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Original Article

Evaluation of dental implant insertion torque using a manual ratchet

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ABSTRACT

Background: Dental implant insertion torque is crucial for the success of the implant and the prosthesis. This in-vivo study was undertaken to determine the average insertion torque being applied to the dental implant while surgically placing it with a non-calibrated manual ratchet. **Methods:** Three dental surgeons placed a total of 45 dental implants (Touareg, ADIN, Afula, Israel) in 42 selected patients. Each surgeon placed 15 implants. Standardised protocols were followed to prepare the site to place the dental implant. Each implant was placed using a manual non-calibrated implant ratchet first. Once the implant was nearly placed, a manual calibrated torque gauge ratchet was used to place the implant in its final position and at that instance, the maximum final torque applied was noted on the torque gauge scale.

Results: The mean dental implant insertion torque applied by three surgeons using a non-calibrated manual ratchet was estimated to be 63.26 Ncm with a standard error of 6.80 i.e. (63.26 + 6.8), which was significantly higher than the baseline of 35 Ncm ($p < 0.0001$). The mean dental implant torque applied by Surgeon 1, 2 and 3, respectively, was 65.93 Ncm, 62.60 Ncm and 62.13 Ncm and this difference amongst them was found to be statistically insignificant ($p > 0.05$) and each of them had reached more than the baseline level of 35 Ncm individually and significantly ($p < 0.0001$).

Conclusion: Without the use of torque measuring devices, an average surgeon may achieve an average insertion torque of 63.26 + 6.8 Ncm.

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Introduction

Constant research and developments are going on in the field of dental implantology to achieve higher success. To be

successful, the inserted implant must achieve primary stability by achieving compression around it. The primary stability, in time, is replaced by secondary stability achieved by bone remodelling. Implant design and surgical modifications

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are harnessed to generate limited compression around the implant. The factors of bone quality, using smaller diameter drills than implant diameter and implant designed to achieve compression, would also pose a resistance to implant insertion.

The force used to insert a dental implant is called insertion torque (IT).¹ It is the amount of torque required to advance the implant into the prepared osteotomy. Apart from indicating the bone quality,² it is an important factor for the implant's primary stability in the site and in deciding the loading protocol, which in turn are important for implant survival. Higher insertion torque leads to higher primary stability.³ Lower ranges have been associated with failures.⁴ Studies have indicated insertion torque near the range of 35 Ncm to be satisfactory.^{2,5,6} Some clinicians prefer higher insertion torque whereas some suggest low. Certain implant manufacturers recommend an insertion torque value that should not be exceeded or a minimum torque value to be achieved for immediate implant loading.

Implant insertion torque can be assessed by electronic devices incorporated with physiodispenser or with torque gauge incorporated with manual ratchets. Most of the dental implant systems presently being used in Armed Forces do not contain a calibrated torque ratchet or a physiodispenser which has an inbuilt electronic torque control setting for implant insertion. Prevalent systems in use have a manual non-calibrated ratchet/screw for implant insertion. Thus, it is not known that how much insertion torque had been applied to place the implant. In view of the above, inadequate or excessive implant insertion torque as a factor contributing to inadequate implant primary stability levels or bone over-compression cannot be pinpointed, as it had not been measured and remains a subjective matter.

Thus, this in-vivo study was undertaken with the aim to determine the average insertion torque being applied to the dental implant while surgically placing it with a non-calibrated manual ratchet (Touareg Dental implants by ADIN, which are tapered, threaded, Titanium alloy implants). The objective of this study was to measure whether average dental implant insertion torque being applied by a Dental Surgeon using a non-calibrated manual ratchet reaches 35 Ncm or not. Also, the study attempted to find out the average insertion torque range achieved by a surgeon under the proposed set-up of study.

Material and methods

A total of 45 dental implants (Touareg, ADIN, Afula, Israel) were to be placed for this study. 42 patients attending the dental OPD, requiring replacement of single/multiple missing tooth/teeth in mandibular posterior region with dental implant supported crown/prosthesis were selected. Inclusion criteria were: age group of 20–50 years, healthy dentition, fair oral hygiene, no known local or systemic complications, have had a healing period of at least six months post dental extraction at the selected site for implant placement.

To reduce experimental error, three Dental Surgeons were selected to carry out implant placement. They were termed as Surgeon No.-1, Surgeon No.-2 and Surgeon No.-3. Each

Fig. 1 – Manual non-calibrated implant ratchet.

Fig. 2 – Implant being placed with manual non-calibrated implant ratchet.

Surgeon had to place 15 implants and the patients were randomly allotted to each Surgeon.

