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Research Article

Dynamic Correlation Between Initial Implant Stability and Implant Torque

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ABSTRACT

Objective: To apply the Resonance Frequency Analysis (RFA) method to measure the initial implant stability quotients (ISQ), and to research the dynamic relationship between the initial stability of implant placement and the insertion torque value (ITV). Provide reference for clinicians to evaluate the initial stability of different implant torque implants. Materials and methods:171 patients who underwent dental implantation at Stomatology Center of the First Affiliated Hospital of USTC(Anhui Provincial Hospital) were chosen from June 2018 to December 2019 , with an average age of (42.52±13.87) years. There were 85 males and 86 females, a total of 209 implants were implanted. During the operation, the peak torque during implant placement was recorded, and the resonant frequency analysis method was used to record the stability quotients immediately after implant placement. A total of 66 patients were reviewed regularly at 4, 8 and 12 weeks after implantation, with an age range of 41.59±12.19 years, 29 males and 37 females, with a total of 78 implants. Record the implant stability quotients at the follow-up visit. Results: ISQ and ITV have a significant correlation. ISQ in the low, medium, and high torque groups showed a continuous rise after implantation. ISQ in the low torque group increased accordingly. Conclusion: The use of Ostell to evaluate and monitor implant stability has clinical significance. Implant torque and RFA methods can be used to evaluate the initial stability quotients of implants during surgery. Both ISQ and ITV are objective indicators to evaluate the initial stability of the implants. The change trend of the implant stability quotients is related to the implant torque. Over time, implants with low torque can also achieve a higher stability coefficient.

Keywords: Resonance frequency analysis; Implant stability; Implant stability coefficient; Implant torque

Introduction

Since Meredith [1, 2] introduced the Resonance Frequency Analysis (RFA) to the clinic in 1996, this non-invasive operation method has been widely used to assess the initial stability of implants. This method has many advantages in clinical application, simple and highly repeatable, strong objectivity. It also can monitor the dynamic stability changes of implants for clinicians. The value measured by resonance frequency analysis is also called Initial Implant Stability Quotients (ISQ). This quantitative value generally ranges from 0 to 100. The larger ISQ value, the more stable the implant. The Insertion Torque Value (ITV) refers to the torque value required for the implant to be placed in the implant socket, which can be read directly on the implant display screen, and is often used to estimate the initial stability of the implant in the early stage [3]. Although this method is easy to operate clinically, it can only be recorded once when the implant is placed. ISQ and ITV are often used clinically as reference data for evaluating implant stability. However, it is not clear whether the implant torque value can truly assess the initial stability of the implant. Also the relationship between the implant torque value and the initial stability of the implant is not clear. This experiment monitors the relationship between the implant torque and the initial stability at different time points to provide a clinical basis for studying the dynamic changes of implant stability.

Materials and Methods

Objects

171 patients who underwent dental implantation at Stomatology Center of the First Affiliated Hospital of USTC were chosen from June 2018 to December 2019, with an average age of (42.52±13.87) years. There were 85 males and 86 females. A total of 209 implants. During the operation, the peak torque during implant placement was recorded, and the resonant frequency analysis method was used to record the stability quotients immediately after implant placement. Among them, 66 patients had regular follow-up visits as required. The follow-up time were 4 weeks,8 weeks and 12 weeks after surgery. Imaging and clinical examinations were performed during the follow-up visit, and the ISQ value and periodontal index of the patients were recorded. The age range of 66 patients who had regular follow-up visits after surgery was 41.59±12.19 years old, 29 were males and 37 were females, with a total of 78 implants. This research has been reviewed and approved by the Ethics Committee of the First Affiliated Hospital of the University of Science and Technology of China (Anhui Provincial Hospital) (ethics number: 2018-ky019). All patients were informed of the surgical plan and signed an informed consent form.

