Stability of aggressive thread design implant (BLX): A pilot study

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Abstract

Primary stability is an important factor to determine an osseointegration process. The Resonance Frequency Analysis (RFA) is approved to use for evaluating the implant stability due to the non-invasive and highly precise method. RFA values are converted to ISQ (Implant Stability Quotient) values ranging from 0 to 100. The newly launched aggressive thread design implant (BLX, Straumann, institute AG, Switzerland) was developed to maximize the stability of the implant. This pilot prospective cohort study was performed to investigate the stability of aggressive thread design implant (BLX) using Implant Stability Quotient *(*ISQ*)* values. Patients who fulfilled the study requirements were selected. Twelve BLX implants were placed in the healed site without the need for guided bone regeneration under the manufacturer's protocol. The RFA values were measured immediately after implantation and 6 weeks after implant placement at the buccal and mesial directions. The ISQ at the buccal and mesial sides were calculated for a mean ISQ in each follow-up time. The mean ISQ value immediately after implant placement was 77.96 ± 5.81, ranging from 65.5 to 84.5. The mean ISQ value at week 6 was 73.92 ± 4.38, ranging from 68.5 to 82. The ISQ values at the buccal and mesial sides at the operative day as well as 6-week follow-up were not statistically significant *(p = 0.709, 0.761)*. The mean ISQ values on operation day and week 6 are also not significantly different (*p = 0.177)*. Regarding different insertion torque groups, for the implant that has the insertion torque over 50 Ncm, the mean ISQ at the operative day is statistically significantly superior to the insertion torque group of 25-30 Ncm *(p = 0.49)*. In conclusion, the mean ISQ values of newly launch BLX implants were high and more than 70 indicating the high stability of this implant leading to successful clinical outcomes.

Keywords**:** *Dental implant, Aggressive thread design implant, Implant stability, Resonance frequency analysis, Osseointegration*

1. Introduction

Primary stability is a crucial parameter to determine a successful osseointegration process. Ellis et al. (2020); Javed et al. (2013); and Cochran et al. (1998) stated that implant stability is a condition in which the implant is ensured and has no mobility. At the time of implant placement, primary stability is achieved from an engagement of the implant thread to the alveolar bone. The amount of stability can vary by surrounding bone quality, surgical technique, implants configuration as implant length, diameter, shape, and thread design. The close contact between the implant and alveolar bone can imply a level of primary stability (Koyama et al. 2011).

Due to the bone remodeling process, the primary stability is reduced and replaced by secondary stability continuously. The secondary stability is affected by the rate and amount of the new bone formation. If the decrease rate of primary stability is more rapid than the elevation rate of secondary stability, the overall stability is lessened to the lowest point (stability dip). This primary and secondary stability shows an inverted relationship (Berglundth et al., 2003; Smeets et al., 2017; Miri et al., 2017).

Thongborisoot et al. (2017) reported that the stability pattern of SLA (Sandblasted, large grit, acid-etched) surface implant was increased at 4 weeks after dropping from implant placement day and continuously increase nearly to implant placement day. A study by Bornstein et al. (2005) found that the early loading at 6 weeks of SLA surface implant has a successful clinical outcome with high predictability as the 5-year success rate was presented at 99%.

There are several methods to evaluate implant stability. The methods can be categorized as invasive and non-invasive methods (Swami et al., 2016). The invasive method test, for instance, the Reverse torque test, cutting torque resistance test, and damping capacity analysis (Periotest) interfere with the implant osseointegration process during the measurement. Resonance frequency analysis (RFA) is a

recommended non-invasive method to detect implant stability. The RFA device detects the specific vibrate frequency from a piezoelectric transducer and converted it to ISQ (Implant Stability Quotient) values ranging from 0 to 100 (Meredith, 1998). Earlier studies noticed that RFA is a highly precise method with a reproducibility property. Thus, twice the record in the perpendicular direction is adequate (Thongborisoot et al., 2017; Herrero et al., 2013).

The Implant Architecture and design is an important parameters to promote primary stability. The aggressive tread design promotes a mechanical engagement of implant to the bone leading to greater primary stability, especially in loose bone types. Karl & Irastorza-Landa's (2017) study shows that the stability of aggressive thread design implant is significantly higher than nonaggressive thread design using the ISQ.

