BONE CHARACTERISTICS AND IMPLANT STABILITY

Elitsa Sabeva[1], Stefan Peev[1], Mariya Miteva[1], Milena Georgieva[2]

[1]Department of Periodontology and Dental Implantology, Faculty of Dental Medicine, Medical University of Varna
[2]Department of Pediatric Dental Medicine, Faculty of Dental Medicine, Medical University of Varna

ABSTRACT

The aim of this literature data review was to investigate the influence of the bone density, bone volume, cortical bone thickness and the anatomical area on the primary stability of dental implants. Understanding the effect of the bone quality could help us predict the primary stability and prevent to some extent the poor implant stability by choosing implants of different design, diameter, length or surface modification.

Considering the reviewed articles, we have concluded that inserting implants in dense bone of higher quality with thick cortical portion, as well as implant placement in lower jaw could lead to higher primary stability of those implants. To enhance the primary stability in bone of poor quality we suggest the use of implants with such characteristics of the design or dimensions, which are proven to influence the primary stability of the implant in a positive way.

Keywords: *bone quality, density, primary stability*

INTRODUCTION

The aim of this literature data review was to investigate the influence of the bone density, bone volume, cortical bone thickness and the anatomical area on the primary stability of dental implants. Understanding the effect of the bone quality could help us predict the primary stability and prevent to some extent the poor implant stability by choosing implants of different design, diameter, length or surface modification.

Address for correspondence:
Elitsa Sabeva
Faculty of Dental Medicine
Medical University of Varna
84 Tsar Osvoboditel Blvd
Varna
e-mail: Elitsa.Sabeva@mu-varna.bg

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Influence of the Bone Volume and Bone Density on the Primary Stability

In implantology, mainly two classifications are used to determine the density and the characteristics of the bone: Misch (1) and Lekholm and Zarb (2).

Misch (1) divides the bone into four groups according to the characteristics of the cortical and the trabecular bone, which compose it. The cortical bone could be dense, porous, thin, thick or missing. The trabecular bone could be coarse or fine. The classes are identified as D1, D2, D3 and D4, respectively:

- D1 - Dense cortical bone
- D2 – Porous cortical and coarse trabecular bone
- D3 – Porous cortical (thin) and fine trabecular bone
- D4 – Fine trabecular bone

According to the study of Merheb et al. (3): the presence of bone dehiscence does not affect significantly the mean ISQ (implant stability quotient) values during the implant placement, as they found significant linear relationship between the resonance frequency analysis, PTV (Periotest values) and the cortical bone density ($P<0.05$), both during the insertion and during the loading of the implants. The authors concluded that the results of the resonance frequency analysis and the damping capacity could be predicted based on the bone-related factors.

Barikani et al. (4) found the following relation: ISQ values, measured during implant placement in bone type D1 are significantly higher than those for implants placed in bone D3. In an experimental study, some authors described a specific implant design as advantageous in terms of implant placement in soft bone (5). According to a study of Ahmad et al. (6) the implant stability could be increased by increasing the density of the monolithic artificial bone blocks.

Degidi et al. (7), who investigated the relationship between the implant primary stability and the bone density, concluded that the IT (insertion torque) values and the resonance frequency analysis are two independent functions of the primary stability. IT depends on the bone density, while the resonance - frequency analysis is influenced by the implant length.

Pommer et al. (8) concluded that the bone density affects more the IT, PTV and ISQ values than the residual bone height does. His results were established during sinus floor elevation with simultaneous implant placement.

Javed et al. (9) claimed that the factors, which can influence significantly the primary stability of the implants and the success of the implant treatment are: bone quality and quantity, implant form and surgical technique. The authors concluded that the bone quality and quantity are also significant in regard to the immediate loading of the dental implants (10).

According to some authors there is a positive relation between the primary stability and the mineral bone density of the recipient site (11).

Merheb et al. (12) conducted a study on the impact of the skeleton and local bone density on the implant stability in patients with osteoporosis and osteopenia, and in control group patients. The authors evaluated the stability of the implants using resonance frequency analysis. During the measuring of the primary stability they found lower mean ISQ in the osteoporosis group (63.3±10.3 ISQ) compared to the values, observed in the osteopenia group (65.3±7.5 ISQ). The highest mean ISQ values were measured in the control group (66.7±8.7 ISQ). During the implant loading the same measurements were performed again and similar relation was found: the lowest ISQ was in the osteoporosis group and the highest - in the control group. The results were as follows: osteoporosis group (66.4±9.5 ISQ), osteopenia group (70.7±7.8 ISQ) and control group (72.2±7.2 ISQ).

