UDC: 616.314-089.843

ANALYSIS OF CROWN/IMPLANT RATIO ON IMPLANTS STABILITY

АНАЛИЗА НА СООДНОСОТ КОРОНКА/ИМПЛАНТ ВРЗ СТАБИЛНОСТА НА ИМПЛАНТИТЕ

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Abstract

In total edentulousness treatment the choice is between complete denture or implant therapy. Implant therapy gives better results in terms of prosthetic stability, patient safety, aesthetics and phonation and prevents alveolar ridge resorption. But implant-prosthetic treatment requires optimally defined indications and conditions. The crown/implant ratio is an important factor in the implant treatment success and its prophylactic effect on the bone tissue. From that aspect, this article will review the available published articles on crown/implant ratio in literature. **Key words:** crown/implant ratio, implant, crown, stress analysis, cortical bone, spongiosseus bone, prosthetic restoration, implant treatment.

Апстракт

При третманот на тоталната беззабност изборот е помеѓу тотална протеза или терапија со импланти. Терапијата со импланти дава подобри резултати во однос на стабилноста на протетската изработка, сигурноста на пациентот, естетиката и фонацијата и ја спречува ресорпцијата на алвеоларниот гребен. Но имплантопротетскиот третман бара оптимално определени индикации и услови. Соодносот коронка/имплант е значаен фактор за ефектот од имплантолошкиот третман и неговото профилактично дејство на коскеното ткиво. Од тој аспект во трудот ќе биде направен преглед на достапните објавени трудови за соодносот коронка/имплант во литературата. **Клучни зборови:** Соодност коронка/имплант, имплант, коронка, стрес анализа, кортикална коска, спонгиозна коска, протетичка реставрација, имплантолошки третман.

Introduction

Toothloss leads to morphological, functional, and aesthetic disturbance in the functions of the masticatory system.

The treatment is choice between usual fixed prosthetic or mobile prosthetic restorations or implant therapy.

In total edentulousness treatment the choice is between complete denture or implant therapy.

Each option has its own advantages and disadvantages. However, implant therapy gives better results than other available treatment options.

The advantage of implant prosthetic therapy is that prosthetic suprastructures over implants provide more reliable stability and restore 60-80% of lost function. This gives the patient greater comfort. Also, the transmission of occlusal forces on the bone through the implant prevents resorption of the alveolar ridge[4].

As an edentulousness therapy, implant treatment is preferred in clinical practice due to the quality of modern dental implant materials and the resolved osseointegration problem. Still, implant therapy is not without problems.

The determination of the number of implants, their size, the type of prosthetic construction (suprastructure), and the method of implant placement depends on many factors.

Most important are the bone tissue condition, crown height space (CHS) and the patient's finance capacity.

Besides other indications, resorption of alveolar bone tissue may be crucial in treatment planning, especially for determining the location and dimensions of implants.

Although implant treatments provide better dental rehabilitation than other treatments, overloading the implants is considered one of the risk factors for implants survival.

Gómez-Poloet et al.[2] and Teixeira et al.[3] believe that it occurs when greater resorption of alveolar bone tissue is present, which causes two important problems in implantology: there is insufficient bone tissue for implant placement, but there is more space for crown height.

This conditions shorter implants and construction of longer crown suprastructures. In that case, the prosthodontic concept for natural teeth, minimum crown/root or crown/implant ratio of 1:1, is not respected[4].

According to literature, suprastructure height and implant ratio may be one of the reasons for implants overload, i.e., for stress increasement in the peri-implant bone tissue and treatment failure.

In June 2004, in Las Vegas, Nevada, the International Congress of Oral Implantologists sponsored a consensual conference to determine the space needed for crown height[5].

Despite numerous consensus discussions and meetings, no general guidance consensus was developed, thus leaving room for further research.

Aim

The purpose of this article is to analyse the findings on crown/implant ratio in the published literature.

Material and method

The material consists of reviewed articles that examine crown/implant ratio. The articles were acquired by research in international journals, as well as PubMed and EBSCO database in the period from January 2005 to January 2020. Research was done using keywords according to the Mesh index. 325 articles were reviewed, out of which 50 were analyzed.

Discussion

Implantology treatments in modern dental practice are widely accepted methods for edentulousness treatment. Due to osseointegration of implants, the success of implant treatments is over 95%[6].

Implant treatment failure can be attributed to poor planning, inadequate compliance with surrounding structures, improper design and occlusion of suprastructure.

Initially, dental implantology has accepted the prosthetic standards that were applied to natural teeth. Thus, according to traditional prosthetics, the length of the implant placed in the alveolar bone (equivalent to the root) should be greater than the height of the suprastructure. According to the prosthetic principle, crown/root ratio should be ideally 1:2, 1:1.5 ratio would be optimal, while 1:1 ratio should be minimum. The implant is placed in bone tissue, so the base for implants placement is to have sufficient amount of bone. However, teethloss results in vertical bone tissue loss. Vertical bone tissue height is a prerequisite for determining the implant length.