Inclusion criteria: ①Tooth missing for more than 3 months, no obvious bone defect in the planned implantation area; ② The bone mass is sufficient, and intraoperative operations such as bone splitting, bone squeezing and bone grafting are not required. Exclusion criteria: ①Patients with severe hypertension, diabetes, heart disease and other system diseases that cannot tolerate surgery; ②Patients with poor oral hygiene and active periodontal disease; ③Patients who are currently receiving radiation therapy for the head and neck, or who have received radiation therapy within two years. ④Patients with large-scale bone defects in the planned implantation area or intraoperative bone augmentation surgery.

Main materials and equipment:

Meiya Optoelectronics dental cone-beam CT machine (SS-X9010DPro-3D, Meiya Optoelectronics Technology Co, Hefei, China); KaVo dental implant machine (KaVo Company, Germany); Sraumann soft tissue horizontal implant, Sraumann special implant surgical instrument (Sraumann, Switzerland); Osstell resonance frequency measuring instrument (Germany).

Methods

Patients were routinely given antibiotics three days before surgery and on the day of surgery. In accordance with the Sraumann surgical operation manual, the mucoperiosteal was incised along the top or on the palatal side of the alveolar ridge in the implantation area. After opened the mucoperiosteal flap, a bone extraction ring drill with an outer diameter of 2.3*10mm was used to remove bone block embedded in a path. Then, prepared holes step by step, placed a Sraumann implant which was soft tissue level, recorded the peak torque value when the implant is placed as the implant torque. After the implant was fully seated,

connect the resonance frequency induction rod (SmartPeg) to the implant. The OSStell resonant frequency analyzer was used to measure the measuring rod in four directions of proximal, distal, buccal and lingual, with two measurements in each direction, and the average value of the eight measurements was finally obtained. After removing the resonance frequency induction rod, install the upper healing cap and suture the opened gingival flap.

The patient was recalled in accordance with the time required for the follow-up visit on the signed informed consent form. The stability quotients of the implants immediately after implantation (0 weeks postoperatively), 4 weeks postoperatively, 8 weeks postoperatively, and 12 weeks postoperatively were recorded. Periodontal tissue examination was performed around the implant, and image data were taken to monitor the bone tissue condition around the implant. Meanwhile, image data were taken to monitor the bone tissue condition around the implants. Once there was irreversible inflammation around the implant and bone resorption that affected the long-term stability of the implant, implant maintenance was performed immediately and the implant was withdrawn from this study.

Results

The initial stability of the implant

In this study, a total of 171 patients, aged 42.52±13.87 years, had 209 implants, including 85 males and 86 females. The peak torque during implant placement was recorded, and the resonant frequency analysis method was used to record the stability coefficient immediately after implant placement. The intraoperative implant torque was 14-50 N.cm, and the average value was 32.40±10.47 N.cm. The initial stability quotients immediately after surgery was 30.00-78.50, with an average value of 54.57±12.22. The correlation coefficient between the two is r=0.780, P<0.01, so ISQ is positively correlated with ITV (Figure 1).

