Study on Measurement of the Implant Stability Quotient and Choice of Restoration Time

SUN Yuan-yuan[1], XIAO Fei[2], ZHAO Bao-dong[1△], WANG Wei-ying[1], LIU Shu-jiao[1]

(1.Department of Oral and Maxillofacial Surgery, Affiliated Hospital of Qingdao University Medical College.

2.Department of Oral and Maxillofacial Surgery, Eighth People's Hospital of Qingdao City. Shandong Qingdao,266003)

ABSTRACT Objective: To investigate the osseointegration condition of ITI and Osstem-SS implants by measuring the implant stability quotient (ISQ) so as to provide guidance for proper restoration time. Method: Ninety-three patients were selected as subjects. 179 implants were implanted. According to bone quantity of edentulous area, all the subjects were divided into two groups. 62 patients with sufficient bone quantity were in group A, while 31 patients with insufficient bone quantity who needed bone-added surgery were in group B. 125 implants were implanted in group A, including 64 ITI implants and 61 Osstem-SS implants. 54 implants were implanted in group B, including 28 ITI implants and 26 Osstem-SS implants. Implant stability quotient (ISQ) was measured immediately after surgery as well as at the 4, 6, 8, 12, 16, 24 weeks after surgery. Clinical and imaging examination was taken at the same time. Results: In group A, final restoration of ITI implants was completed 8 weeks after surgery when the ISQ was 74.17± 1.85, while 12 weeks with ISQ was 72.00± 2.59 for Osstem-SS implants. In group B, 16 weeks with ISQ was 65.09± 3.42 for ITI implants and 24 weeks with ISQ was 62.09± 6.16 for Osstem-SS implants. In the following period of 3 to 24 months after restoration, no failure case was observed. Conclusion: Implant stability quotient (ISQ) can represent the osseointegration condition of implants, which will help to choose the proper restoration time.

Key words: Implant; Osseointegration; Implant stability quotient (ISQ)

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Introduction

Implant denture has been well recognized by large quantities of patients. They often have high expectations on implant denture after a long period suffering of anodontia, even hoping to use the implant denture immediately after surgery. However, the osseointegration theory is the groundwork of implantology [1-3]. When well osseointegration will be achieved after surgery, in other words, when the implant can load has always been a groping subject.

X-ray images and percussion of the implant are the main references to estimate the osseointegration condition, lacking of objective and effective criteria. Recently, the technique of resonance frequency analysis (RFA) has already been in clinical use. Based on this theory, OSSTELL mentor has been used to measure the implant stability quotient,and proved to be effective [4-6]. Since 2009, OSSTELL mentor was used to evaluate the osseointegration condition of implants, helping to determine the restoration time, which proved to be simple, objective and effective.

1 Materials and methods

1.1 Participants

93 patients with dentition defect who visited Oral Implantology Center, Affiliated Hospital of Qingdao University Medical College from February 2009 to August 2011, were enrolled in this study. They were consisted of 52 males and 41 females, aged from 21 to 60 years at a mean of (42± 9.7) years. 36 cases had single tooth loss 32 cases had two teeth loss, 21 cases had three teeth loss and 4 cases had four teeth loss. According to different bone quantity of edentulous area, all the patients were divided into two groups. 62 patients with sufficient bone quantity were in group A, while 31 patients with insufficient bone quantity who needed bone-added surgery were in group B. A total of 179 implants were implanted. Inclusive criteria: good dental hygiene; normal occlusion; no systemic diseases of heart, liver, kidney and blood; no systemic infection; good compliance and had informed consent to treatment scheme.

Table 1 Distribution of 179 implants in two groups

	ITI implants	Osstem-ss implants	Total
Group A	64	61	125
Group B	28	26	54
Total	92	87	179

1.2 Equipments and Materials

OSSTELL ISQ device (Intergration Diagnosties AB, Sweden), OSSEOCISION implant machine (Biomet 3i, America), ITI implant system (Straumann, Switzerland), Osstem-SS implant system (Osstem, Korea), Hydroxyapatite bioceramics (Tianbo, Beijing), Oral repair membrane (Heal-all, Yantai).

