Clinical Note

Investigation of Implant Stability Quotient Values of Dental Implants Placed in Vascularized Bone Grafts

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Abstract: Vascularized autologous bone grafts are widely used for mandibular reconstruction. There have also been numerous reports of occlusal reconstruction by placement of implants in the grafted bone following reconstruction of the mandible. However, the histological structure of the bone used for the graft is different from that of healthy mandibular bone, and the osseointegration process of implants placed in grafted bone is not clear. In this study, implants placed in reconstructions using grafted bone were assessed by measuring the implant stability quotient (ISQ), and their values were compared to those from implants in healthy mandibular bone. The subjects were 5 implants placed in the sites of mandibular reconstructions with vascularized fibula flaps. The controls were 54 implants placed in the molar region of healthy mandibles. All implant placements were carried out by a two-stage procedure, and the ISQs were measured at first-stage surgery and at second-stage surgery. The ISQ values thus obtained and the change in ISQ from first-stage surgery to second-stage surgery were examined statistically. There was no significant difference in the ISQ between the two groups at first-stage surgery, but the values of the ISQ and the change in ISQ were significantly greater in the mandibular reconstruction at second-stage surgery. This appears to be the result of histological differences between the reconstruction site and the healthy bone. The ISQ is an objective index of osseointegration of the implant. The present results suggest that observing changes in ISQ over time allows investigation of the usefulness of different types of bone grafts for implant therapy.

Key words: Dental implant, Implant stability quotient value, Vascularized autologous bone graft, Mandibular reconstruction

Introduction

Vascularized autologous bone grafts are now widely used for mandibular reconstruction[1,2]. There have also been numerous reports of occlusal reconstruction by placement of dental implants in the grafted bone following reconstruction of the mandible[3,4]. However, the histological structure of the bone used for grafts is different from that of healthy mandibular bone[3], and the osseointegration process of implants placed in grafted bone is not clear. In the present study, implants placed in mandibular reconstructions with grafted bone were assessed by measuring their implant stability quotients (ISQs), and their values were compared to those from implants in healthy mandibular bone.

Materials and Methods

5 implants (Brånemark System® TiUnite MK III, 3.75-mm-diameter, Nobel Biocare Services AG, Zurich, Switzerland) that were placed in mandibular reconstructions using vascularized fibula flaps at this clinic between 2016 and 2019 were examined. These implants were placed in 4 years after reconstruction. 2 implants were 11.5-mm-length and 3 implants were 10-mm. They were compared to 54 implants (SPI® ELEMENT, 4.0-mm-diameter, Thomen Medical AG, Grenchen, Switzerland) placed in the molar region of healthy mandibular bone, taken from the same period to ensure that the conditions were the same. 2 implants were 12.5-mm-length, 14 were 11.0-mm, 14 were 9.5-mm, 21 were 8.0-mm and 3 were 6.5-mm. All implant placements were carried out by a two-stage procedure, and the ISQ was measured using the Osstell IDx™ tooth contact analyzer (Osstell AB, Gothenburg, Switzerland) at first-stage surgery and at second-stage surgery. The ISQ values thus obtained and the changes in values were analyzed statistically using the Mann-Whitney U test and the Kruskal-Wallis test (JMP® 14 software, SAS Institute Inc., Cary, NC, USA). The present study was conducted after obtaining the approval of the Clinical Research Review Board (Ethics Committee of Osaka Medical College approval no. 2311) and after obtaining the informed consent of the patients.

Results

ISQ of implants in mandibular reconstruction

The ISQ was 71.6±3.7 at first stage-surgery and 81.8±5.8 at second-stage surgery; it was significantly higher (p<0.05) at second-stage surgery (Fig. 1).

ISQ of implants in healthy mandibular bone

The ISQ was 72.6±6.4 at first-stage surgery and 75.5±4.8 at second-stage surgery; it was significantly higher (p<0.05) at second-stage surgery (Fig. 2).
Figure 1. ISQ values of implants placed in mandibular reconstructions. The ISQ is significantly greater at second-stage surgery than at first-stage surgery (Mann-Whitney U test. * p<0.05).

Figure 2. ISQ values of implants placed in healthy mandibles. The ISQ is significantly greater at second-stage surgery than at first-stage surgery (Mann-Whitney U test. * p<0.05).

