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Dental Implant Insertion Torque and Bone Density – Short Review

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ABSTRACT

Clinical success in implant practice is influenced by both the volume (quantity) and the density (quality) of bone at the implant site. Bone quality and quantity differ from site to site and from patient to patient. Factors that are important to the success of dental implant treatment include material, biocompatibility, and design issues related to the dental implant; patient factors, such as general health, local tissue health, and quality and quantity of bone; and procedural issues, such as insertion torque (IT), timing of loading, healing duration, biomechanical loading, and prosthetic design. Osteoporotic patients require particular attention to their implant site bone quality as an indication of prognosis and may require modified surgical technique Insertion Torque (IT).

Keywords: Insertion torque, Bone density, Dental implants, Osteoporosis, Cone beam computed tomography (CBCT), primary stability.

INTRODUCTION

Success of an implant depends on various factors, beginning with the diagnosis and case selection up to prosthetic rehabilitation and maintenance. After being placed in the selected site, implant must achieve primary stability in the surrounding bone which is important in the bone healing, by resisting micromovement and the resultant damage to the bone healing process.[1] Micromovement or motion between freshly placed implant and bone can jeopardise osseointegration. Therefore primary stability immediately post implant placement and in the early healing phase is necessary till the time secondary stability is gained by bone remodelling and osseointegration.[2,3] Successful outcome of implant placement can be attributed to primary stability.[3,10,11] It is determined by the density of the bone at site, the surgical technique used to place the implant and the implant design.[4] Primary stability depends on mechanical engagement of an implant with bone but it decreases with time as bone remodelling occurs around it.[5] Also, there is a sharp reduction in interfacial strain due to mechanical stress relaxation in the bone.[6] The primary stability is also important as the loading protocol would depend on it. Shortening of overall length of implant treatment and reduction in the number of procedures is desirable by the patient and by the clinicians in practice. This has encouraged the immediate loading protocol of the implant. Achieving high primary stability is crucial for the immediate loading protocol. With this comes into play the importance of assessing the primary stability of implant, as the clinician, based on the primary stability can make judgements about the treatment procedures such as healing period, location and the loading protocol. It can be measured by non-invasive clinical methods such as Periotest, Resonance Frequency Analysis (RFA) and the Insertion Torque.[1,4,5] Insertion torque can provide assessment of bone quality as a function of density and hardness, either subjectively in experienced hands or quantitatively by electronic drill devices which measure the torque required to insert implant in the bone.[6] Torque is a measure of the turning force on an object such as a bolt. For example, pushing or pulling the handle of a wrench connected to a nut or bolt produces a torque (turning force) that loosens or tightens the nut or bolt. In dental implantology, the force used to insert a dental implant is called insertion torque.[5] It is the amount of force required to advance the implant into the prepared osteotomy, expressed in Ncm (Newton centimetre) units. The energy required in inserting implant is due to the thread placement force from the tip of instrument and the friction generated as the implant enters bone.[4]

Insertion Torque and Bone density

The factors affecting the insertion torque are - bone density and hardness, use of under-dimensioned drills and tapered implant design. Torque is directly proportional to the bone density. In D-1 type bone, it will be the highest. In D-4 type bone, it will be the lowest without the use of compression techniques. With the use of compression techniques to achieve better stability, insertion torque could be improved in poor quality bone. Inducing over-compression could jeopardise the healing process. Under high stress, angiogenesis gets altered and it impairs new blood vessel formation. This leads to hypoxia in peri-implant tissues which inhibit bone formation and adversely affects stability.[7] The tubule network of bone is filled with interstitial fluid supplying the bone cells. It is able to transmit external stresses to bone cells through “Mechanotransduction”. Mechanical energy from external stresses gets converted into bioelectric and biochemical signals that modulate bone cell metabolism. When this mechanical energy is too high, osteocytes are induced to death, followed by emergence of osteoclasts and bone destruction ensues. This could affect the process of osseointegration.[8] Insertion torque is reduced in implant macrodesigns that incorporated cutting edges, and lesser insertion torque was generally associated with decreased micromovement as this thread-cutting geometry creates a high level of bone to implant contact.[6,9]

