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Crown-Implant Ratio versus Crown-Root Ratio – A Review

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Abstract: *The terms crown root ratio and crown implant ratio have always been a controversial topic for determining the diagnosis, treatment planning and prognosis of a prosthesis due to scarcity of evidence based research on the same. The height of the crown is an important determinant in implant prosthesis as it bears the lateral forces and distributes it to the crest thereby resulting in a favorable treatment outcome. This article will help in understanding the basic difference between the two terms and their applied aspects in Prosthodontics. Till date, no definitive guidelines have been formulated for crown to implant ratio based on a scientific research.*

Keywords *- Crown-to-root ratio (CRR), Crown to implant ratio (CIR)*

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I. Introduction

In modern dentistry, dental implants are a popular and widely accepted treatment approach for rehabilitating fully and partially edentulous patients. The placement of these implants in the bone poses technical and biological complications if a proper crown to implant ratio is not established. However, dentists often apply the prescribed principles of crown to root ratio in implant dentistry also, which is not justified in Implant Biomechanics. The crown to implant ratio guidelines have not been established till date or are either based upon empiricisms rather than actual scientific data. Let us first understand both the terminologies separately.

The crown-to-root ratio (CRR) plays a very important role in determining the coronal and radicular portion of the tooth in relation to the alveolar bone. It also helps in assessment of the prognosis of a tooth as an abutment for the long term success of a fixed or a removable partial prosthesis. According to Newman et al [1], the periodontium is liable to be damaged by the occlusal forces acting on it due to inappropriate crown-to-root ratio and decreased surface area for support. In another study conducted by McGuire and Nunn [2] for predicting tooth loss in hundred periodontally compromised patients, the results depicted that the crown root ratio is a prime factor for achieving long term success and favorable treatment results.

In a crown to implant ratio (CIR), the crown height is measured from the most coronal bone contact to the most coronal restoration surface and implant length is measured from the most coronal bone contact to the apex. (Fig-1) A disproportionate CIR will render the abutment or an implant to harmful lever forces resulting in the failure of the treatment. Though both the concepts appear similar but they cannot be interchanged in their application for planning a successful prosthesis in a patient.

The aim of this article is to enlighten the importance of both the concepts and their difference in application in planning a treatment, based on the literature available.

II. Crown-Root Ratio

In natural teeth, the centre of rotation or the fulcrum (class I lever) lies in the centre of the root which moves apically when there is bone loss rendering the tooth to damaging lateral occlusal forces. The anatomical ratio is determined from the CEJ to the incisal/occlusal edge whereas the clinical crown root ratio is determined from the free gingival margin to the incisal/occlusal edge. In many clinical situations, clinical crown root ratio becomes the actual determinant in the success of prosthesis as it varies due to bone loss around the abutment. (Fig-2)

The optimum crown -root ratio in an ideal situation is considered to be 2:3 which is not much seen in the clinical practice. However, 1:1 is the minimum ratio required for a favorable abutment in a fixed partial denture as suggested by Dykema et al [3] and Shillinberg et al [4] respectively. (Fig-3) Grossmann and Sadan [5] gathered data from literature and concluded that since there are no definitive guidelines for establishing an

optimal crown to root ratio, prosthesis has a good prognosis even if the ratio is 1:1. Later on this became the gold standard for prosthesis designing.

The clinical significance of crown root ratio is that increase in CRR is directly proportional to the severity of periodontitis and is mostly related to increase in age. As the bone loss occurs, the centre of rotation of abutment moves apically resulting in hypersensitivity, mobility and caries on the exposed surfaces due to harmful lateral forces acting on it. Therefore, patients with increased vertical dimension and bruxism should be carefully evaluated as it is crucial that the abutment will be under increased load in these cases. [5, 6]

The inherent shortcoming in evaluating crown root ratio is that it is a two dimensional radiographic assessment and does not depict the actual bone loss and area of support around the abutment. There is no definitive method to evaluate the ratio and therefore, Kaimenyi JT et al recommended that the clinician should calculate it directly from the CEJ and by measuring the proportion of the tooth length supported by bone from a panoramic radiograph. [7] If there is extensive bone loss with only one third of apical bone left, loss of one third of the periodontal support or true pockets of about 6-7 mm depth around the abutment, it will often pose a risk to the prosthesis and therefore, should not be preferred due to poor prognosis.[8, 9]

