The ratio between the two (CL-AP) represents a measure of

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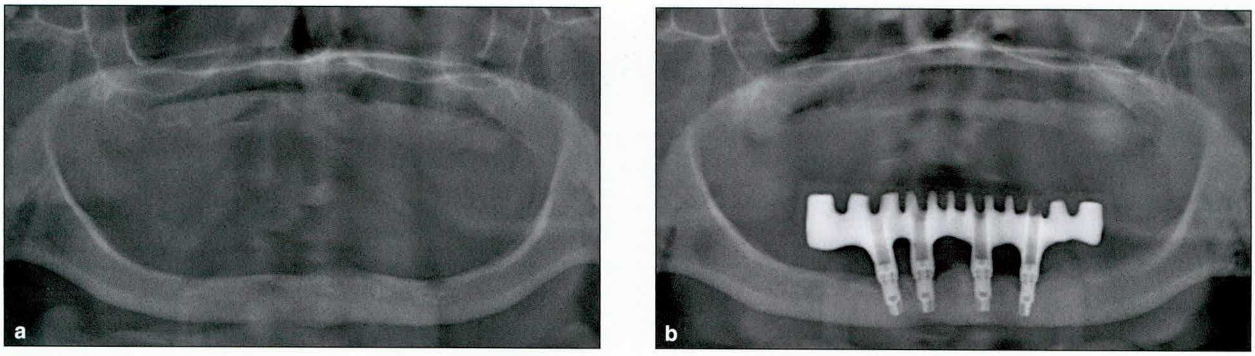

Fig 1 Short implant placement in severely atrophic jaws **(a)** may result in unfavorable biomechanics related to reduced tBICA, compromised CL-AP, and diminished oCIR, resulting in prosthetic and/or biologic complication **(b)**.

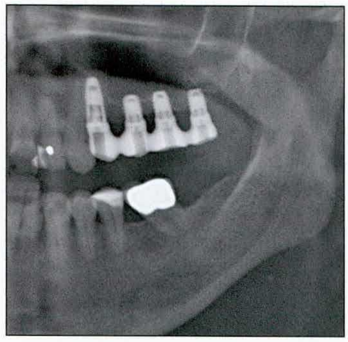

Fig 2 In splinted reconstruction on short implants opposing shorter dental arches (eg, two maxillary molars vs one mandibular molar) the tBICA may be less significant than the oBICA (oBICA = tBICA / number of occluding crowns).

occlusal load distribution and has been suggested to guide the fabrication of full-arch implant prostheses (Fig 1). The maximum acceptable CL-AP ratio has been postulated to range between 1.5 and 2.0 based on biomechanical models; however, this has never been ascertained clinically. No consensus has yet been reached in the scientific literature, least of all concerning the ability to cantilever partial dentures on short implants.[3]

Crown-to-Implant Ratio

Anatomical crown-to-implant ratio (CIR) is calculated as crown length by implant length and may differ from clinical CIR, which is defined as crown height space (incisal edge to marginal crest) by implant length within bone, in cases of supracrestal implant placement or marginal bone resorption. Crowns of molars should be measured from the highest cuspid along a parallel to the implant axis.[3] CIR, by definition, represents an implant-related determinant only to be used in single-tooth implants. In fixed partial dentures the overall CIR (sum of individual CIRs by the number of implants) may be used as a denture-related biomechanical factor. Individual CIRs may show great variation in partial dentures involving different implant lengths, as CIRs ≥ 2 can be seen in no less than one-third of short implants.[3]

Bone-to-Implant Contact Area

Traditionally, the surface area of implants available for osseointegration has been described in terms of implant length and diameter. It has been an axiom in implant dentistry that longer implants guarantee lower failure rates, although a linear relationship between implant length and success has never been proven. Clinical strategies to increase the surface area of implants include the use of wider implant diameters as well as rough implant surfaces. The contact area toward bone, however, depends not only on an implant's microscopic surface or microgeometry (currently 0.1 to 0.3 µm) but also on macroscopic design characteristics. Potential bone-to-implant contact area (BICA) may be estimated by calculating the lateral surface of an implant cylinder ($2 \times \pi \times r \times h$),[4] although this approach ignores the base circular surface as well as the conicity of tapered designs. Three-dimensional scanning technology should be used to precisely compute the total bone-to-implant contact area (tBICA) as the sum of all implant surface areas involved.

Opposing Dentition

Description of the dentition opposing an implant-supported fixed prosthesis should discriminate between natural dentition (ND), fixed partial dentures on teeth

(FPDs), implant-supported fixed prostheses (IFPs), removable partial dentures (RPDs) and complete dentures (CDs), or implant-supported overdentures (IODs).[5] If the opposing dental arch is shorter, nonoccluding implants serve as additional prosthesis stabilization (Fig 2) and an overall bone-to-implant contact area (oBICA) may thus be calculated as tBICA by the number of occluding crowns. Future research should place a far greater focus on preliminary descriptions and documentation of prosthesis-related criteria so as to explore biomechanical limits of the evolutional therapeutic concept of short implants.

Conclusion

Scrupulously documented and impressive treatment outcomes in dental implant therapy have yielded compelling information regarding the merits of employing sound biomechanical protocols as integral parts of routine treatment planning. However, the routine prescription and scientific veracity of current implant-related therapy is largely based on results with the originally described 10-mm-long (or even longer) implant. Current surgically led initiatives to use compromised and atrophic bone in implant therapy without resorting to bone augmentation techniques has now catalyzed widespread use of shorter implants. While this may seem like a prudent, logical, and perhaps even more versatile alternative to traditional implant lengths that otherwise require a larger potential host site, it must be recognized that an entirely new biomechanical evaluation of established protocols now needs revision if similar successful time-dependent prognoses are to be expected.

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Literature Abstract

Fluorodeoxyglucose positron emission tomography with computed tomography detects greater metabolic changes that are not represented by plain radiography for patients with osteonecrosis of the jaw

This investigation compared the diagnostic findings of plain radiographs (panorex, periapical radiographs) with fluorodeoxyglucose positron emission tomography with computed tomography (FDG PET/ CT) images for the evaluation of osteonecrosis of the jaw (ONJ) associated with antiresorptive therapy. Twenty-three patients (35% men and 65% women, mean age = 65 years) with 25 ONJ lesions met the inclusion criteria. Plain radiography and FDG PET/CT with 1-mm sections were evaluated for each patient. Radiographic examination showed local changes in 17 ONJ lesions (68%), diffuse changes in 3 ONJ lesions (12%), and no changes in 5 patients (20%). FDG PET/CT imaging showed local changes in 17 ONJ lesions (68%) and diffuse changes in 8 ONJ lesions (32%). Limitations of the study were mentioned, such as interpretation of findings related to the pathogenesis of ONJ, types and duration of chemotherapy and antiresorptive therapy regimens, timing of clinical examination and imaging, and the lack of a control group. It was concluded that FDG PET/CT detects local and diffuse metabolic changes that may not be represented by plain radiography for patients with ONJ. The authors suggested future studies using FDG PET/CT imaging to validate risk assessment and surgical efficacy for ONJ.

Fleisher KE, Raad RA, Rakheja R, et al. *J Oral Maxillofac Surg* 2014;72:1957–1965. **References:** 76. **Reprint:** Dr Fleisher, Department of Oral and Maxillofacial Surgery, Clinic 2-S, New York University College of Dentistry, 345 East 24th Street, New York, NY 10010. Email: kef3@nyu.edu
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