The BLX implant (Straumann AG) was recently launched. This implant design has an aggressive implant thread with a two-sided cutting edge for engaging alveolar bone and obtaining maximum primary stability. The core material is Titanium combined with Zirconia (Ti-Zr, Roxolid), which are higher tensile and fatigue strength than pure titanium (Koyama et al., 2011). Nevertheless, the study about this implant is few and only in the case report and in vitro studies. Meijndert et al. (2020) reported 3 cases of immediate placement of BLX implant in the anterior area. They showed favorable clinical outcomes in one year with a 100% survival rate. The biological or mechanical complications were not observed. The crestal bone was stable and the patient was satisfied with the outcome.

Therefore, this study examined the stability of a newly aggressive thread design implant (BLX) using Implant Stability Quotient (ISQ) values.

2. Objectives

To investigate the stability of aggressive thread design implant (BLX) using Implant Stability Quotient (ISQ) values

3. Materials and Methods

A prospective cohort study was performed at the Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Chulalongkorn University. The study design and protocol were approved by the Human Ethics Committee of the Faculty of Dentistry, Chulalongkorn University (HREC-DCU 2021-055).

Patients who have at least one missing tooth were recruited and selected using the criteria presented below:

Inclusion criteria

- Healthy patients aged ≥ 21 years (ASA class I, II)
- The implantation site was healed ≥ 2months before operation day
- Adequate bone quality and quantity to place an implant without bone augmentation
- Adequate good oral hygiene and can follow the post-op instruction
- After implant placement, the insertion torque is equal to or more than 25 Ncm

Exclusion criteria

- Maxillofacial pathology Patient
- A patient who wears orthodontic appliances
- Parafunctional habits (bruxism and clenching) patient
- Patients who smoke more than 10 cigarettes per day or chewing tobacco.

3.1 Materials

1. BLX implant SLA surface, Roxolid material (Straumann, institute AG, Switzerland)
2. Resonance frequency analysis (RFA) device (Osstell ISQ, Integration diagnosis AB, Sweden)
3. Smartpeg (Osstell ISQ, Integration diagnosis AB, Sweden)
4. Implant stability test (IST) device (Anycheck: Neobiotech, Korea)

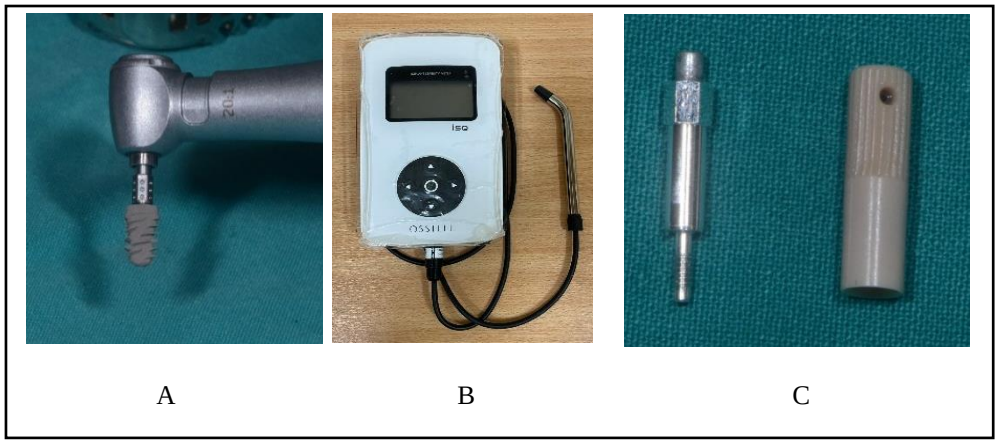

Figure 1 (A) Aggressive thread design implant (BLX)**,**
(B) Resonance frequency analysis device (RFA, Osstell), and (C) Smartpeg and cap