1.3 Surgical procedures

Author introduction: SUN Yuan-yuan(1985-), famale, master, Department of Oral and Maxillofacial Surgery, Tel:18669770980, E-mail: xinqidiansyy@163.com

△Corresponding author: ZHAO Bao-dong, E-mail: zbd315@sina.com

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All the operations were carried out in the sterile operating room of our Oral Implantology Center. Before operation, plaster model of the patient's dentition was prepared and guide plate was made, which would help to guide drilling direction during surgery. Holes were prepared step by step, and implants were placed in. For patients with insufficient bone quantity, bone condensing, bone splitting, maxillary sinus floor elevation and guided bone regeneration technique was adopted accordingly.

1.4 Main Outcome Measures

For each implant, try to measure 3 times at the labial (buccal), lingual (palatal), mesial and distal sides respectively, and then take the average. All the measurements were obtained by one doctor. (Fig.1)

For group A, Implant stability quotient (ISQ) was measured immediately after surgery as well as at the 4, 6, 8, 12 weeks after surgery. For group B with bone-added surgery, more healing time was required, so ISQ was measured immediately after surgery as well as at the 4, 6, 8, 12,16 and 24 weeks after surgery.

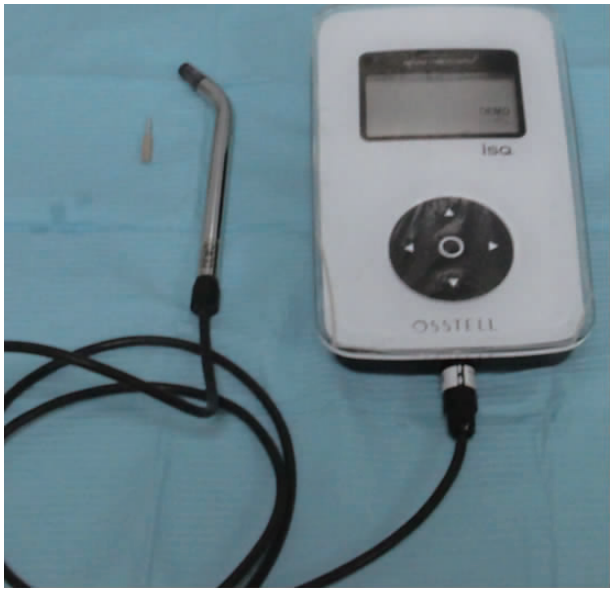

Fig.1 OSSTELL ISQ device

2 Results

2.1 Clinical observation

No patients complained about continuous uncomfortable symptoms which can not be alleviated during the whole process of this study. All the implants were loaded at a postponent time after surgery. There were no implants or prostheses loosening or shedding during the 3 to 24-months follow-up. No X-ray radiolucent area around the implants was observed. All the patients were satisfied with good mastication function.

2.2 Measurements of ISQ

Immediately after surgery, there was no significant difference between ISQs of ITI implants and those of OSSTEM-SS implants in both group A and B ($P>0.05$), while ISQs of the same implant system between group A and B were significantly different ($P=0.002$). In group A, ISQs of ITI implants were higher than those of OSSTEM-SS implants at the 4th, 6th and 8th week after surgery, with significant differences ($P<0.05$). In group B, ISQs of ITI implants were also higher than those of OSSTEM-SS implants at the 4th, 8th, 12th and 16th week after surgery, with significant differences ($P<0.05$) (Table 2, Table 3).

In group A, ISQs of the two implant systems at the 4th, 6th and 8th week after surgery were lower than those immdiately after surgery ($P<0.01$). ISQs at the 6th week were higher than those at the 4th week ($P=0.004$), and the 8th week higher than the 6th week ($P=0.002$). Restorations were finished at the 8th week after surgery for ITI implants, with ISQ (74.17± 1.85) on average, which was higher than those at the 4th and 6th week. For OSSTEM-SS implants, restorations were finished at the 12th week after surgery, with ISQ (72.00± 2.59) on average, which was higher than those at the 4th, 6th and 8th week.