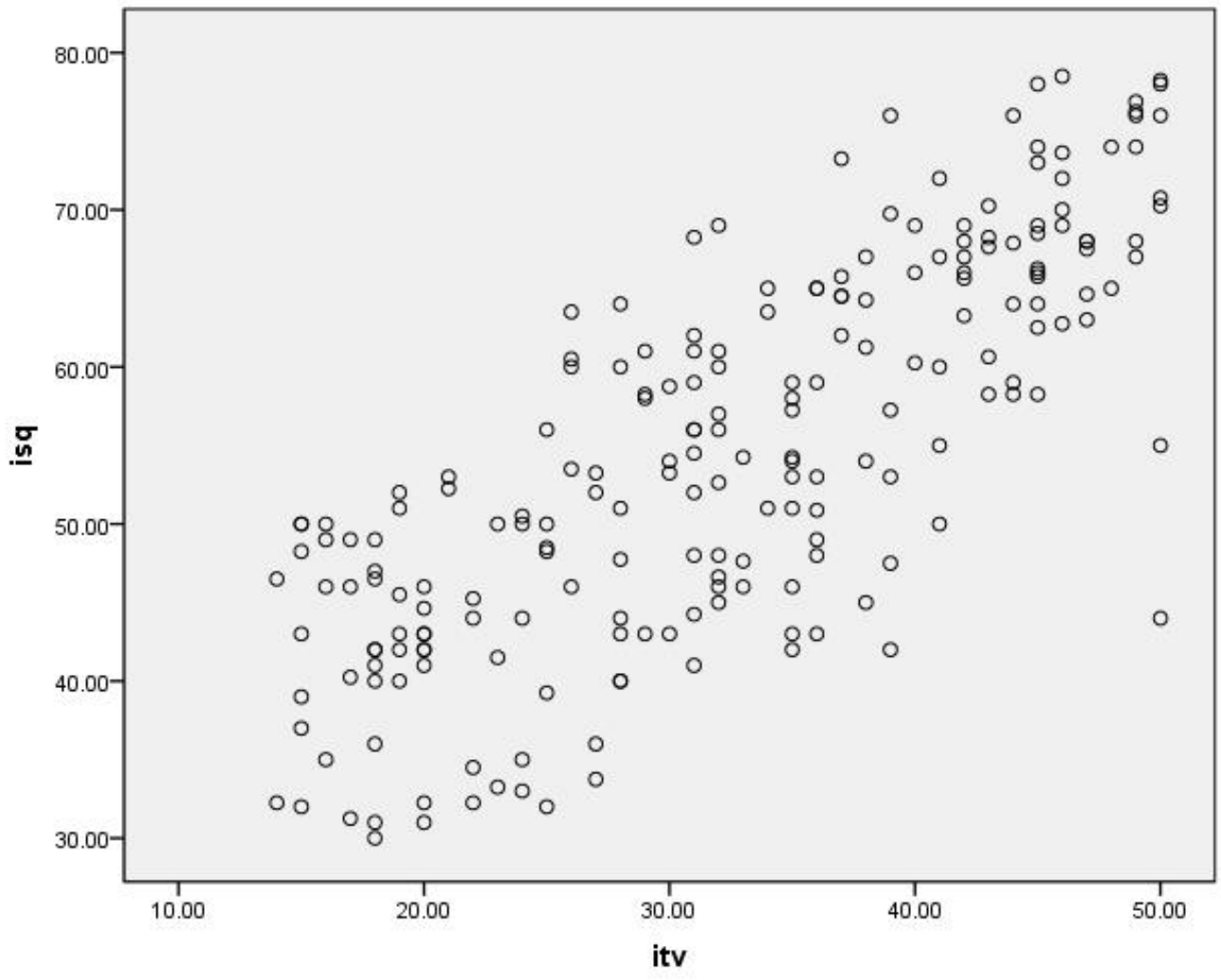

Figure 1: Distribution of initial implant stability coefficient and implant torque value

According to the research results of Ottoni, we divided the implant torque values of all implants into three groups. The implants with a torque value of less than 20N.cm are included in the low torque group, a total of 42 implants. The torque value greater than 20N.cm, and less than or equal to 32N.cm is recorded as the medium torque group, a total of 65 implants. The remaining torque value less than or equal 50N.cm, and greater than 32N.cm is recorded as the high torque group, a total of 78 implants. The results showed that the initial stability quotients of the low torque group was about 43.22±6.01, the middle torque group had a stability quotients of 48.65±8.93, and the high torque group had an immediate stability quotients of 60.30±10.55.

Implant stability monitoring

Among the 171 patients in this study, 66 patients had regular follow-up visits as required and the implant stability coefficient was fully recorded at the follow-up visit. The time of return visit was 4th weeks, 8th weeks and 12th weeks after surgery. Imaging and clinical examinations were performed at the same time, and the ISQ value and periodontal index of the patients were recorded. These 66 patients were 41.59±12.19 years old, including 29 were males and 37 were females, with a total of 78 implants.

