# EFFECT OF IMPLANT DESIGNS ON INSERTION TORQUE AND IMPLANT STABILITY QUOTIENT (ISQ) VALUE

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**Statement of problem.** Primary implant stability has long been identified as a prerequisite to achieve osseointegration. So the application of a simple, clinically applicable noninvasive test to assess implant stability and osseiointegratation are considered highly desirable.

**Purpose.** The purpose of this study was to evaluate the ISQ value and the insertion torque of the 3 different implant system, then to evaluate whether there was a correlation between ISQ value and insertion torque; and to determine whether implant design has an influence on either insertion torque or ISQ value.

**Material and method.** The experiment was composed of 3 groups: depending on the implant fixture design. Group1 was Brånemark type parallel implant in 3.75 × 7mm. Group2 was Oneplant type straight implant in 4.3 × 8.5mm. Group3 was Oneplant type tapered implant in 4.3 × 8.5mm. Depending on the density of the bone, 2 types of bone were used in this experiment. Type I bone represented for cortical bone, type II bone represented for cancellous bone. With the insertion of the implant in type I and type II bone, the insertion torque was measured, then the ISQ value was evaluated, and then the correlation between insertion torque and ISQ value was analyzed

**Result and conclusion.** Within the limitations of this study, the following conclusions were drawn.

1. Within the 3 different implants, the insertion torque value and ISQ value were higher in type I bone, when compared with type II bone.($p<0.05$)
2. In type I and type II bone, Oneplant type tapered implant has the highest value in insertion torque.($p<0.05$)
3. In type I and type II bone, there was no difference in ISQ values among the 3 types of implant. ($p>0.05$)
4. Significant linear correlation was found in Brånemark type parallel implant: 3.75 × 7mm in type II bone.

**Key Words**

Implant stability, Insertion torque, Resonance frequency analysis, Implant design

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In some circumstances, early and immediate loading protocols have now been recognized to be alternatives to the traditional 1 or 2 stage delayed loading approaches.[1-10] Primary implant stability has long been identified as a prerequisite to achieve osseointegration[11-12] and many authors also suggested that primary stability may be a useful predictor for osseointegration[13-14] and that a high primary stability makes immediate loading more predictable.[4,5,7]

The degree of primary stability after implant placement is dependent on factors related to the properties of the bone, the design of the implant, and the surgical technique used.[15] When primary stability is achieved and a proper prosthetic treatment plan is followed, immediate functional loading is a feasible concept.[16]

So the application of a simple, clinically applicable noninvasive test to assess implant stability and osseiointegratation are considered highly desirable. Many tests have been suggested: percussion, radiographic method, resonance frequency analysis, placement resistance, the Periotest, reverse torque and vibration methods in sonic and ultrasonic ranges.[17] Of these, resonance frequency analysis (RFA) and placement resistance methods appear to be the efficient and least contraindicated.

RFA has been introduced to provide an objective measurement of implant primary stability and to monitor implant stability over the healing period.[18-19] The specific value that indicated the implant stability of a given situation is called the resonance frequency.[20] It may range from 5000Hz (suggesting no primary stability or non-integration of the implant) to 15,000 Hz (suggesting high primary stability or rigid implant integration) and is calculated into the implant stability quotient (ISQ, ranging from 0 to 100) by the instrument' s software.[20] The higher the ISQ value the higher the implant stability.

Bone quality is one of the key parameters influencing successful implant placement. It can be evaluated in terms of 2 factors: its mechanical properties (density, hardness, and stiffness) and its physiologic properties (healing ability and regenerative capacity).[21] Johansson and Strid[22] assessed the bone quality during implant surgery by the application of cutting resistance measurements. The cutting torque was determined from the current fed to the electric motor while cutting a thread into a hole in the bone. The bone quality was expressed as the energy required cutting away a unit volume of bone.

Friberg et al.[14] have reported that the highest correlation was found when comparing the mean torque values of the upper/crestal portion with the resonance frequency values at implant placement. There was correlation between the cutting resistances and the ISQ values. O' sullivan et al.[23] have also reported that there was correlation between the peak insertion torque and ISQ values. But Cunha et al.[21] have reported that the correlation between the insertion torque and ISQ values only occurred in some implant designs.

The purpose of this study was to evaluate the ISQ value and the insertion torque of the 3 different implant systems and to verify whether there was a correlation between ISQ value and insertion torque; and to analyze the influence of implant design on the insertion torque and ISQ value.

## MATERIALS AND METHODS

### Implant

Three types of different implants were used in this experiment: Brånemark type parallel implant: 3.75 × 7mm (Warantec, Seoul, Korea), Oneplant type straight implant: 4.3 × 8.5mm (Warantec, Seoul, Korea) and Oneplant type tapered implant: 4.3 × 8.5mm. (Warantec, Seoul, Korea). There were a total of 20 implants for each type of implant group.

