Clinical Note

Examination of Factor to Influence Dental Implant Stability Quotient Change

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Abstract: The success rate of dental implants depends largely on osseointegration of the implant. One method for evaluating osseointegration that has garnered attention is measurement of the implant safety quotient (ISQ) using resonance frequency analysis, but there have been few studies that have observed chronological changes in ISQ in the same implant type. Here, we observed chronological changes in ISQ in high-temperature acid-etched implants. The implants that were studied were 43 Swiss Precision and Innovation implants (SPI® implant, Thommen Medical, Grenchen, Switzerland) with a diameter of 4.0 mm that were placed at our clinic in 2017–2018 by the same technician. ISQ was measured at primary and secondary surgery using an Oststell IDx tooth contact analysis device (Ostell AB, Gothenburg, Sweden). Secondary surgery was carried out 6 months after placement in the maxilla and 3 months after placement in the mandible. The ISQ and change in ISQ thus obtained were investigated by placement site. ISQ at primary surgery was significantly higher in the mandible than the maxilla (p<0.001). Change in ISQ from primary to secondary surgery tended to be greater in the maxillary anterior tooth region and the maxillary molar region than the mandibular anterior tooth region and the mandibular molar region. By comparing ISQ from primary to secondary surgery using a single implant type, it was observed that ISQ and change in ISQ varied according to placement site.

Key words: Dental implant, Implant safety quotient, Implant safety quotient change

Introduction

The success rate of dental implants depends largely on osseointegration of the implant. Osseointegration has conventionally been evaluated by radiological examination or torque value at insertion time, but there are limits to the diagnosis by these methods. More recently, there has been interest in evaluation of osseointegration through measurement of the implant safety quotient (ISQ) using resonance frequency analysis (RFA), and there have been a number of reports of its clinical effectiveness. However, implant types currently in use vary greatly, and as osseointegration depends on implant type, there is no regularity in the change in degree of osseointegration during the period from immediately after implant placement until attachment of the superstructure. Here, we report observation of chronological changes in the ISQ of high-temperature acid-etched implants.

Materials and methods

A total of 43 high-temperature acid-etched implants (SPI® implant, Thommen Medical AG, Grenchen, Switzerland) with a diameter of 4.0 mm that were placed at our clinic in 2017–2018 by the same technician were studied. All implants were placed using a two-stage procedure, with the secondary surgery taking place 6 months after placement in the maxilla and 3 months after placement in the mandible. The items surveyed were number of patients, sex, age, placement site, longest diameter, and survival rate, and ISQ. All ISQ measurements were carried out by the same person using an Oststell IDx tooth contact analysis device (Ostell AB, Gothenburg, Sweden). Placement site, ISQ, and change in ISQ were statistically analyzed by the Mann–Whitney U test and Kruskal–Wallis test using JMP® 14 software (SAS Institute Inc., Cary, NC, USA).

Number of patients, sex, age, placement site, fixture diameter, longest diameter, and survival rate

The number of patients was 17 (9 men, 8 women), with a mean (+standard deviation) age of 60.8±11.6 years. The placement sites were maxillary anterior tooth region, n=5; maxillary molar region, n=12; mandibular anterior tooth region, n=4; and mandibular molar region, n=22. The longest diameter was: 6.5 mm, n=1; 8.0 mm, n=12; 9.5 mm, n=11; 11.0 mm, n=15; and 12.5 mm, n=4. There were no cases of implant loss during the observation period.

Each patient provided informed consent for all the procedures. This study was approved by the Ethics Committee of Osaka Medical College (approval no. 2311).

Results

Comparison of ISQ at primary and secondary surgery

ISQ was significantly higher at secondary surgery (72.2±6.7 [range, 55.5–80.0]) than at primary surgery (66.3±11.0 [25.0–80.0]) (p<0.01) (Fig. 1).