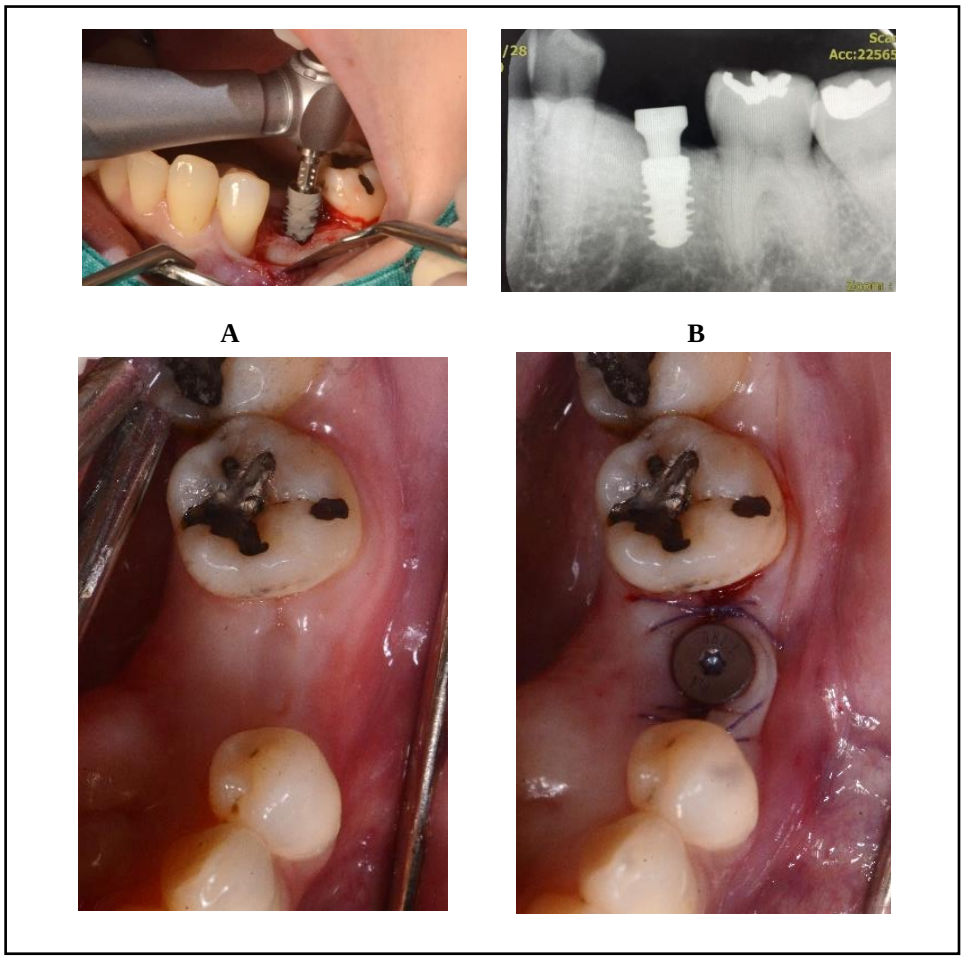

Figure 2 (A) Implant BLX was placed in preparation bed, (B) The periapical film immediately after placement (C) Preoperative intraoral photo, and (D) Postoperative intraoral photo

3.2 Methods

Patients who met the inclusion were included in the study. Demographic and clinical data were recorded. The Dental Computed Tomography Scan (CBCT) was used to evaluate the implantation site. The length and diameter of the implant were selected due to specific clinical considerations according to edentulous space width, prosthetic design, and anatomical structure. The length of the implant is 8 and 10 mm limited by the distance from crestal bone to the inferior alveolar nerve in the mandible and the distance from crestal bone to maxillary sinus in the maxilla. The diameter of the implant is 4.0 and 5.0 mm depending on the prosthetic design. The implant was placed by a master's student of the Department of Oral and Maxillofacial surgery under the supervision of one experienced professor. The implantation site was drilled following Straumann protocol, after that implant was placed into a prepared bed with a non-submerged technique. A healing abutment was placed for transmucosal healing. The insertion torque was measured at the time of implant insertion. The Implant Stability Quotient (ISQ) was measured twice: immediately after implant insertion and at a 6-week follow-up. All the measurements were obtained by two calibrated clinicians.

Besides, a periapical radiograph will be taken after implant placement for baseline and 6 weeks after implantation to estimate the bone healing process.

3.3 Measurement parameter

1. Implant Stability Quotient (ISQ) values

Implant Stability Quotient (ISQ) values will be measured by resonance frequency analysis (RFA). Firstly, a small piezoelectric transducer (Smartpeg) was attached to an implant. Then, the probe of the Ostell Menter device was used to measure the values at the buccal and mesial side at the tip of Smartpeg. The ISQ values were obtained immediately after implant insertion and 6-week after surgery.

A B C

Figure 3 (A) Smart peg was attached to the implant, (B) The RFA device probe measured the values at the Buccal side, and (C) Mesial side

3.4 Statistical analysis

All statistical analysis was performed by IBM SPSS Statistics program version: 28.0.0.0 (SPSS Inc., Chicago, IL, USA). The parameters were tested for the distribution of data by the Shapiro-Wilk test. The paired t-test was used to compare the difference between the ISQ values of the buccal and mesial sides at the operative day and week 6 follow-up. The One-Way ANOVA test was used to evaluate the insertion torque group and ISQ values at each time. The level of significance was set at 0.05 with a confidence interval of 95%.