In group B, ISQs of the two implant systems at the 4th, 8th, 12th and 16th week after surgery were lower than those immdiately after surgery ($P<0.01$). ISQs at the 8th week were higher than those at the 4th week ($P=0.004$), the 12th week higher than the 8th week ($P=0.002$), and the 16th week higher than the 12th week ($P=0.004$). Restorations were finished at the 16th week after surgery for ITI implants, with ISQ (65.09± 3.42) on average. For OSSTEM-SS implants, restorations were finished at the 24th week after surgery, with ISQ (62.09± 6.16) on average. All the implants were loaded competently. The survival rate was 100% during the follow-up.

3 Discussion

3.1 Significance of resonance frequency analysis (RFA) and evaluation of its effect

Resonance frequency analyzer is made up of transducer, resonance frequency analysis system, computer and special software.

Table 2 ISQs of different period after surgery in group A (ISQ, $\bar{x}\pm s$)

Implant System	Timing				
	immediately	4W	6W	8W	12W
ITI	78.73± 3.54	58.43± 1.29	69.32± 3.57	74.17± 1.85	-
Osstem-ss	77.40± 2.95	43.21± 2.56	50.36± 3.47	62.21± 4.32	72.00± 2.59

Table 3 ISQs of different period after surgery in group B (ISQ, $\bar{x}\pm s$)

ImplantSystem	Timing					
	immediately	4W	8W	12W	16W	24W
ITI	67.09± 3.42	50.23± 2.14	56.33± 3.46	62.87± 3.46	68.13± 2.26	-
Osstem-ss	63.09± 6.16	46.31± 1.23	49.63± 4.38	50.24± 3.34	58.56± 5.67	65.23± 4.32

When it working, the cantilever beam drives the implant to vibrate and resonance will occur at a certain frequency. Then the receiver will record the maximum amplitude which will be converted into voltage and transmitted to the resonance frequency analyzer. The special software of the computer will analyze the voltage and translate it into data, expressed in a form of Implant Stability Quotient (ISQ). The more stable the implant is, the higher resonance frequency will be, so the ISQ is also higher. Compared the ISQ with the normal value measured in advance, the implant stability will be evaluated [7-8]. Superstructures can be restored when the implants are perfectly stable. Traditionally, the implants can be restored 3 to 6 months after surgery. With the development of implant surface preparation technique and improvement of surgery, the restoration time changes accordingly. Therefore, it needs to judge whether the osseointegration is stable enough so as to choose the proper restoration time. According to Buser evaluation criteria of osseointegration are as follows: (a) no detectable mobility of the implants; (b) no pain or other discomfortable symptoms; (c) no peri-implantitis ; (d) no obvious bone resorption around implants in X-ray image [9] . Conventional approaches to evaluate osseointegration include subjective feelings of patients, clinical examination and X-ray image. Resonance frequency analysis can monitor the process of osseointegration, evaluating the integral structure of implant and bone tissue around it [10]. This method is handy and non-invasive, and can produce objective evidence to choose implant loading time [11].

The primary stability of implants is related to bone density of operation area, insertion torque, configuration of implants, surgical techniques and so on. The secondary stability will be achieved after 2 to 4 months, which indicated that osseointegration has completed [12]. It is the secondary stability that determines the restoration time. Nedir R et al reported that 49 was the minimum ISQ for implant loading [13]. In this study, OSSTELL RFA device was used to evaluate osseointegration condition by measuring the ISQs at regular time. Superstructures were restored when ISQ was higher than 49 with no clinical and imaging abnormalities. It turned out that all the implants were loaded successfully.