In cases of increased crown root ratio, the dentist might resort to options such as splinting to reduce and distribute the forces acting on the abutment by shifting the centre of rotation to prevent the prosthetic failure. According to Dawson, splinting should be done only when it is needed as it is cumbersome to clean the splinted areas. [10]

After a thorough diagnosis has been done and if the crown root ratio is reckoned as reduced in the formulated treatment plan, it will affect the long term results. Therefore, one can resort to certain treatment modalities such as regenerative periodontal surgeries like bone grafting, maintenance of oral hygiene and plaque control, occlusal crown reduction in extruded teeth, and increasing the stability of the dentition by grinding occlusal surfaces of mobile teeth with poor CRR in order to resist axial forces. The last resort in a hopeless case is the extraction of the involved teeth with compromised periodontal condition.

According to Saxe and Carmen, [11] a problematic unopposed tooth in an arch, a mobile secluded distal abutment or a periodontally compromised tooth with other better treatment alternatives can be extracted without giving much thought.

III. Crown-Implant Ratio:

The concept of crown implant ratio is entirely different and should not be confused with the crown root ratio. In the anatomical crown implant ratio, the fulcrum is between the implant shoulder and crown-abutment complex whereas in the clinical crown implant ratio, the fulcrum is at the most coronal bone to implant contact. [5, 8, 12] (Fig-4) However, the exact guidelines implying a crown-implant ratio are not established yet.

According to Misch, [13] the implant doesn't rotate around a central two-third portion of the root as in the crown root ratio. He also suggested that the length of the implant has no relation with the implant mobility and resistance to the lateral forces. Bidez and Misch conducted a research based on which it was concluded that an increase of 10-20 mm in the height of a crown increases the force on an implant by 100% and an increase in the angulation by 12^0 escalates the resultant forces by 20%. [14]

As stated by a consensus conference, the optimum height of prosthesis is considered to be 8-12 mm which includes 3mm soft tissue covering the collar of an implant along with the biological width, 2mm thickness of the porcelain and average height of the abutment as 5mm. [15] Many historical studies considered the maintenance of CIR to prevent the fracture resulting from raised forces which is directly proportional to increase in the crown height while the others described some technical and biological complications based on their research. These technical complications resulting due to increased CIRs are loosening of the screw, decementation of the crown, food accumulation in the interdental spaces and occlusal strain. And the biological hitches include peri-implantitis, formation of deep pockets, poor oral hygiene, pain, swelling, bleeding gums and transient paraesthesia. Thus, this can be counteracted by resorting to options like augmentation of ridge and distraction osteogenesis.

IV. Discussion:

The basic aim of this article is to enlighten the difference between the two concepts and their emerging trends based on the literature available. The crown root ratio has been studied in detail and today we have come to a consensus that if there is minimum crown root ratio also, then the prognosis of prosthesis is good. But in case of crown-implant ratio there are no fixed guidelines. So, various articles from the literature were reviewed, to reveal some basic guidelines, which should be considered in making the prognosis of implant prosthesis favorable.

Reiger et al (1990) [16] observed increased stress levels and high forces during bending movements around the neck and apex of the implant fixture. They concluded that increased C/I ratios produce more stress thereby resulting in bone loss and implant failure. Another study by Tawil G et al (2006) [17] confirmed that the

long term survival rate of implants with increased C/I ratio is not hampered if the occlusion and para-functional habits are under control. According to Birdi et al (2010) [18], there is no association between C/I ratio and the marginal bone loss based on his evaluation of 309 implants in his cohort study.
However, as further research continued, it was seen that the increased CIR's showed similar peri implant bone loss when compared to the restorations that don't have increased CIR's. A crown implant ratio up to 2 shows a high survival rate and can be considered as a favorable option in conditions that rule out the placement of long implants. [19-26]

According to the recent literature available, short implants show a high survival rate and are a favourable option to support prosthesis since the length of an implant plays no role in the amount of forces transmitted at the crest or implant interface [20, 27-38] but they often result in increased CIR's. [39] Therefore, prosthesis with an elevated CIR can escape the undue stress and further complications by following certain principles described below:

1. The surface area can be increased by increasing the number of implants or using implants with reduced thread pitch that will help in distributing the forces acting on the prosthesis.
2. Try achieving minimum contact in lateral mandibular excursions by providing canine guided occlusion.[35]
3. Use of wide diameter and textured implants to achieve maximum bone implant contact.
4. Centralising the centric contacts over implant by reducing the width of the posteriors.
5. Splinting when necessary to provide cross arch stabilization.
6. By flattening the inclines of the cusps.[39]

Cáceres La Torre et al (2012) [40] evaluated the influence of the crown-to-implant ratio on crestal bone loss around dental implants. They found that the factors like C/I ratio, implant or restoration design, antagonist type, time of loading and the gender does not alter the crestal bone loss. The results indicate that factors such as crown to-implant ratio, implant design and loacation, restoration design, type of antagonist, loading time and gender might have influence on peri-implant crestal bone loss. They also predicted that the greatest influence is seen during the first 12 months of the follow up which suggests that higher the C/I ratio, more will be the crestal bone loss. Kyung-Jin Lee et al (2012) [41 determined how the crown-to-implant (C/I) ratio affects the marginal bone level including the site-related factors influencing the relationship between the C/I ratio and peri implant marginal bone loss. They suggested that less marginal bone loss is seen in implants with high C/I ratio particularly in the posterior regions. This occurs due to bone formation as a result of concentrated masticatory forces around implant fixtures and is known as "stress-shielding" effect.

Another study by Okada et al (2013) [42] suggested an enhanced bone remodelling activity and similar marginal bone loss (as in implants with low or same C/I ratios) in implants with increased C/I ratio. They further added that proper hygiene and plaque control improves implant stability. However, a research conducted by Garaicoa-Pazmiño et al (2014) [43] on the influence of C/I ratio over marginal bone loss and survival of dental implants showed a negative association and no statistical difference between implant type, period of observation or procedure of analysing the ratio. They suggested that higher the C/I ratio, lesser will be the peri implant marginal bone loss (within 0.6/1 up to 2.36/1) if proper occlusal considerations are taken.

More recently, Güngör H (2016) [44] studied the effects of C/I ratio using a 3-D finite element analysis on stress distribution both in bone and implant under axial and oblique loads. They found that the high C/I ratio affected both cortical and cancellous bone along with the implant under oblique and axial load with more stress under oblique load when compared to axial load. Thus, in distal cantilever fixed dental prosthesis, increased C/I ratios should be avoided due to increased stress concentration on bone and around implants. The data also showed dynamic stress values under oblique load than axial in high C/I ratio cases. However, more research needs to be conducted to support these findings.

V. Figures And Tables

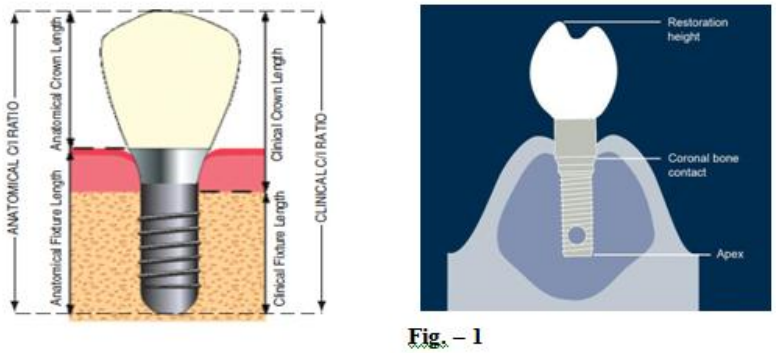
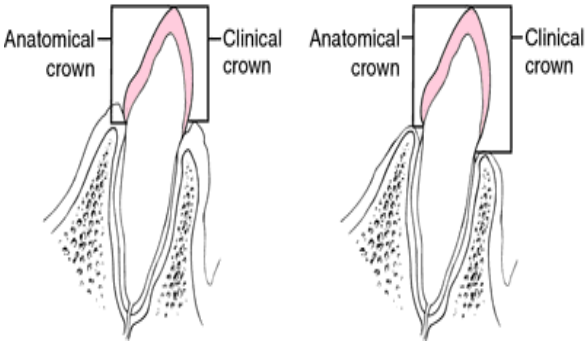


