Crown-to-implant ratio: A misnomer

The term "crown-to-implant ratio" is commonly used in dental implant prosthodontics. It was modified from "crown-to-root ratio" in fixed prosthodontics. Ante's law discussed the root support of natural teeth used as abutments for a fixed partial denture, stating that "the total periodontal membrane area of the abutment teeth must equal or exceed that of the teeth to be replaced"[1]; however, this theory was not evidence-based. In this context, a longer root length, multiple roots or a wider root diameter would all be favourable characteristics for improving biomechanical support of a fixed partial denture on teeth.

It is a well-established fact that the supporting interface of a tooth root is vastly different to a dental implant. Natural teeth have a periodontal membrane with fibres that insert into the root cementum and surrounding alveolar bone. Under function, these fibres transmit occlusal loads to the supporting alveolar bone. As such, a longer tooth root would resist displacement and provide a greater surface area for load distribution.

Osseointegrated dental implants are supported by a direct connection with the surrounding jawbone. Various stress analysis studies (finite element, strain gauge) on models replicating dental implants in bone have all shown that load distribution occurs primarily around the neck region, with minimal stress below this area.[2-5] The maximum bone stress is virtually constant, independent of implant length. If the stress distribution is concentrated in the first 4 to 6 mm of supporting bone, then placing a longer implant (i.e., 12 mm instead of 8 mm) would not improve the crown-to-implant ratio. If the denominator in this ratio (implant length) becomes less relevant beyond the neck area, then the term "crown-to-implant ratio" is a misnomer.

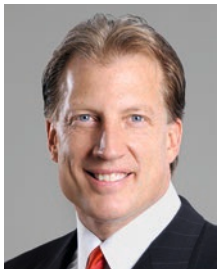
The focus of this discussion should be on the numerator of the equation, crown-to-abutment height. As the dimension of the crown-to-abutment height increases, there is a greater risk of biomechanical complications. This is especially the case with off-axis loading of the crown or prosthesis. A moment load (M), produced by off-axis forces, is the product of the applied force (F) × the moment arm distance (d). The distance (d) is measured from the implant platform to the applied load. Occlusal loading of the implant crown cusps and working or balancing contacts would produce a moment or torque on the implant abutment connection. This magnified load can result in technical complications such as abutment screw loosening or breakage and even implant neck fracture.

In the past, it was theorised that greater loads and higher stresses around the implant neck could cause marginal bone loss; however, systematic reviews on crown-to-implant ratio have not shown a strong correlation between a high crown-to-implant ratio and marginal bone loss.[6-9] This finding can be explained by the response of bone to loading. Wolff's law stated that bone will adapt to the loads under which it is placed.[10] Under higher loads, adaptive changes occur to increase bone remodelling and formation (density). Frost's mechanostat theory established that bone overload results in bone gain (higher density) rather than bone loss.[11] This can explain radiographic studies on short implants that show increased radiodensity as a function of time.[12,13]

The use of shorter dental implants (< 8 mm) in an atrophic ridge may result in a greater crown-to-abutment height. As the focus should be on crown-to-abutment height, the clinician should be cautious when this measurement approaches 15 mm.[14-17] Several measures may be taken to improve the biomechanical profile in this situation. The use of a tissue level implant will decrease the crown-to-abutment height and provide a wider platform for crown support. Splinting adjacent implants will better resist moment loading. The

occlusion should be adjusted to minimise contacts that produce off-axis loads. Night-time wear of bite guards may also be prescribed for patients with parafunctional habits.

The use of short dental implants has been shown to be an effective alternative to vertical bone augmentation for the placement of longer implants.[18] Clinicians should understand that crown-to-abutment height is more important than implant length in avoiding technical complications. Increasing implant length does not appear to decrease biological or technical problems around dental implants restored with greater crown–abutment heights. As such, we should consider replacing the term "crown-to-implant ratio" with "crown-to-abutment height" in discussions on this important topic.



Craig M Misch, DDS, MDS
Editor-in-Chief

Guo-Hao Lin, DDS, MS
Associate Professor and Director of Postgraduate Periodontics

References

1. Ante LH. The fundamental principles of abutments. Mich State Dent Soc Bull 1926;8:14–23.
2. Geng JP, Tan KB, Liu GR. Application of finite element analysis in implant dentistry: A review of the literature. J Prosthet Dent 2001;85:585–598.
3. Pierrisnard L, Renouard F, Renault P, Barquins M, Influence of implant length and bicortical anchorage on implant stress distribution. Clin Implant Dent Related Res 2003;5:254–262.
4. Yang TC, Maeda Y, Gonda T. Biomechanical rationale for short implants in splinted restorations: An in vitro study. Int J Prosthodont 2011;24:130–132.
5. Anitua E, Tapia R, Luzuriaga F, Orive G. Influence of implant length, diameter, and geometry on stress distribution: A finite element analysis. Int J Periodontics Restorative Dent 2010;30:89–95.
6. Blanes RJ. To what extent does the crown-implant ratio affect the survival and complications of implant-supported reconstructions? Clin Oral Implants Res 2009;20(suppl 4):67–72.
7. Garaicoa-Pazmino C, Suarez-Lopez F, Monje A, et al. Influence of crown/implant ratio on marginal bone loss. J Periodontol 2014;85:1214–1221.
8. Quaranta A, Piemontese M, Rappelli G, et al. Technical and biological complications related to crown to implant ratio. Implant Dent 2014;23:180–187.
9. Ravida A, Barootchi S, Alkanderi A, et al. The effect of crown-to-implant ratio on the clinical outcomes of dental implants. Int J Oral Maxillofac Implants 2019;34:1121–1131.
10. Wolff J. Das Gesetz der Transformation der Knochen. Deutsche Medizinische Wochenschrift 1893;19:1222–1224.
11. Frost HM. Bone "mass" and the "mechanostat": A proposal. Anat Rec 1987;219:1–9.
12. Sluka B, Naenni N, Jung R, et al. Changes of radiopacity around implants of different lengths: Five-year follow-up data of a randomized clinical trial. Clin Oral Implants Res 2020;31:488–494.
13. Gil A, Strauss FJ, Hämmerle CHF, et al. Radiographic density changes may be associated with overloading and implant loss on short implants: A 5-year analysis of a randomized controlled clinical trial. Clin Implant Dent Relat Res 2022;24:766–775.
14. Nissan J, Ghelfan O, Gross O, Priel I, Gross M, Chaushu G. The effect of crown/implant ratio and crown height space on stress distribution in unsplinted implant supporting restorations. J Oral Maxillofac Surg 2011;69:1934–1939.
15. Verri FR, Batista VE, Santiago JF Jr, Almeida DA, Pellizzer EP. Effect of crown-to-implant ratio on peri-implant stress: a finite element analysis. Mater Sci Eng C Mater Biol Appl 2014;45:234–240.
16. Ramos Verri F, Santiago Junior JF, de Faria Almeida DA, et al. Biomechanical influence of crown-to-implant ratio on stress distribution over internal hexagon short implant: 3-D finite element analysis with statistical test. J Biomech 2015;48:138–145.
17. Gehrke SA. Importance of crown height ratios in dental implants on the fracture strength of different connection designs: an in vitro study. Clin Implant Dent Relat Res 2015;17:790–797.
18. Iezzi G, Perrotti V, Felice P, Barausse C, Piattelli A, Del Fabbro M. Are < 7-mm long implants in native bone as effective as longer implants in augmented bone for the rehabilitation of posterior atrophic jaws? A systematic review and meta-analysis. Clin Implant Dent Relat Res 2020;22:552–566.