**Experiment**

Two different types of pig rib bone were used in this experiment (type I and type II). 10 implants from each group of 20 implants were inserted into the type I bone and the rest were inserted into the type II bone. Type I bone was retrieved from the distal aspect of the rib, with more cortical bone. Type II came from a more proximal region with less cortical components and a higher content of bone marrow and spongeous trabeculae. The bones were firmly attached to a base vice. 3 types of implants were inserted into each type of bone separately. The implants were placed with an ELCOMED (W&H Dentalwerk, Bürmoos Gmbh, Austria) with a calibrated torque of 50 Ncm at 30 rpm.

**Insertion Torque Measurements**

ELCOMED is a machine developed for perforation of bone and implant placement. It also enables measurement of insertion torque during the placement procedure.

**Resonance Frequency Measurement**

The Osstell™ (Integration Diagnostic Ltd., Göteborg, Sweden) was used to measure resonance frequency. Resonance frequency analysis was completed immediately following implant placement. An L-shaped transducer was directly connected to each implant, one implant at a time. The transducer was attached to the top of the implant, perpendicular to the crest, tightening them with a hand driver.

**Statistical Analyses**

SPSS 12.0 for Windows software (Apache Software Foundation, Chicago, Illinois, USA) was used for statistical analysis. One way ANOVA test ($p<0.05$) was used to evaluate the insertion torque and ISQ value of 3 different design implants in type I and type II bone. T-test ($p<0.05$) was used to analyze the insertion torque and ISQ value of the same implant in the different type of bones. Then correlation analysis was used to evaluate whether there was correlation between the insertion torque and the ISQ value between the same types of bones.

## RESULTS

All the data form type I and type II bone are shown in Table I and II.

### 1. Insertion Torque

Insertion torque was measured during placement of the implant.

Table III shows the t value for comparison of the 3 types of implants used and statistical analyses for variables evaluated. Table IV shows the t value for comparison of the same implant in the different type of bones.

The mean torque values for the 3 types of implants in type I and type II bone differed significantly.($p< 0.01$) (Fig. 1, 2) In type I and type II bone Oneplant type tapered implant had the highest insertion torque. The mean torque value of the same implant in the different type of bones differed significantly.($p<0.01$) (Table IV) The insertion torque in type I was higher than the type II bone.

### 2. ISQ value

Resonance frequency analysis was completed immediately following implant placement.

Table III shows the t value for comparison of the 3 types of implants used and statistical analyses for variables evaluated. Table IV shows the t value for comparison of the same implant in the

**Table I.** Data used in the statistical analysis of 3 types of implants in type I bone

| | Brånemark | | Straight | | Tapered | |
|---|---|---|---|---|---|---|
| | IT(B1)Ncm | ISQ(B1) | IT(S1) Ncm | ISQ(S1) | IT(T1) Ncm | ISQ(T1) |
| 1 | 19 | 73 | 30.5 | 68 | 43 | 69 |
| 2 | 20 | 73 | 23 | 82 | 32.5 | 77 |
| 3 | 16 | 66 | 17 | 79 | 28.5 | 65 |
| 4 | 15 | 80 | 19 | 70 | 25 | 67 |
| 5 | 16.5 | 67 | 19.5 | 77 | 25 | 72 |
| 6 | 23 | 80 | 31 | 80 | 40 | 65 |
| 7 | 14 | 72 | 21 | 70 | 32 | 73 |
| 8 | 17 | 72 | 23 | 71 | 30 | 73 |
| 9 | 14 | 68 | 17 | 79 | 18 | 72 |
| 10 | 16 | 73 | 18 | 75 | 26 | 84 |
| MEAN | 17.05 | 72.4 | 21.9 | 75.1 | 30 | 71.7 |

IT: Insertion Torque
ISQ: Implant Stability Quotient

**Table II.** Data used in the statistical analysis of 3 types of implants in type II bone

| | Brånemark | | Straight | | Tapered | |
|---|---|---|---|---|---|---|
| | IT(B2) Ncm | ISQ(B2) | IT(S2) Ncm | ISQ(S2) | IT(T2) Ncm | ISQ(T2) |
| 1 | 9 | 65 | 8.5 | 70 | 14.5 | 69 |
| 2 | 9.5 | 65 | 6.5 | 61 | 8.5 | 56 |
| 3 | 6 | 61 | 6.5 | 56 | 7 | 67 |
| 4 | 7 | 58 | 8.5 | 74 | 13.5 | 64 |
| 5 | 12.5 | 70 | 11.5 | 65 | 17 | 67 |
| 6 | 9 | 63 | 17.5 | 65 | 23 | 70 |
| 7 | 11 | 70 | 15 | 71 | 21 | 69 |
| 8 | 6 | 63 | 9 | 62 | 11 | 68 |
| 9 | 10 | 62 | 10 | 74 | 20 | 65 |
| 10 | 14 | 70 | 15 | 66 | 20 | 65 |
| MEAN | 9.4 | 64.7 | 10.8 | 66.4 | 15.55 | 66 |