4. Results and Discussion

12 participants (five male and nine female) who fulfilled the inclusion criteria were enrolled in this study. The mean patient age is 51.25 ± 11.51 years ranging from 37-75 years. Twelve BLX implants were placed in each patient. The site were 4 cases of maxilla premolar, 3 cases of mandible premolar, and 5 cases of Mandible molar. The size of the implant (diameter x length) is 4x8 mm 1 case, 4x10 mm 5 cases, 5x8 mm 3 cases, and 5x10 mm 3 cases. Demographic data of the study participants are presented in Table 1.

The implant stability quotient values (ISQ) of all implants at operation day and 6 weeks follow-up were presented in Table2. The ISQ in the buccal and mesial side were calculated to the Mean of ISQ in each follow-up time. The position and insertion torque was described as well.

Table 1 Demographic data and Implant distribution of the study participants

Variables	BLX implant
Sex, n (%)	
Male	5 (41.7)
Female	7 (58.3)
Age (Mean ± SD) (y)	51.25 ± 11.51
Implant location	
Maxilla premolar	4
Mandible premolar	3
Mandible molar	5
Implant size (Diameter x Length) (mm)	
4 x 8	1
4 x 10	5
5 x 8	3
5 x 10	3

Table 2 ISQ and IST measurement values of each BLX implant

Patient	Position	Insertion torque	ISQ Op Day			ISQ week6		
			B	M	Mean	B	M	Mean
1	45	80	80	81	80.5	74	76	75
2	37	30	74	74	74	80	80	80
3	46	35	75	75	75	78	70	74
4	35	35	85	84	84.5	66	75	70.5
5	47	35	70	76	73	82	82	82
6	24	60	74	75	74.5	70	70	70
7	24	35	83	85	84	68	69	68.5
8	37	50	83	83	83	71	71	71
9	37	50	85	84	84.5	79	79	79
10	24	50	79	77	78	73	73	73
11	14	35	79	79	79	71	70	70.5
12	35	25	67	64	65.5	73	74	73.5

ISQ, Implant stability quotient; B, buccal; M, Mesial; Op Day; operative day

Table 3 Mean and standard deviation of measurement

Measurement	Mean	SD	Minimum	Maximum
ISQ Op Buccal	77.83	5.88	67	85
ISQ Op Mesial	78.08	5.96	64	85
Mean ISQ Op	77.96	5.81	65.5	84.5
ISQ week6 Buccal	73.75	5.01	66	82
ISQ week6 Mesial	74.08	4.400	69	82
Mean ISQ week 6	73.92	4.38	68.5	82

ISQ, Implant stability quotient; Op Day; operative day; SD, standard deviation

Table 3 demonstrated ISQ and IST mean, standard deviation, minimum and maximum of all BLX implants. On operation day, the ISQ values at the buccal side ranged from 67 to 85 with a mean value of 77.83 ± 5.88. The ISQ values at the mesial side ranged from 64 to 85 with a mean value of 77.08 ± 5.96.

The ISQ values at operation day were calculated for the mean ISQ operative day. The mean ISQ values ranged from 65.5 to 84.5 with a mean value of 77.96 ± 5.81. The ISQ values at the buccal and mesial sides were not statistically significant *(p = 0.709)*.

At week 6, The mean ISQ values at the buccal side were 73.75 ± 5.01 ranging from 66 to 82. The mean ISQ values at the mesial side were 74.08 ± 4.4 ranging from 69 to 82. The mean ISQ values at week 6 ranged from 68.5 to 82 with a mean value of 73.92 ± 4.38. The ISQ values at the buccal and mesial sides were not statistically significant *(p = 0.761)*.

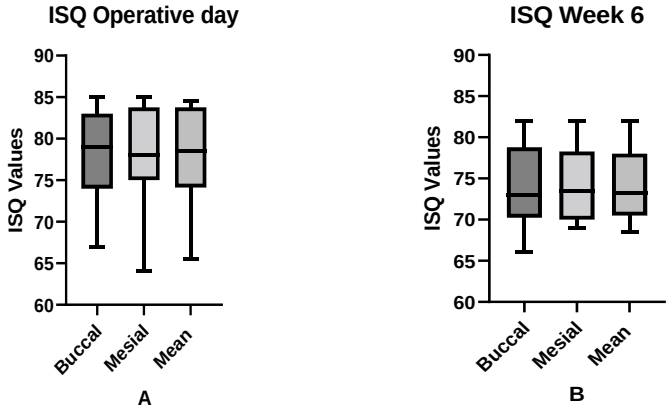

Figure 4 Box plot of (A) ISQ at operative day, (B) ISQ at week 6 follow-up

Table 4 The difference between ISQ values

Measurement	Significance *(p)*
ISQ Op Buccal / ISQ Op Mesial	0.709
ISQ week6 Buccal/ ISQ week 6 Mesial	0.761
Mean ISQ Op / Mean ISQ week 6	0.177

ISQ, Implant stability quotient; Op Day; Operative day

The ISQ at operative day and week 6 were also illustrated in the box plot in Figure 4. The ISQ at the buccal and mesial sides were not statistically different (Op; *p = 0.709*, Week6; *p = 0.761*). Although the mean ISQ at week 6 is lower than the mean ISQ, the mean ISQ values at operative day and week 6 were not statistically different *(p = 0.177)* (see Table 4).