Many studies have been carried out to investigate the optimum insertion torque, the minimum and the maximum limits. Certain implant manufacturers suggest optimum insertion torque for immediate loading and the maximum limit that should not be crossed, for the reasons of causing over-compression or for the metallurgical reasons, while using their implants. Neugebauer and associates[10] considered insertion torque above 50 Ncm to be higher and should not be exceeded, whereas a torque of 35 Ncm was considered optimum for immediate loading protocol. Duyck and co-workers[11] suggested that insertion torque above 50 Ncm could lead to higher peri-implant bone loss. Ottoni et al[12] in their study, suggested that a minimum of 32 Ncm insertion torque was necessary for implants to achieve osseointegration. When the torque was 20 Ncm, nine out of 10 implants failed in their study. The average insertion torque in their study was 38 Ncm. da Cunha and co-workers[13] reported mean insertion torque of 33.4 Ncm and 40.81 Ncm with two designs of implants in their study. Turkyilmaz and McGlumphy[4] had an average of 37.2± 7 Ncm insertion torque in their study. Failed implants had an average of 21.8 ±4 Ncm insertion torque. Horwitz et al[14] studied insertion torque and Implant Stability Quotient (ISQ) as measured by RFA on implants placed in extraction and non-extraction sites, in maxilla and mandible, and on immediately restored, nonrestored and submerged implants. Their overall mean insertion torque values ranged between 36 and 41.60 Ncm, with no significant difference in torques with implants in extraction and non-extraction sites and in immediately restored, nonrestored and submerged implants. Trisi et al[15] studied high (mean 110 Ncm) and low (mean 10 Ncm) insertion torques and concluded that high torque does not induce bone necrosis in dense cortical bone, and that high torque is important for increased primary stability and for immediate loading protocol. Makary[16] reported insertion torque ranging from 15 to 150 Ncm (mean 78.30 Ncm) in D-1 to D-4 types of bone. Only one out of forty implants failed. In their study, mean insertion torque with D-1 type bone was 126.67 Ncm and 40.22 Ncm with D-4 type bone.

Table 1: Brief Literature review on insertion torque

Author	Result
Neugebauer *et al* 2006[10]	Reached a similar conclusion, that is, implants placed with an average insertion torque higher than 35 Ncm were associated with success.
Duyck *et al* 2010[11]	Insertion torque above 50 Ncm could lead to higher peri-implant bone loss.
Ottoni *et al* 2005[12]	Minimum of 32 Ncm insertion torque was necessary for implants to achieve osseointegration.
Makary *et al* 2011[16]	Insertion torque ranges from 15 to 150 Ncm (mean 78.30 Ncm) in D-1 to D-4 types of bone
M. Wada *et al*[19]	Revealed that bone density around the implant is a useful index. This study indicates that preoperative CT may enable the prediction of initial implant stability
Venkatakrishnan *et al* 2017 [20]	the amount of stress– strain that exhibits at 40 N load in normal bone will be almost the same stress–strain given at 32 N load in osteoporotic bone
Chai John *et al* 2012[21]	Insertion torque (IT) was significantly correlated to implant site bone density but not to implant length. IT can be a viable and practical means to assess mandibular bone quality in patients with compromised general bone density
Gary Greenstein *et al* 2017 [22]	The minimum torque that can be employed to attain primary stability is undefined. Forces e”30 Ncm are routinely used to place implants into healed ridges and fresh extraction sockets prior to immediate loading of implants. Increased insertion torque (e”50 Ncm) reduces micromotion and does not appear to damage bone.

Sotto-Maior and co-workers[1] studied stress and strain in cancellous and cortical bone with insertion torque ranging from 30 to 80 Ncm. They found that maximum principle stress increased by 648% between insertion torque of 50-60 Ncm. Campos et al[17] studied insertion torque due to difference in the diameter of the drill/prepared site and the implant diameter. They had torque ranging from 70 to 160 Ncm, but observed different healing patterns with different torque ranges. With torque ranging 130-160 Ncm, there was more bone “dieback” as compared to 70 Ncm torque range. The amount of insertion torque lead to different healing patterns but the outcome was the same for 70-160 Ncm values. Venkatakrishnan et al[18] used Materialise’s Interactive Medical Image Control System (MIMICS) software for visualizing and segmenting medical images (such as CT and MRI), study revealed that bone density as represented by mm3 obtained from Interactive Medical Image Control System (MIMICS) software is statistically significant in a group of osteopenic and osteoporotic patients when compared with normal patients. The author concluded by stating that bone density values (as measured in mm3) obtained from preoperative cone beam computed tomography (CBCT) examination may be an objective technique for preoperative evaluation of bone density. This tool when combined with MIMICS software can serve as diagnostic tool for predicting implant success, thus providing the implant surgeon with an objective assessment of bone density, especially were poor bone quality is suspected.

CONCLUSION

Further research in this area is recommended by means of stronger study designs, with more control on confounding factors, and to give scope and idea to find out what amount of force (In newtons-IT) can be given to any patient by using CBCT and software, which will give perfect assessment for clinician for dental implant placement.

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