Misch defines the space for suprastructure as "crown height space" (CHS, Crown Height Space)[7].

The crown height space (CHS) is measured from the crest of the alveolar bone to the occlusal plane in the posterior region for the upper and lower jaw, and in the anterior region the upper CHS is measured to the occlusal plane, and the lower CHS is 1-2 mm above the occlusal plane. The ideal CHS for a fixed suprastructure over the implant should be between 8 and 12 mm. This dimension provides space of 3 mm for soft tissue, 2 mm for occlusal suprastructure thickness and more than 5mm for abutment[8].

The clinical C/I ratio is determined by radiography[9].

In situation of greater crestal bone resorption, the space for the implant suprastructure, i.e. C/I ratio, is increased, which is considered as risk factor for success and implant treatment[10].

Grossmann also believes that correct C/I ratio is one of the key factors in achieving a long-term prognosis in prosthetic rehabilitation[11].

The crown/implant ratio is an important factor for the success of implant-supported prosthetic reconstructions and for the implants stability in general. It is basically taken from the prosthodontic concept for natural teeth but still there are fundamental differences. According to Suham et Effie[12] the differences are because the implants have no periodontal ligament, therefore no rotation, and forces are transferred from the implant directly to the bone tissue. For these reasons, increasing the length of the implant cannot compensate for the increased crown height. Instead, he proposes to increase the area of functional load by increasing the number implants placed, the size of the implant used or the implant design.

Excessive stress on the surrounding tissues, which is caused by the loading stress forces, is one of the possible causes of implant failure. Since the stress is transmitted directly to the bone through the implant, careful planning, the correct number of implants, and the positioning of the implants are crucial to ensure proper stress distribution. However, researches on the optimal number of implants necessary to support the suprastructure are insufficient. Recognizing this problem, Gizem, Sercan et Sedat[13] carried out an in vitro study of finite elements analysis to determine the optimal location, number, and diameter of implants needed to support the suprastructure. The study showed that as the number of implants increased, stress values in peri-implant bone tissue decreased. However, changes in implant diameter had no significant effect on stress.

This can be explained by Rangert et al.'s theoretical analyses[14], who say that axial loads are more favorable for a uniform distribution of stress around the implant, while non-axial forces are danger. Similarly, Papavasiliou et al.[15] found that non-axial forces increased concentration of stress in implant and bone.

These results are also consistent with the literature describing the impact of increased crown height on transfer of occlusal forces[16-24].

There are various opinions in the literature regarding correlation between crown/implant ratio (C/I) and implant treatment success.

Misch et al.[8, 25] say that several factors can increase the mechanical load of the implant, and increasing the height of suprastructure is one of those.

According to Nissan[26] some longitudinal clinical studies for implants with high crowns suggest that this factor does not compromise the predictability of treatment. According to him, CHS is more significant than the C/I ratio in assessing biomechanical-related detrimental effects.

Rokni[27] also reports that there are clinical studies for high-crown implants that prove that this factor does not compromise implant treatment.

Research study and results received by de Moraes et al.[28] suggest that by increasing crown height the stress concentration in the peri-implant bone tissue is increased.

The stress concentration increases by increasing the crown height. It was concluded that: increased C/I ratio increases the stress concentration in the implant components and cortical bone[29].

According to Hadzik et al.[30], no significant correlation was found between C/I ratio and secondary implant stability, as well as between C/I ratio and marginal bone loss.

The crown/implant ratio of 0.9 to 2.2 did not affect the occurrence of biological or technical complications. One tooth restorations with a crown/implant ratio of between 0.9 and 2.2 can be considered a viable treatment option[31].

According to Ramos et al.[32] crown heights of 12.5 and 15 mm caused a statistically significant stress distribution on screws and cortical bone ($p<0.001$) only at non-axial load. Therefore, he concluded that crown increase was a possible deleterious factor to the screws and to the different regions of bone tissue.

According to Bulaqi et al.[33] the increase in crown height space causes the corresponding distribution to become more nonuniform and increases the maximum compressive and tensile stresses in the peri-implant bone.

Also, de Moraes et al.[28] found that increasing the crown height during non-axial load caused a higher concentration of stress in the crown, at the implant/bone level, and increased bone tissue micro movement.

Meijer et al.[34] have researched the impact of the C/I ratio on implant treatment. They selected 154 articles, eight studies met the inclusion criteria. Average C/I ratio was in the range of 0.86 (with 10 mm implants) to 2.14 (with 6 mm implants). Data reviewed in the articles did not show high incidence of biological or technical complications.

