

Relation between the Initial Stability of Dental Implant and the Host Bone quality

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Abstract—The purpose of this study was to determine the correlation between the initial stability of the dental implant, which represented by maximum insertion torque value (ITV), and the host bone density, which represented by grayscale value measured by dental cone-beam computed tomography (CBCT). Twenty one lumbar vertebrae were collected from seven healthy bovine. Each bone specimen was subjected to CBCT to obtain the bone density (in grayscale value). The dental implants were inserted into the bone specimen and recorded the maximum ITV. Pearson's correlation coefficient (r) was used to evaluate whether there was a statistically significant correlation between the ITV and bone density. The experimental results indicated that the initial stability of the dental implant, quantified as the ITV, was strongly positively correlated ($r=0.968$) with the bone density in grayscale, as measured from dental CBCT.

Keywords— Dental implant, initial stability, insertion torque, bone quality, dental cone-beam computed tomography

I. INTRODUCTION

Implant stability is an important factor for the successful rate of the dental implant [1-3]. Basically, the implant stability can be divided into two stages: initial stability and secondary stability [4]. The initial stability is a function of the mechanical stability immediately after inserting the dental implant into the host bone, while the secondary stability is formed by osseointegration, which is the bone ingrowth into the surface of the dental implant. Basically, a higher implant initial stability can result in more bone ingrowth. However, so far, there is still no method for directly measuring relative movement at the interface between the host bone and dental implant. Among the commonly approaches, the maximum insertion torque value (ITV) has often been used to quantify the initial stability of the implant [5-6]. A high ITV may indicate a mechanically stable implant. Many researchers indicated that the initial stability might be affected by the host alveolar bone quality or quantity. Lekholm and Zarb [7] classified jawbone into four types based on the amounts of cortical bone versus trabecular bone. However, this approach was subject to interexaminer inconsistencies. Recently, the dental cone-beam computed tomography (CBCT) was extensively used in the clinical trial. Some investigators used grayscale value or

Hounsfield units to represent the bone density, which so called radiographic bone density. The objects of this study was to evaluate the relationship between the initial stability of dental implant, which represented by ITV, and the host bone density, which represented by bone density in grayscale value.

II. MATERIALS AND METHODS

A. Specimen preparation and CBCT scanning

Twenty one lumbar vertebrae were collected from seven healthy bovine. Bone specimens, which obtained from each lumbar vertebra, with dimensions of $15 \times 30 \times 30 \text{ mm}^3$ were prepared. A dental CBCT device (AZ 3000, Asahi Roentgen, Japan) was used to obtain dental CT images of each bone specimen (Figure. 1). The CBCT images were imported into medical imaging software (Mimics 15.1, Materialise, Leuven, Belgium) that enabled the construction of a three-dimensional model of each bone block. The cylinders (4 mm in diameter and 10 mm long) were defined in the implant site of each bone specimen. The grayscale value to represent the bone density of the cylinder of the bone specimen was used in this study.



Figure 1. (Left) Dental CBCT machine; (Right) bone specimen obtained from bovine lumbar vertebra.

B. Insertion torque measurement

Pilot holes were drilled into each artificial foam bone specimen using a 3.5 mm diameter drill, and a commercial

dental implant (4 mm in diameter and 10 mm long; 3i Implant Innovations Inc, West Palm Beach, FL, USA) was inserted according to the manufacturer's instructions. The ITV (N \times cm) was recorded for each bone specimen using a torque meter (TQ-8800, Lutron Electronic Enterprise, Taipei, Taiwan) (Figure 2).



Figure 2. Experimental setup for measuring the ITV: (Left)entire view; (Right)closed view.

C. Statistical analysis

The values of the bone density of the bone specimen and maximum ITV of the implants were summarized as mean \pm SD values. Pearson's correlation coefficient (r) was used to evaluate whether there was a statistically significant correlation between the ITV and bone density. The significance cutoff level was deemed to be $P < 0.05$. All statistical analyses of the data were performed using OriginPro (OriginLab, Northampton, MA, USA). The level of the statistical significance was set as $p < 0.05$.

III. RESULTS AND DISCUSSION

The bone densities in grayscale value of the bone specimen obtained from the bovine lumbar vertebrae are 947.5 ± 172.3 , range from 756.0 to 1312.0. The maximum ITV of dental implant are 26.6 ± 17.7 , range from 8.2 to 64.1. There was strong positive correlation between the ITV and bone density ($r = 0.968$, $P < 0.0001$) (Figure 3.)

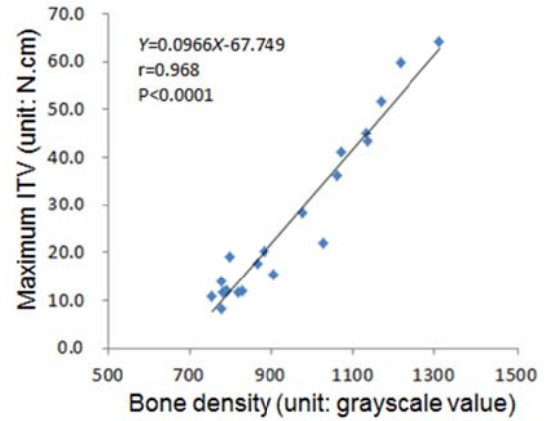


Figure 3. Scattergraph illustrating the correlation between ITV and bone density.

The initial stability of a dental implant crucially affects its long-term performance. Determining the ITV of an implant represents a nondestructive clinical approach for measuring the implant stability. Nomura et al. [8] recently contended that the dental CBCT may be possible to determine the bone mineral content. In addition, the CBCT has been demonstrated to be a good approach for evaluating the alveolar bone quality and quantity prior to implant surgery [8]. Therefore, in this study, we evaluated the bone density by using the dental CBCT. Some limitations of this study should be considered. First, the bovine bone specimen did not fully represent the real human jawbone. Second, the effect of cortical bone thickness on the initial stability was not evaluated. Third, in this study, the initial stability of implants was only evaluated by ITV. Other methods for measuring the initial stability of the dental implant, such as the resonance frequency and Periotest should be applied in the future.

IV. CONCLUSIONS

The experimental results obtained in this study indicated that the initial implant stability, quantified as the ITV, was strongly positively correlated ($r = 0.968$, $P < 0.0001$) with the bone density in grayscale, as measured from dental CBCT.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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