IT: Insertion Torque
ISQ: Implant Stability Quotient

different type of bones. The mean ISQ values for the 3 types of implants in type I and type II bone did not differ significantly.($p>0.05$) (Fig. 3, 4) The mean ISQ values of the same implant in the different type of bones differed significantly. ($p<0.01$) (Table IV) The ISQ values in type I was higher than in type II bone.

**Table III.** t values of comparison for insertion torque and ISQ values in type I and type II bone

| Bone Type | Variable | t |
|---|---|---|
| | **Insertion Torque** | |
| | B1 vs S1 | 1.99 |
| I | B1 vs T1 | 5.313 *** |
| | S1 vs T1 | 3.323 ** |
| | B2 vs S2 | 0.7497 |
| II | B2 vs T2 | 3.294 ** |
| | S2 vs T2 | 2.544 |
| | **ISQ** | |
| | B1 vs S1 | 1.158 |
| I | B1 vs T1 | 0.3003 |
| | S1 vs T1 | 1.459 |
| | B2 vs S2 | 0.7981 |
| II | B2 vs T2 | 0.6103 |
| | S2 vs T2 | 0.1878 |

B: Brånemark type parallel implant
S: Oneplant type straight implant
T: Oneplant type tapered implant
IT: Insertion Torque ISQ: Implant Stability Quotient
**p<0.01; ***p<0.001 I: type I bone II: type II bone

**Table IV.** t values of comparison for the insertion torque and ISQ values of the same type of implant in the different type bones

| Variable | t |
|---|---|
| **Insertion Torque** | |
| B1 vs B2 | 0.002 * |
| SI vs S2 | 0.0001 ** |
| T1 vs T2 | 0.0008 ** |
| **ISQ** | |
| B1 vs B2 | 0.0012 ** |
| SI vs S2 | 0.0022 ** |
| T1 vs T2 | 0.0199 * |

B: Brånemark type parallel implant
S: Oneplant type straight implant
T: Oneplant type tapered implant
IT: Insertion Torque ISQ: Implant Stability Quotient
*p<0.05; **p<0.01 I: type I bone II: type II bone