The results showed that the ISQ value of 16 implants in the low-torque group were 43.21±6.01, 48.69±5.78, 51.39±5.85 and 53.30±6.12 at 0th, 4th, 8th and 12th weeks, respectively. The implant stability quotients has a continuous upward trend. Paired-sample t-test analysis compared the 0th week, 4th week, 8th week and 12th week implant stability quotients, $P<0.05$, the difference was statistically significant.

In the medium torque group, the ISQ value of 35 implants at 0th week, 4th week, 8th week and 12th week were 48.65±8.93, 50.74±8.00, 53.52±7.93 and 55.22±8.42, respectively. Except for one case of maxillary anterior implants, the stability quotients decreased slightly in the 4th week, and the stability coefficient gradually increased during the follow-up visit. Overall, the implant stability coefficient is showing a continuous upward trend. The increase rate gradually decreases, and the increase rate is slightly lower in the corresponding time section of the torque group with a lower increase rate. Paired-sample t-test analysis compared the 0th week, 4th week, 8th week and 12th week implant stability quotients, $P<0.05$, the difference was statistically significant.

There were 27 implants in the high torque group, and the stability c quotients of implants at the 0th week, 4th week, 8th week and 12 week were 60.30±10.55, 58.79±8.12, 60.21±8.11 and 61.62±7.64, respectively. A comprehensive analysis of the data found that most implants in the high torque group showed a transient stability quotients reduction phenomenon in the 4th week, and gradually increased in the 8th and 12th week, and the increase rate gradually decreased. Paired-sample t-test analysis compared the 0th week, 4th week, 8th week and 12th week implant stability quotients, $P<0.05$, the difference was statistically significant (Table 1).

Group	0th week	4th week	8th week	12th week
Low Torque Group	43.22±6.01	43.69±6.78	51.39±5.85	53.30±6.12
Medium Torque Group	48.65±8.93	50.74±8.00	53.52±7.93	55.52±8.42
High Torque Group	60.30±10.55	58.79±8.12	60.21±8.11	61.62±7.64