Schulte, Flores et Weed[35] monitored the survival of 889 implant supported suprastructures with average C/I ratio of 1.3 (from 0.5:1 to 3:1), in the 2.3 year period (from 0.1 to 7.4 years). He found out that the average survival rate was 98.2%. Sixteen implant failures had an average 1.4 C/I ratio, similar to successful ones. Due to the similarity of the results of the failed and successful implants, they concluded that the C/I ratio was not the cause for implant loss.

Sanz et Naert[36] convey conclusion of the European Association for Osseointegration: „The use of implant supported restorations with C/I ratio up to 2 does not influence crestal bone loss".

Blanes et al.[37] for more than ten years were evaluating the impact of C/I ratio on 142 implants. The respondents were divided into three groups, according to C/I ratio: The first group C/I ratio of 0 to 0.99, the second with 1 to 1.99, and the third with C/I ratio higher than 2. The third group had a success rate of 94.1% (48 of 51 implants). They concluded that restorations with C/I ratio between 2 and 3 can be successfully used. The authors noted that 81.3% of the implants tested were single crown.

Zhao et al.[38] from January 2007 to January 2012, followed 119 patients with 208 ITI implants in posterior region, during period of 6-66 months. Implant restorations were divided into three groups; first group $C/I \leq 1$; second group $1 < C/I \leq 1.5$ and third group $C/I > 1.5$. The clinical C/I ratio did not significantly affect peri-implant bone loss and biomechanical complications of the suprastructures.

Garaicoa-Pazmiño et al.[39] made literature review on 196 articles and 13 were valid for comparison. They found a negative correlation between the C/I ratio and marginal bone loss ($P = -0.012$).

De Moraes et al.[28] have evaluated the impact of crown height on micro movement and stress distribution at implant/bone level by using the three-dimensional finite element method. The implants were sized (3.75 x 10.0 mm) with external hex connections, and the crowns were 10 mm, 12.5 mm and 15 mm high. Axial forces of 200 N and non-axial forces (45°)100 N were applied.

The height of the crown under axial load did not affect the stress distribution and stress concentration, while on oblique forces load they increased. The results of this study suggest that increasing crown height increases stress on implant/bone tissue and increases the micro movement in bone tissue, especially during oblique forces load.

Kyung-Jin et al.[40] evaluated the impact of the C/I ratio on the change in the marginal bone level around the implant in order to determine the location-related factors that influence the correlation between the C/I ratio and the peri-implant marginal bone loss. The study was performed on 259 implants total, placed on 175 patients with an average follow-up period of five years. The implants were divided in two groups according to C/I ratio: ≤1 and >1. Implants with a higher C/I ratio showed less marginal bone loss than implants with a lower C/I ratio.

Urdaneta et al.[41] have done research to evaluate the effect of increased C/I ratio on single tooth implants. The study was performed on group of 81 patients with 326 implants between 2001 and 2003. Patients with at least one single tooth implant were followed. Higher C/I was associated with a significant increase in prosthetic complications, but had no significant effect on the level of bone tissue.

Cinar et Imirzalioglu[42] using the finite element method investigated the amount and localization of functional stress in implants placed in two different bone types (type 3 and type 4) with three different crown heights. They investigated three C/I ratios: 1/1, 1.5/1 and 2/1. The greatest functional stresses occurred around the implant collar with a C/I ratio of 2/1 (430.57 MPa). When doubling the C/I ratio from 1/1 to 2/1 functional stresses were increased, as well as tensile and compression values in cortical and spongiosseus bone in both bone types (type 3 and type 4). As the C/I ratio increased from 1/1 to 2/1, the largest deformations occurred in type IV spongiosseus bone.

Gehrke[43] made an experimental static load at 30° angle to the longitudinal axis of the implant. He concluded that load resistance significantly decreased by increasing C/I ratio.

In the study of Verri et al.[44] an increase in the C/I ratio of 1:1 to 1:1.25 showed increase of average stress in bone tissue by 30% and the increase of C/I ratio from 1:1 to 1:1.5, increased average stress by 51.5%.

Kwan et al.[45] examined the displacement of crown with different height (10, 12 and 14 mm) and different axis of load. The largest displacement was on highest crown with no-axial load.

Most authors agree that there is no established protocol to determine the maximum allowable C/I ratio for dental implant treatment since the experimental studies are not fully consistent with clinical studies[44, 46].

Conclusion

In most articles there is contradiction regarding the importance of crown/implant ratio for stress in peri-implantable bone tissue.

According to the literature, axial forces cause less stress and non-axial forces cause more stress on peri-implant bone tissue.

Stress in peri-implant bone tissue depends more of the direction of the loading force (higher on non-axial-force load) than of the crown/implant ratio.

Most of the studies are paraclinical, made on three dimensional computer models. Clinical studies are mostly with periodic follow-ups monitoring of changes in peri-implant bone tissue.

The results of both methods, in most cases, complement and thus provide corresponding recommendations for clinical practice.

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