Bayarchimeg et al. (13) investigated the relation between the insertion torque of the implants and their primary stability, as they used bone blocks. They concluded that the primary stability does not depend only on the insertion torque, but also on the bone quality.

Influence of the Cortical Bone Thickness on the Primary Stability

It was established in an experimental study that the increase of the cortical bone thickness and cancellous bone density is associated with the increase of the coefficient of the 3D bone-to-implant contact. Strong linear correlation was found between the bone-to-implant contact at the cortical bone and the primary stability of the implants (14).

According to Miyamoto et al. (15) the primary stability of the dental implants is mostly influenced by the cortical bone thickness. Hsu et al. (16) commented the positive impact of the strength of the trabecular bone and the cortical bone thickness on the initial stability. They also reported mostly nonlinear correlation between both factors and the ITV, PTV and ISQ.

Wang et al. (17) observed the influence of the implant design and the bone quality on the insertion torque, insertion energy and ISQ values by monitoring change in IT and ISQ, while implants were placed in artificial bone blocks simulating poor or poor-to-medium bone quality. They concluded that the cortical bone and the implant design have a more significant impact on the torque dynamics compared to their impact on the ISQ. They also claimed that some implant designs are more appropriate if high insertion torque is required in bone of poor quality.

Other authors also studied the influence of the cortical bone on the primary stability using the insertion torque values and resonance frequency analysis (18). According to their results the primary stability is influenced by the existence of cortical bone.

Han et al. (19) inserted implants in artificial monocortical and bicortical bone blocks and found that the bicortical conditions could improve the primary stability.

Some authors did not support the opinion that the cortical bone thickness influences the implant stability.

Heidari et al. (20) investigated the influence of cortical bone thickness on the primary stability of 23 implants, inserted into fresh sheep bone. The authors measured the cortical bone thickness at the recipient site using conical beam computed tomography. They registered the maximum insertion torque, during the placement of each implant, as they evaluated the primary stability using resonance-frequency analysis. Their results demonstrated that the correlation between the cortical bone thickness and the resonance frequency analysis values are not statistically significant. They concluded that the cortical bone thickness, measured using conical beam computed tomography, has no relation to the primary stability of the implants.

Influence of the Anatomical Area on the Primary Stability

Assessing the impact of the recipient area on the primary stability, the relative distribution of the bone classes in the upper and lower jaw should be considered: bone type D1 is almost absent in the upper jaw, as often there can be found bone type D3, which in some cases also occurs in the lower jaw. Bone D4 could be found very rarely in the lower jaw, occurring in areas after augmentation procedures. For the lower jaw, the most characteristic is bone D2, and some authors considered that bone type D4 is associated with the lowest success rate of the implants placed in it (21,22).

Friberg et al. (23) observed the following relation: most of the implants placed in the lower jaw had an ISQ of more than 60, whereas in the upper jaw only one quarter exceeded this value. Other authors also commented on the higher ISQ in the lower jaw compared to those measured in the upper jaw (24).

Ostman et al. (25) investigated the primary stability according to the bone density and the area, in which the implants were inserted. They obtained the following results: implants inserted into the lower jaw demonstrated higher ISQ compared to the implants, which were placed in the upper jaw. They also observed higher ISQ in the posterior area compared with the anterior sites and lower ISQ values for the implants, inserted in softer bone.

Other authors found significant difference between the insertion torque values of the implants placed in the upper and in the lower jaw. They did not observe any statistically significant difference between the ISQ and the insertion torque values of the implants, inserted into extraction sites, compared to those of the implants inserted into non-extraction sites and also between the values of the implants, placed in areas with and without previously conducted augmentation procedures (26).

Monje et al. (27) investigated the effect of the implant location on its primary stability and the healing period after 4 months. Higher primary stability was described in the lower jaw compared to the upper jaw. After 4 months, the stability in the lower jaw remained higher than that in the upper jaw.

Seong et al. (28) compared the primary stability of implants placed in different anatomical areas in the jaws of fresh human cadaver, and found that mandibular implants had significantly higher primary stability than the maxillary implants; implants placed in the posterior area of the upper jaw are the least stable.

CONCLUSION

Considering the reviewed articles, we concluded that inserting implants in dense bone of higher quality with thick cortical portion, as well as implant placement in lower jaw could lead to higher primary stability of those implants. To enhance the primary stability in bone of poor quality we suggest the use of implants with such characteristics of the design or dimensions, which are proven to influence the implant primary stability in a positive way.

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