Fig. – 1


Anatomical crown
Clinical crown
Anatomical crown
Clinical crown

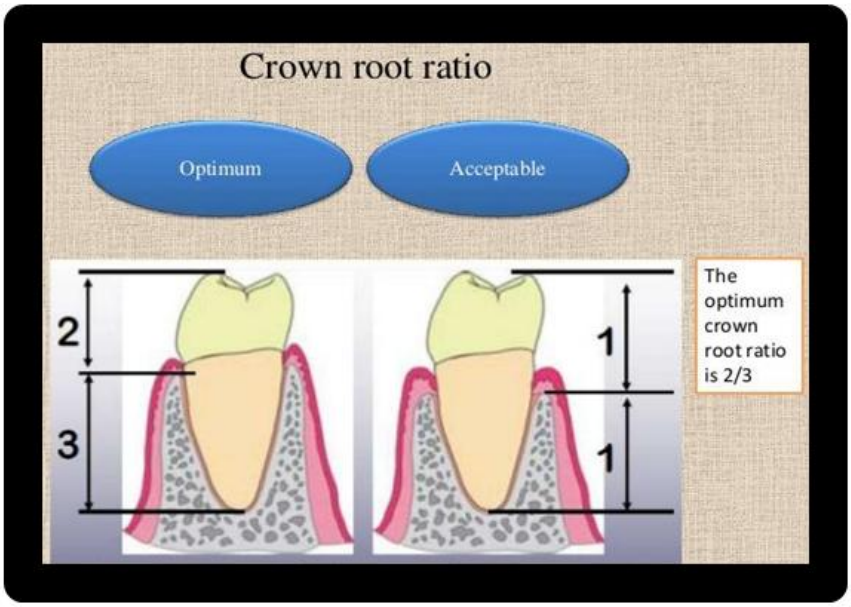

Crown root ratio
Optimum
Acceptable
2
3
1
1
The optimum crown root ratio is 2/3

Fig. 3

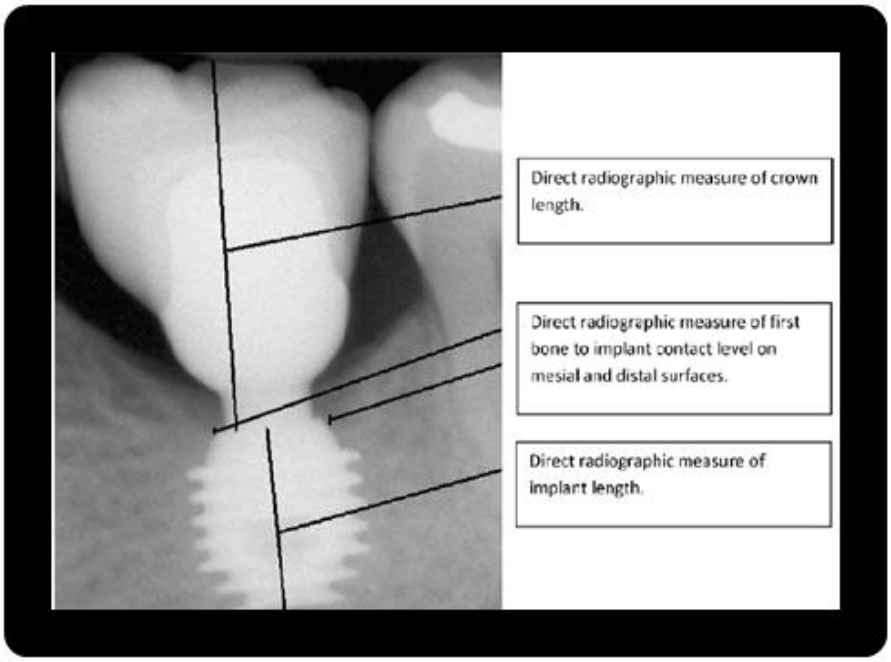

Direct radiographic measure of crown length.
Direct radiographic measure of first bone to implant contact level on mesial and distal surfaces.
Direct radiographic measure of implant length.

Fig. 4

VI. Conclusion

Thus, the data retrieved in this review clearly explains that the crown implant ratio between 0.5 and 2 show a favorable prognosis and can be maintained successfully if other prosthetic principles are equally taken into consideration. Increased CIR is not associated with bone loss or prosthetic failure if the forces are well distributed and cannot be considered as risk factor for biological complications around dental implants & implant failure. However, there is a lack of evidence based research on the crown implant ratio making it difficult for the clinician to plan a treatment with long-term favorable prognosis thereby proposing the need for the formulation of crown-implant ratio guidelines since teeth and implants are held by two different mechanism.

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