Figure 3. Comparison of ISQs at first-stage surgery. There is no significant difference in ISQs between implants placed in mandibular reconstructions and implants placed in healthy mandibles (Mann-Whitney U test).

Figure 4. Comparison of ISQs at second-stage surgery. The ISQ value is significantly greater for implants placed in mandibular reconstructions than for implants placed in healthy mandibles (Mann-Whitney U test. * p<0.05).

Figure 5. Comparison of changes in ISQs. The change in ISQ from first-stage surgery to second-stage surgery is significantly greater for implants placed in mandibular reconstruction (Mann-Whitney U test. * p<0.05).

Figure 6. Changes in ISQs in mandibular reconstructions and healthy mandibles.
**Comparison of ISQ at first-stage surgery**

The ISQ of implants placed in mandibular reconstruction was 71.6±3.7 and that of implants placed in healthy mandibular bone was 72.6±6.4, with no significant difference between them (Fig. 3).

**Comparison of ISQ at second-stage surgery**

The ISQ of implants placed in mandibular reconstruction (81.8±5.8) was significantly higher (p<0.05) than that of implants placed in healthy mandibular bone (75.5±4.8) (Fig. 4).

**Comparison of changes in ISQ**

The change in ISQ from first-stage surgery to second-stage surgery was 10.2±6.8 for implants placed in mandibular reconstruction, significantly greater (p<0.05) than the value for implants placed in healthy mandibular bone (2.9±6.9) (Figs. 5 and 6).

**Implant survival rate**

As of July 2021, none of the implants has fallen out, and the survival rate is 5/5 in mandibular reconstruction and 54/54 in healthy mandibular bone, or 100% in both cases.

**Discussion**

The ISQ and changes in the ISQ were observed to assess implants placed in bone grafts used for mandibular reconstruction, and the values were compared with those of implants placed in healthy mandibles. The ISQ is a numerical value obtained using resonance frequency analysis (RFA), with higher values indicating higher intraosseous stability of the implant. The ISQ is extremely useful in that it gives objective values from a simple, non-invasive technique, and recent reports have documented its validity as a method for clinical assessment of osseointegration.[10]

In the present study, all implants showed good osseointegration, with significantly greater ISQ at second-stage surgery than at first-stage surgery in both mandibular reconstruction and healthy mandibles. These results were consistent with the clinical findings.

At first-stage surgery, implants in healthy mandibles showed tendency that greater ISQ than mandibular reconstruction. Huang et al. reported that ISQ is affected by implant width.[10] The differences in ISQ at first-stage surgery are likely linked to implant width.

Implants in mandibular reconstruction showed a significantly greater ISQ at second-stage surgery and significantly greater change in the ISQ than implants in healthy mandibles. Fariña et al. reported that surviving grafts retained the characteristics of the donor sites, such as the Haversian system.[11] However, as reported by Takahashi et al., healthy mandibular bone has an outer layer of cortical bone with non-uniform trabecular bone resulting from the formation of trabeculae on the inner surface, and the two layers have different properties.[12] The differences in peri-implant bone formation and the differences in ISQ values and changes in the ISQ seen during the healing period in the present study are most likely linked to this difference in histological structure.

Various different vascularized autologous bone flaps are used for mandibular reconstruction, but there have been few studies looking at the ISQs of implants placed in the grafted bone. The fixation of implants to bone has conventionally been judged by methods such as the torque value, tactile sensation, and X-ray examination.[13] Use of ISQ values allows observation of osseointegration with a greater degree of precision. With vascularized autologous bone grafts, the grafted bone is transplanted into the defect site while preserving the blood circulation of the donor site[14], but the actual mechanism of engraftment is not clear. In the present study, comparison of the ISQ values and the changes in ISQ values over time between implants in mandibular reconstruction and implants in healthy mandibular bone gave an objective index of osseointegration of implants placed in grafted bone, suggesting that it may be possible to investigate the usefulness of different types of bone in bone grafts for implant therapy. We intend to carry out a more precise analysis in the future by evaluating the histological properties of grafted bone and assessing the ISQs of implants placed in grafted bone of different types with a greater number of cases.

In the present study, the ISQs of implants placed in bone grafts used for mandibular reconstruction were measured, and their values were compared with those of implants placed in healthy mandibles.

**Conflict of Interest**

The authors declare that they have no conflicts of interest with regard to the present study.

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