Table 1: Comparison of implant stability coefficients in different periods

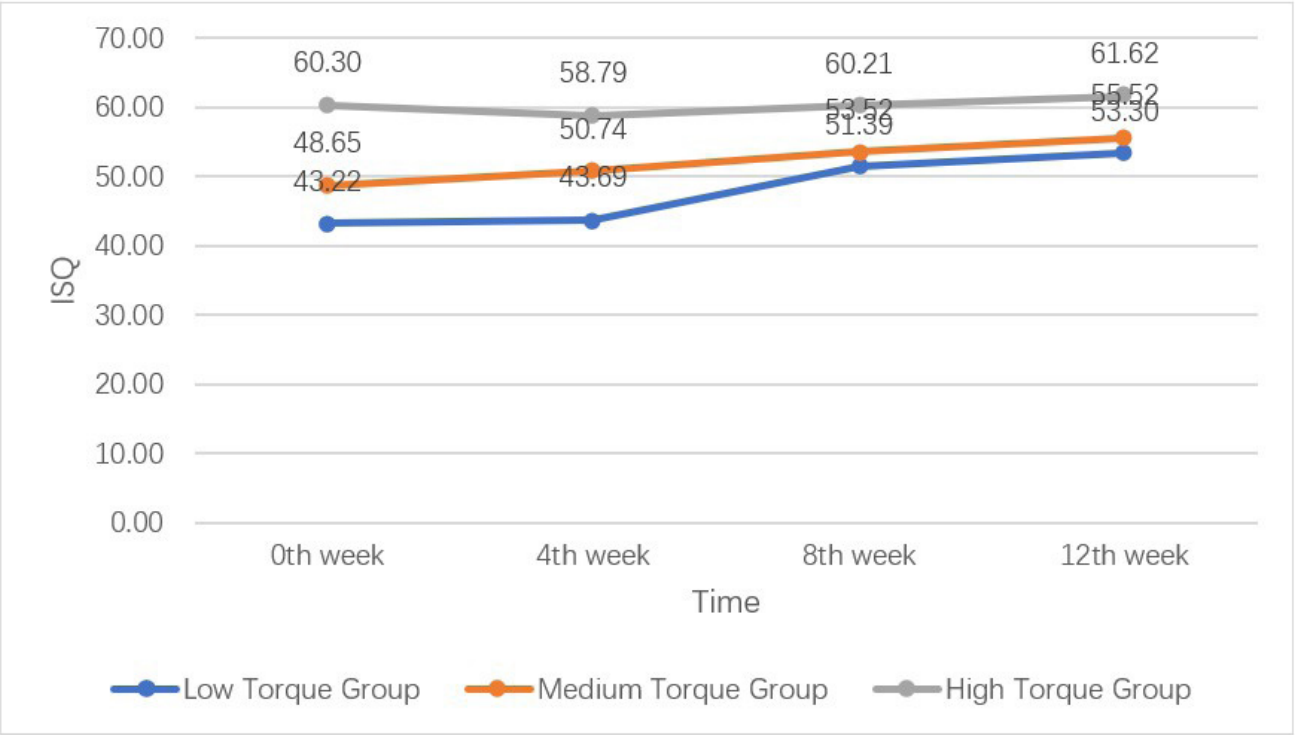

Figure 2: Implant stability quotients changes with time in different implant torque groups

Discussion

Initial stability coefficient

How to accurately and non-invasively judge implant stability and osseointegration is an important way to estimate the success rate of implants. In the early stage, clinicians often use the sound of tapping the implant to roughly judge the degree of osseointegration of the implant. Imaging detection is a relatively conventional method, which can judge the osseointegration of the implant by observing the height of the edge bone around the implant and whether there is a shadow after bone resorption around the implant. These methods mainly rely on the doctor's experience, are highly subjective without precise quantitative indicators to compare and record. In laboratory research, scholars often use bone tissue slices for histomorphological characteristics determination, which is more accurate and intuitive [4]. Some scholars have used the implant torque and the unscrewing torque for comparative research to detect the dynamic changes of the osseointegration interface [5]. However, the above-mentioned bone tissue morphology research and screw-out torque detection are both destructive and cannot be applied to clinical applications. Since Meredith introduced Resonance Frequency Analysis (RFA) to the clinic in 1996, the Osstell instrument developed with the background of resonance frequency analysis technology had been widely used [1].

The Osstell instrument mainly receives the bending resonance frequency of the implant released by the connecting rod and summarizes it in the computer software. The resonance frequency is expressed as a value between 1-100. The higher the ISQ value, the higher the stability of the implant. Andersson et al. conducted a 5-year retrospective study on 745 implants of 328 patients and found the lower the ISQ value, the higher the implant failure rate [6]. Research results show that the ISQ value of implants is affected by many factors, which are related to the degree of osteoporosis in the intended implantation area, the length and type of implants, and the implant placement method [7, 8]. Kim et al. used a simplified cavity preparation method to implant a 5.2mm diameter implant, and compared with the traditional step-by-step cavity preparation method, they found that the implantation method will also affect the ISQ value after implant placement. [9]. However, there are also many studies on the contrary, that ISQ has no correlation with the bone quality of the intended implantation area [10]. Veltri et al. found that the ISQ value will be affected when the probe and the connecting rod are at different angles, which may be related to the thickness of the bone wall around the implant [11]. Therefore, in this study, in order to reduce the influence of the sensor probe's orientation on the results of bending resonance frequency analysis, the Osstell resonance frequency analyzer was used to measure 3 times in different directions, and the average value was recorded. The results were more accurate, objective and accurate.