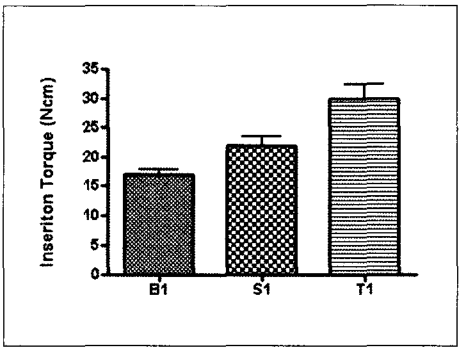


**Fig. 1.** Type I Bone Insertion Torque value.

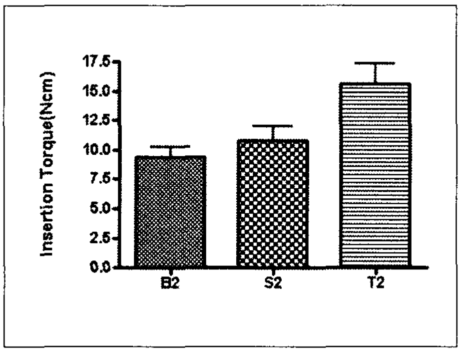


**Fig. 2.** Type II Bone Insertion Torque value.

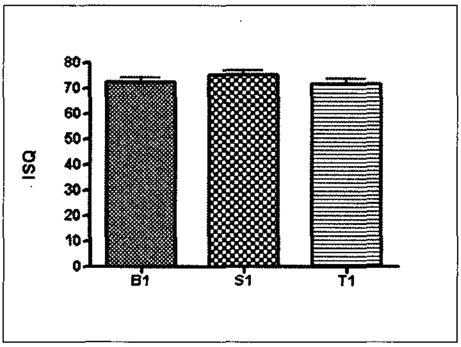


**Fig. 3.** Type I Bone ISQ value.

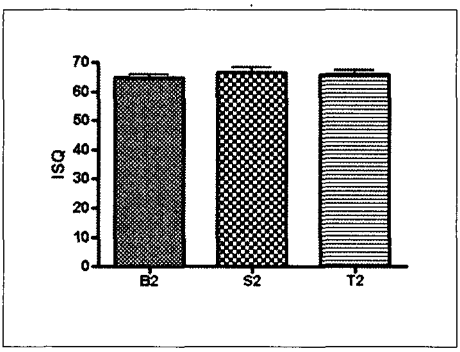


**Fig. 4.** Type II Bone ISQ value.

**Table V.** Correlation Coefficient r between the insertion torque and ISQ values

| Bone type | IT vs ISQ | Correlation(r) |
|---|---|---|
| | **Implant** | |
| I | Brånemark | 0.458 |
| | Straight | -0.1575 |
| | Tapered | -0.2777 |
| II | Brånemark | 0.8346** |
| | Straight | 0.2533 |
| | Tapered | 0.461 |

** p<0.01

IT: Insertion Torque ISQ: Implant Stability Quotient

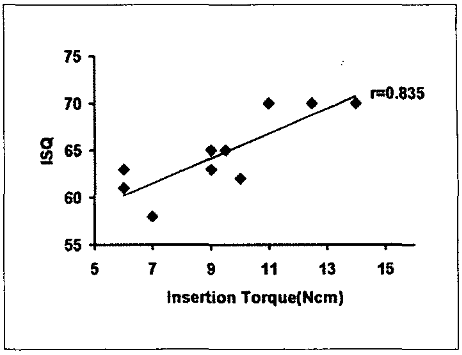


**Fig. 5.** Correlation of insertion torque and ISQ value in type II bone Brånemark type parallel implant.

**3. Correlation Analysis**

Table IV shows the correlation coefficient (r) between the insertion torque and ISQ values. (Fig. 5) Significant linear correlations were found in Brånemark type parallel implant: 3.75 × 7mm, in type II bone. (r=0.8346)

## DISCUSSION

Many authors agree that primary stability is important for the success and longevity of ossointegrated implants.[13,20]

The present study was undertaken to evaluate the ISQ value and insertion torque of 3 types of implants to determine if the implant design has an influence on implant performance.

Sennerby et al.[25] have shown the importance of engaging cortical bone, and they found that implants connected to the cortical bone by only a few threads still had a higher initial holding power than implants completely surrounded by cancellous bone.[24-25] In this study, in order to standardize the bone, in type I bone, the upper region of the cortical surface was ground until the spongeous part was 3.5mm in width, and the total width of the bone was more than 6mm. By the same method, in type II bone, the upper cortical region was ground until the spongeous region was larger than 6mm. Within the same type of implant, the insertion torque in type I bone was significantly higher than that in type II bone (p<0.01). There are 3 determinant parameters for achieving primary stability: implant geometry, surgical procedure, and bone quality of the recipient site (in regard to density and stiffness).[15] So as that in this study, the ISQ value in type I bone was significantly higher than that in type II bone (p<0.01). But, within type I and type II bone, the ISQ value showed no significant difference among the 3 types of the implants in the same type of bones.

Tapered implant systems have been developed with a view to facilitating implant placement. The theory behind the use of the tapered implants is to induce a degree of compression of the cortical bone in a poor bone implant site. The degree of compression is related to three factors: the degree of taper of the implant, the relationship of the final drill diameter used to maximum diameter of the implant and the mechanical properties of the bone itself.[24] In this study, both in type I and type II bone, the highest insertion torque was accrued in Oneplant type tapered implant, followed by the Oneplant type straight implant and the Brånemark type parallel implant. But within the same type of bones, there was no significant difference between the Oneplant type straight implant and the Brånemark type parallel implant ($p>0.05$).

Through statistical analysis it was observed that among all the compared variables a significant statistical correlation was found only with the use of Brånemark type parallel implant in type II bone ($r=0.8346$) ($p<0.01$). When using other types of implants in the two types of bones, there was no significant statistical correlation for any variable studied in this investigation. Some implants showed higher insertion torque but not greater primary stability. That may be because in type II bone, without the thread engaged in the cortical bone, the parallel design may have some effect on the primary stability and insertion torque.

The 3 types of implants used in this study were not the same size, so in some circumstances may affect the accuracy of the result. So in the subsequent study, the same size of the implants may be needed.

## CONCLUSIONS

From this study we could conclude that:

1. Within the 3 different implants, the insertion torque value and ISQ value were higher in type I bone, when compared with type II bone. ($p<0.05$)
2. In type I and type II bone, Oneplant type tapered implant has the highest value in insertion torque.($p<0.05$)
3. In type I and type II bone, there was no difference in ISQ values among the 3 types of implant. ($p>0.05$)
4. Significant linear correlation was found in Brånemark type parallel implant: 3.75 × 7mm in type II bone.

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