Comparison of ISQ in the maxilla and mandible at primary surgery

ISQ at primary surgery was significantly higher in the mandible.
Comparison of change in ISQ in the maxilla and mandible

The change in ISQ from primary surgery to secondary surgery was $10.0\pm12.6$ ($-6.0$ to $40.0$) in the maxilla and $3.3\pm7.9$ ($-11.0$ to $29.0$) in the mandible. Although the change tended to be greater in the maxilla than the mandible, the difference was not statistically significant (Fig. 3).

Comparison of change in ISQ in the anterior tooth region and molar region

The change in ISQ from primary surgery to secondary surgery was $7.3\pm10.0$ ($-4.0$ to $26.0$) in the anterior tooth region and $5.6\pm10.7$ ($-11.0$ to $40.0$) in the molar region. Although the change tended to be greater in the anterior tooth region than the molar region, the difference was not statistically significant (Fig. 4).

Comparison of change in ISQ in the maxillary anterior tooth region, maxillary molar region, mandibular anterior tooth region, and mandibular molar region

The greatest change in ISQ from primary surgery to secondary surgery was in the maxillary anterior tooth region ($13.3\pm9.7$ [$1.5$ to $26.0$]), followed by the maxillary molar region ($8.6\pm13.8$ [$-6.0$ to $40.0$]), the mandibular molar region ($3.9\pm8.4$ [$-11.0$ to $29.0$]), and the mandibular anterior tooth region ($-0.3\pm2.9$ [$-4.0$ to $2.0$]). Although the change tended to be greater in the maxillary anterior tooth region and the maxillary molar region, the differences were not significant (Fig. 5).
molar region than the mandibular anterior tooth region and the mandibular molar region, the difference was not significant (Fig. 5).

Discussion

An evaluation of differences in ISQ and change in ISQ, which were utilized as indices of osseointegration of high-temperature acid-etched implants, was carried out by placement site. ISQ was significantly higher at secondary surgery than at primary surgery, and satisfactory osseointegration was obtained in all 43 implants in the present study. This is in agreement with clinical findings.

ISQ at primary surgery was significantly higher in the mandible than the maxilla. It has been reported that ISQ is affected by the bone density of cortical bone\(^7,8\), and the fact that the mandible is formed of more compact bone than the maxilla is probably a major factor for the present result. On this basis, initial anchoring is likely to be more favorable in the mandible, which anatomically has a fine bone structure. This agrees with the recommendation of Nkenke et al. supporting a shorter load-bearing time for the mandible than for the maxilla\(^9\).

Although the difference was not significant, change in ISQ tended to be greater for the maxillary anterior tooth region and the maxillary molar region than the mandibular anterior tooth region and the mandibular molar region. Du et al. reported that the maxilla has more abundant differentiated mesenchymal cells, which have osteogenic and angiogenic capability, than bones in other regions\(^7,8\). It may therefore be conjectured that the maxilla showed greater change in ISQ because these differentiated mesenchymal cells promote bone formation in the area surrounding implants placed in the maxilla. This suggests that peri-implant osteogenic capability may be higher in the maxilla than the mandible. Another possibility is that, as reported by Tsaï et al., the maxilla has more abundant trabecular bone and therefore a more plentiful blood flow, which is necessary for bone formation, than the mandible, which has more compact bone\(^10\).

There is a wide diversity of dental implant systems, but there have been few studies that have focused on change in osseointegration in the same system and evaluated it clinically. Here, we carried out clinical observation of change in ISQ by comparing the ISQ of 43 high-temperature acid-etched implants measured at primary and secondary surgery. Measuring the ISQ of a single implant type allowed highly precise observation of osseointegration, and the factors causing site-dependent differences in osseointegration at primary and secondary surgery were discussed. We intend to conduct a more accurate analysis in the future by increasing the number of cases, while also investigating the factors that affect ISQ by adding histological evaluation of bone quality and radiological evaluation of bone density to the analysis.

In conclusion, Osseointegration of high-temperature acid-etched implants was evaluated by ISQ. It was observed that ISQ and change in ISQ following placement differed according to the placement site.

Conflict of Interest

The authors have declared that no COI exists.

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