Diagnostic procedures for each selected case were carried out which included Ortho Pan-Tomograph (OPT), Intra Oral Peri-apical (IOPA) radiographs and study casts. Stents for placing the implant were prepared for each case.

Standardised surgical protocols were followed to prepare the site to place the dental implant. The size of the implant i.e.

Fig. 3 – Manual calibrated torque gauge ratchet.

diameter and length, was based on the diagnostic aids and clinical situation. Stent was then placed to initiate drill sequence with the pilot drill. Drill RPM was kept upto 800 and external irrigation with normal saline was done. Drilling was sequentially followed till the final diameter and length drill.

The implant was placed using a manual non-calibrated implant ratchet (Figs. 1 and 2) supplied with the basic implant surgical kit. Once the implant was nearly placed, a manual calibrated torque gauge ratchet (Figs. 3 and 4) was used to place the implant in its final position and at that instance, the maximum final torque applied was noted on the torque gauge scale (Fig. 5) and observation recorded to make the database. Since the torque gauge had analogue markings on its scale at unequal distance for 35, 50, 70 and 100 Ncm (Fig. 6), the torque achieved was recorded in five range blocks of-

- 34 Ncm or less (when the gauge did not come upto the centre of the mark 35),
- 35–49 Ncm (gauge touched the centre of mark 35 till when the gauge remained short of touching the centre of the mark 50),
- 50–69 Ncm (gauge touched the centre of mark 50 till when the gauge remained short of touching the centre of the mark 70),
- 70–99 Ncm (gauge touched the centre of mark 70 till when the gauge remained short of touching the centre of the mark 100) and
- 100 or more Ncm (when the gauge touched the centre of the mark 100 or crossed it).

For example, if the torque gauge reached a point just above the centre of the 50 mark on the scale, the reading would be that the torque achieved was in the block range of 50–69 Ncm, and if it failed to touch the centre of the 35 mark, it would be read as in the block “34 Ncm or less”.

In each case, the implant collar was placed at level with the crestal bone. Implant cover screw was then fitted and the flap sutured back. Post-operative instructions were explained. Medications along with 0.2% Chlorhexidine mouthwash were prescribed to the patient. Post-operative OPT and IOPA radiographs were taken. Patients were recalled at 24 h, followed by 48 h recall schedule till suture removal, which was one week post-operatively.

All the cases were prosthetically loaded vide a two-stage protocol, i.e. after 3–4 months of placing the implant. Second stage procedures were initiated after assessing improved bone density around the implant on IOPA radiographs. Thereafter, patients were kept on recall schedule every three months.

All the implants were followed at least up to six months post-operatively and none of the implants failed in this study.

Results

Table 1 depicts surgeon-wise frequency (no. of cases and percentage) of insertion torque range achieved. Table 2 depicts the overall average frequency (no. of cases and percentage) of insertion torque range achieved for total of 45

Fig. 4 – Implant being placed with manual calibrated torque gauge ratchet.

Fig. 5 – Maximum final torque being measured by the torque gauge.

implants inserted. The mean dental implant insertion torque applied by three surgeons using a non-calibrated manual ratchet was estimated to be 63.26 Ncm with a standard error of 6.80 i.e. (63.26 ± 6.8) , which was significantly higher than the baseline of 35 Ncm ($p < 0.0001$). The mean dental implant torque applied by Surgeon 1, 2 and 3, respectively, was 65.93 Ncm, 62.60 Ncm and 62.13 Ncm and this difference amongst them was found to be statistically insignificant

Fig. 6 – Torque gauge scale.

($p > 0.05$) and each of them had reached more than the baseline level of 35 Ncm individually and significantly ($p < 0.0001$).

Discussion

Success of an implant depends on various factors, beginning with the diagnosis and case selection upto 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.⁷ 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.^{8,9} 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.²

Primary stability depends on mechanical engagement of an implant with bone but it decreases with time as bone remodelling occurs around it.¹ Also, there is a sharp reduction in interfacial strain due to mechanical stress relaxation in the bone.³

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.^{1,2,7} 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.³

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.¹ 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.²

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.

The use of under-dimensioned drills and the implant design featuring tapered geometry will cause local compression and thereby achieve good stability.³ Using much under-dimensioned/smaller diameter drill as compared to implant diameter may increase initial primary stability but it also leads to a greater necrotic bone “dieback” and bone remodelling, causing a drop in stability till secondary stability is gained by new bone formation. Using comparatively larger diameter drill leads to a relatively lower primary stability but the compressive strain release reduces the necrotic bone “dieback” and remodelling. This renders prolonged primary stability and rapid woven bone fillings hasten the secondary stability gain.¹²

Tapered implants induce more compression than parallel implants as they are inserted in the bone.¹³ They have continuously increasing insertion torque because of lateral bone compression from the entire length of implant during insertion. Stresses are distributed along entire implant surface and not concentrated to a few spots.¹¹

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.¹⁴ 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 “Mechano-transduction”. 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.¹⁵

Insertion torque is reduced in implant macrodesigns that incorporated cutting edges, and lesser insertion torque was generally associated with decreased micromovement as this

Table 1 – Surgeon-wise frequency of insertion torque range achieved.