Regardless of the follow-up time being only 6 weeks, the mean ISQ value at week 6 is over 70 (73.92, ± 4.38), which can indicate that the BLX implant has high implant stability leading to successful osseointegration (Balleri et al., 2002). Thereby, this aggressive thread design implant is crucial in the challenging situation including poor bone type and immediate implant placement.

4.1 The Implant stability quotient (ISQ) in different insertion torque

Considering implant insertion torque. The insertion torque was divided into 3 groups; group A is 25-30 Ncm, group B is 35-45 Ncm, and group C is more than 50 Ncm. The number for each group is 2,4,6 respectively. The mean ISQ in different insertion torque groups is shown in Table 5. The mean ISQ at operative day is consequently 69.75, 78.5, and 80.83 in insertion torque groups A, B, C, and average. The mean ISQ at week 6 is 76.75, 74.25, 72.75, and 73.92 in insertion torque groups A, B, C and average correspondingly. Overall RFA was high and present at more than 70 despite the mesial side at the operative day of insertion torque group A (mean ISQ = 69.0).

The values of ISQ at operative day at the buccal side are not statistically significant in every insertion torque group *(p = 0.09)*. The ISQ at week 6 at the buccal, mesial side, and mean are also not statistically significant in every insertion torque group.

On the other hand, on an operative day, the ISQ at the mesial side and mean ISQ is statistically significant between insertion torque group A (25-30 Ncm) and insertion torque group C (≥50 Ncm) The one-way ANOVA test shows a *p-value* at 0.30 and 0.49 correspondingly. The Scheffe test shows a significant difference in insertion torque group A and group C for ISQ at the mesial side is $p = 0.31$. The mean ISQ shows a *p-value* of 0.49.

At week 6, The values of all ISQ parameters at buccal, mesial, and mean of different insertion torque groups were not statistically significant *($p > 0.05$)*.

Table 5 The mean ISQ in different Insertion torque group

Measurement	Group A (25-30 Ncm)	Group B (35-45 Ncm)	Group C (≥ 50 Ncm)	Average
ISQ Op Buccal	70.50	77.25	80.67	77.83
ISQ Op Mesial	69.00	78.50	80.83	78.08
Mean ISQ Op	69.75	77.86	80.75	77.96
ISQ week6 Buccal	76.50	74.25	72.50	73.75
ISQ week 6 Mesial	77.00	74.25	73.00	74.08
Mean ISQ week 6	76.75	74.25	72.75	73.92

ISQ, Implant stability quotient; Op Day; Operative day

Thongborisoot et al. (2017) reported that the stability of SLA surface implant was firstly decreased after implant placement until 4 weeks then the stability pattern changed to increase over time. Bornstein et al. (2005) demonstrated that the early loading at 6 weeks of SLA surface implant has a 99%5-year success rate. The remaining implant has favorable clinical and radiographic outcomes. Furthermore, Balleri et al. (2002) presented the mean RFA as 69 ranging from 57-82. The RFA was measured 1 year after functional loading to represent the fully osseointegrated implant. The mean RFA at 6 weeks of this study is 73.92 ± 4.38 ranging from 68.5-to 82. The RFA value is related to an earlier study, therefore, the 2nd measurement of RFA was obtained 6 weeks after implant placement.

However, this study is only a pilot study with small sample size, further study should be done to illustrate the definite BLX stability in different bone type situations. Moreover, a measurement of implant stability at a sequencing time point after implant placement is also suggested to study.

5. Conclusion

In conclusion, this study demonstrated the stability of a newly aggressive thread design implant (BLX) using Implant Stability Quotient (ISQ) values. The ISQ values on operation day and week 6 were not significantly different as well as the mean ISQ values were high and more than 70, demonstrating the high implant stability of this aggressive thread design implant leading to successful clinical outcome. For the implant that had the insertion torque over 50 Ncm, the mean ISQ at the operative day was superior to the 25-30 Ncm torque group.

6. Acknowledgements

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