Implant torque

The implant torque refers to the torque to be applied when the implant is put into the prepared cavity and reaches the predetermined position. This is mainly related to the density of the bone and the mechanical cutting ability of the implant thread. Under the same surgical operation for the same type of implant, the implant torque value is directly related to the bone quality of the surgical area. Previous studies believed that increasing the implant torque can speed up osseointegration and improve the success rate of implant restoration. Ottoni's research found that the success rate of implants is related to the length of the implant, the position of the implant, the bone quality and bone mass of the operation area, etc. The torque value is also an important reference index for the success rate of the implant. When the torque value is greater than 32N. Cm, the implant will have good stability [12]. Giudice's 2-year follow-up study on 322 implants confirmed that although there is no statistical difference between long-term stability, the amount of bone absorption around the implant is lower when the torque value is greater than 32N.cm [13]. Barone divides the implants into a high torque group (between 50N.cm and 100N.cm) and a regular torque group (≤50 N.cm) according to the torque value. The study found more bone reconstruction and regeneration around implants with higher torque value [14]. Galli also confirmed through animal experiments that there is a higher osseointegration rate around implants which with high torque [15]. However, there are also animal experiments that are contrary to the above results. After Cha implanted the implant into the femur of the rat, the study found that higher implant torque would increase the stress and deformation of the bone-implant interface and destroy the osseointegration [16]. These different research results may be related to the difference in bone quality of different animals.

Therefore, this paper divides the torque values of 20N.cm and 32N.cm into three groups according to the results of the above-mentioned researchers. All implants with a torque value of less than 20N.cm are included in the low torque group, a total of 16 implants; and torque The value between >20 and ≤32N.cm is recorded as the middle torque group, with 35 implants; the remaining torque value is ≤50N.cm, and 32N.cm is recorded as the high torque group, with a total of 27 implants.

Implant torque and initial stability quotients

At present, scholars have different research results on the correlation between the implant torque and the initial stability quotients. Diaz-Castro implanted 120 implants into bovine ribs and bovine femurs, and found that torque has a strong correlation with ISQ value, and the correlation coefficient changes with the degree of bone density in the implant area [17]. Wada used porcine iliac bone as the research object and confirmed that the thickness of cortical bone affects the correlation coefficient between ISQ and ITV [18].

In this study, the peak torque of 209 implants was 14-50N.cm, with an average of 32.40±10.47 N.cm, and the immediate postoperative initial stability coefficient was 30.00-78.50, with an average of 56.60±10.88. The correlation coefficient between the two is $r=0.786$, $P<0.01$, and the results confirm that ISQ is positively correlated with ITV. All implants were divided into three groups: high, medium and low according to different torque values. Using resonance frequency analysis method, it was found that the low torque group had a lower initial stability coefficient than the medium and high torque group. However, subsequent follow-up studies confirmed that the low torque group also achieved good stability coefficients during the healing process, and the stability coefficients of the three groups showed an increasing trend. The increase rate of implant stability coefficient in the low torque group was higher than that in the medium torque group and the high torque group in the corresponding time period, and the increase rate of the implant stability coefficient in the high torque group gradually decreased. In the middle torsion group, except for one case of the maxillary anterior implant, the stability coefficient decreased slightly in the 4th week, and the stability coefficient gradually increased during the follow-up visit. Although the high-torque implants showed relatively high stability coefficients in subsequent follow-up visits, the transient stability coefficients decreased in 4 weeks, and gradually increased in the next 8 and 12 weeks, and at the 8th and postoperative weeks There was no statistical difference in the stability coefficient. Comparative studies have found that the implants in the high torque group are mostly concentrated in the posterior mandibular area, where the cortical bone of the mandible is thicker and the bone is denser, which is similar to the results of the above-mentioned scholars [17, 18].

Conclusion

The use of Ostell to evaluate and monitor implant stability has clinical significance. The change trend of implant stability is related to the implant torque, but the later stability of the implant cannot be predicted based on the implant torque alone. The low torque group also achieved a good stability coefficient during the implant healing process.

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