Surgeon no.	No. of implants placed	Implant insertion torque range achieved in no. of cases				
		34 Ncm or less	35–49 Ncm	50–69 Ncm	70–99 Ncm	100 or more Ncm
1	15	NIL	1 (6.67%)	9 (60%)	5 (33.33%)	NIL
2	15	NIL	2 (13.33%)	9 (60%)	4 (26.66%)	NIL
3	15	NIL	1 (6.67%)	12 (80%)	2 (13.33%)	NIL

Table 2 – Overall average frequency of insertion torque range achieved.

Total implants placed	Implant insertion torque range achieved in no. of cases				
	34 Ncm or less	35–49 Ncm	50–69 Ncm	70–99 Ncm	100 or more Ncm
45	NIL	4 (8.89%)	30 (66.67%)	11 (24.44%)	NIL

thread-cutting geometry creates a high level of bone to implant contact.^{3,16}

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 associates¹⁷ 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-workers¹⁸ suggested that insertion torque above 50 Ncm could lead to higher peri-implant bone loss.

Ottoni et al⁴ 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-workers⁵ reported mean insertion torque of 33.4 Ncm and 40.81 Ncm with two designs of implants in their study. Turkyilmaz and McGlumphy² 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 al⁶ 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, non-restored 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, non-restored and submerged implants.

Trisi et al¹⁹ 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. Makary²⁰ 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.

Sotto-Maior and co-workers⁷ 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 al¹² 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.

In practice, insertion torque can be subjectively assessed by the surgeon using manual ratchets or objectively by using electronic drill devices having torque measuring capability. Other option is to use a ratchet with calibrated torque gauge. Most of the prevalent implant systems used in routine clinical practice do not have electronic torque measuring component, instead a non-calibrated manual ratchet is used. Hence, it depends on the surgeon's experience to judge it. With the background of the literature, it can be derived that 35 Ncm torque is required to get adequate primary stability of the implant, especially if immediate loading protocol is to be followed. An average clinician may not know whether he/she has achieved 35 Ncm insertion torque or has exceeded the maximum limit, if so advocated by the implant manufacturer. Hence, this study was undertaken to find whether an average surgeon achieves 35 Ncm insertion torque using a non-calibrated manual ratchet. Three surgeons were selected to participate in this study to reduce experimental error, to have a cross-sectional feedback, as one particular surgeon's assessment would be influenced by his/her muscularity and sensitivity to perceive applied force.

All the selected cases required implants in the mandibular posterior region, so as to have on an average D-2/D-3 type bone and to reduce variability. Torque gauge ratchet was used to measure insertion torque only when the implant was nearly seated for two reasons. Firstly to eliminate surgeon's visual bias and secondly, the peak insertion torque is achieved near the implant's final seating. There are three reasons suggested for the high final peak insertion torque. The implant butts against the prepared bottom of the site, the implant flange contacts the cortical bone at the crest and there is high interfacial stress along the implant surface.³ Also, studies on torque–time curve have showed that maximum insertion torque is during its last seating.¹¹

The data was tabulated, frequency distribution was worked out and statistical analysis carried out. To compare whether average dental implant insertion torque being applied by a Surgeon using a non-calibrated manual ratchet reaches 35 Ncm or not, Student's 't'-test was applied and to find whether the average of dental implant insertion torque being applied by three different Surgeons reaches 35 Ncm or not, 'One Way ANOVA' was used.

There was no statistically significant difference in the mean insertion torque value achieved by the three surgeons. The cross-sectional mean insertion torque value was 63.26 ± 6.8 Ncm, which is significantly higher than the baseline of 35 Ncm.

None of the implants failed in this study. This fact suggests that those implants which had insertion torque above 70 Ncm but below 99 Ncm, were also successful. Out of total 45, there were 11 such cases (24.44%). Within the ambit of this study

and with the implant system used, it is suggested that an average surgeon may achieve insertion torque higher than 35 Ncm.

This study had certain limitations such as the sample size was not large, the manual torque gauge has limited accuracy, it is susceptible to fatigue and inaccurate reading after prolonged usage. Hence, further scope includes studies with larger sample size and improved torque measuring systems.

Conflicts of interest

All authors have none to declare.

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