3.2 Influencing factors of implant loading time

Favorable osseointegration is the critical factor to determine the loading time of implant after surgery. Whether osseointegration can form or not depends on the relatively static interface between implant and bone [14-15]. Prof. Br?nemark summarized the requirements of osseointegration as follows: (a) good biocompatibility of implants; (b) meticulous and minimally invasive surgery; (c) no gap between implant and bone walls around it. Usually, more than 3-months healing time without any load on implant is needed [16]. There are really some cases in which restoration is done immediately after surgery or interim denture is placed on implant short time after surgery in clinic. However, this does not mean that healing time with no load is not needed any more. Only very few cases can be loaded immediately after surgery and there are strict indications. So theory about osseointegration from Prof. Br?nemark is still of great importance. ISQ measured immediately after surgery represents primary stability of implant which is essential requirement of osseointegration. Primary stability results from differential diameter between implant and hole, and represents mechanical inosculation of implant and bone tissue. In this study, there was no significant difference for ISQs two implant system between two groups immediately after surgery ($P>0.05$), which indicates that primary stability has little connection to different implant system (different surface preparation), but is closely related to bone quality and quantity of surgical area. Sevaral weeks after surgery, ISQs of ITI implants was higher than thatof OSSTEM-SS implants measured at the same time in groups. This difference is mainly caused by different surface preparation of the two systems. ITI implants have sandblasted large-grit acid-etched (SLA) surface preparation while OSSTEM-SS implants have resorbable blast media (RBM) surface. And the SLA surface is good for osteoblast to adhere, proliferate and cleavage, which results in faster osseointegration formation and shorter healing time [17,18]. ISQs measured several weeks after surgery was lower than that immediately after surgery in both two groups, and it was the lowest at the fourth week. Reasons may be that when drilling the hole, necrosis of a thin layer bone closely around implant tissue will occur, mainly including dead cells and apoptosis. In one month after surgery, this necrotic bone tissue is absorbed gradually, while new bone forms gradually. However, new bone does not form as fast as bone absorption in the beginning, which will reduce the primary stability of implant. After 4 weeks, new bone formation becomes faster, and exceeds bone absorption gradually, and osseointegration is completed at last. Thus, ISQs measured after 4 weeks shows increasing tendency [19, 20].

In conclusion, osseointegration condition of implants can be evaluated objectively and effectively by measuring implant stability, a handy and non-invasive method, which will help dentists to determine the proper restoration time. In the present study, by comparing ISQs of two implant system at different time, it can be

included that bone quantity of surgical area, healing time and implant surface preparation may be the influencing factors of restoration time.

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种植体稳定系数测定与种植体负重时机选择

孙园园[1] 肖 菲[2] 赵保东[1△] 王维英[1] 刘淑娇[1]

(1 青岛大学医学院附属医院口腔颌面外科;2 青岛市第八人民医院口腔颌面外科 山东 青岛 266003)

摘要 目的:通过测量 ITI 和 Osstem-SS 种植系统的稳定系数(ISQ),评价这两种种植体的骨结合情况,为临床确定其上部结构修复时机提供依据。**方法:**93 例牙列缺损患者共植入 179 颗种植体,根据患者种植区骨量情况分为两组,其中 A 组为种植区骨量良好,不需骨增量手术病例(62 例);B 组为种植区骨量不足,需进行骨增量手术病例(31 例)。A 组共植入 125 颗种植体,其中 ITI 种植系统 64 颗,OSSTEM-SS 种植系统 61 颗;B 组共植入 54 颗种植体,其中 ITI 种植系统 28 颗,OSSTEM-SS 种植系统 26 颗。术后即刻及第 4、6、8、12、16、24 周分别测量各时期种植体稳定系数(ISQ),并同期进行临床和影像学检查。**结果:**A 组中 ITI 种植系统术后 8 周 ISQ 值平均(74.17± 1.85),进行负重;OSSTEM-SS 种植系统术后 12 周 ISQ 值平均(72.00± 2.59),进行负重。B 组中 ITI 种植系统术后 16 周 ISQ 值平均(65.09± 3.42),进行负重;OSSTEM-SS 种植系统术后 24 周 ISQ 值平均(62.09± 6.16),进行负重。负重后临床随访 3- 24 个月所有病例均成功,咀嚼功能良好,患者满意。**结论:**种植体稳定系数(ISQ)能反应种植体骨结合情况,可以协助医生选择种植后合适的冠修复时机。

关键词:种植体;骨结合;种植体稳定系数(ISQ)

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作者简介:孙园园(1985-),女,硕士,口腔颌面外科,E-mail: xinqidiansyy@163.com

△**通讯作者:**赵保东,E-mail: zbd315@sina.com

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