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COMPARATIVE RESONANCE FREQUENCY ANALYSIS OF THE PRIMARY STABILITY AT DIFFERENT DENTAL IMPLANT DESIGNS

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Primary implant stability appears to be a prerequisite for successful osseointegration of dental implants. Different factors may contribute to initial implant stability, and these include implant design, surgical technique and bone quality.

The aim of this study was to determine the effect of different macro design on primary stability, and the evaluation of primary stability relative to the percentage contact surface of the implant and bone.

The research was conducted *in vitro*, with pig ribs as analogue of human bone (cortical thickness 2 mm, non-self taping implants Nobel Biocare Replace 3.5x10 mm and self-tapping implants Bredent 3.5x10 mm. The primary stability was measured with Osstell mentor instrument and Student's t-test was used for statistical data processing.

The average value of primary stability after three measurements with 5mm contact of bone and non-self tapping for Nobel Biocare is 30 ISQ. In self-tapping Bredent implants, the ISQ values were 42 ISQ. When the contact with the bone was on 10 mm, the following average values of primary stability were recorded: Nobel Biocare 70 ISQ, and Bredent 72 ISQ. Chi-square test ($p < 0.05$) showed that there is a statistically significant difference in the values of primary stability in implants with different designs.

Implant design plays an important role in achieving adequate primary stability. In this study, there were statistically significant higher values of primary stability recorded in self-tapping compared to non-self-tapping implants at the 5mm depth, thus recommending it for immediate placement.

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Key words: *primary stability, resonance frequency analysis, implants*

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Introduction

Osseointegration is a prerequisite for achieving success in implant therapy, while the primary stability of the implant is marked as a precondition for achieving osseointegration (1). Also, some authors state that the primary stability can be used to evaluate and predict the osseointegration success (2, 3). Numerous factors affect the primary stability of the implant, but the following three are the most important: implant design, surgical implantation technique, and the quality and quantity of bone (4). Macro design of implants plays an essential role in achieving adequate primary stability (5). Macro design entails the implant shape and thread design, as well as the depth, width, density, angle and shape of the thread. The difference between macro-design of self-tapping and non-self-tapping implants is particularly noteworthy. Some studies show that in lower bone density, type 3 and type 4 of bone types, according to the classification of Lekholma and Zarb (6), use of an example of self-tapping implants in combination with different preparation of site preparation can achieve better primary stability compared to standard surgical technique with non-taping implants (7). Under certain conditions, implants placed by immediate method can be regarded as an attractive substitute compared to classic single-phase or two-phase delayed application techniques (8), and achieving adequate primary stability is stated as a basic parameter for evaluation of success (9).

Aim

The aim of the study was to compare resonance frequency analysis differences in the primary stability of different implant designs with type 3 and type 4 bone, as well as to assess the difference in primary stability in comparison to the percentage contact between the implant and bone.

Materials and methods

Bone

The research was conducted under in vitro conditions, pig ribs with equal cortical thickness of 2 mm (10, 11) were used as a skeletal model of the human upper jaw (bone density types 3 and 4 according to the classification of Lekholma and Zarb).

All samples were obtained from experimental animals - males (due to higher bone density analogue to human density), six month old and weighing 120 kg. The samples were taken from a local slaughterhouse. In order to preserve and cause minimal changes in the physical properties of bones, samples were prepared according to the protocol published by Sedliņe and Hirsch, which means that bone was kept moist, whilst being kept in the saline solution frozen at -10°C, and it was used in the period of 3 to 4 weeks (12, 13).

Twenty samples were used for the purpose of this study.

Implants

In this research, we used 10 cylindrical non-self-tapping Nobel Biocare Replace implants with dimensions 3.5x10 mm, and 10 self-tapping implants Bredent diameter 3.5x10 mm.

Measurement of primary stability

Primary implant stability is measured by resonance frequency Osstell mentor instrument.

The method of resonant frequency analysis (RFA - Resonance Frequency Analysis) represents a non-invasive diagnostic method that enables the measurement of clinical implant stability and monitoring biological response of tissues, as well as osseointegration in the function of time. The method that analyses the resonance frequency uses sophisticated technology with computer-based measurement of the resonant frequency, which is determined by two parameters: the degree of bone density at the intermediate implant – bone, and the level of marginal alveolar bone around the transducer (14).

The measured amplitude of the resonance frequency is displayed numerically and graphically on the analyser, and its maximum value represents the stability of the implant quantified through ISQ units (implant stability quotient units) which is the stability coefficient of the implant. The resulting value in the ISQ units reflects the rigidity of the system transducer - implant - bone and calibration parameters of the transducer. Its measures scale from 0 ISQ (3500 Hz) to 100 ISQ units (8500 Hz), where the higher value of ISQ indicates stronger implant stability. The method is non-invasive and comfortable for patients since it does not cause painful sensations and takes 1 to 2 seconds (13, 14).

Osstell is representative of the RFA technique, which was first tested in 1997. Instruments include an Osstell transducer and Osstell analyzer connected to a PC, or standalone. The transducer is either S-shaped or L shaped screw (SmartPeg) and screwing firmly positioned on the implant or its superstructure (a force from 4 to 5 N/cm^2), and it is composed of two piezo ceramic transducers. High energy pulse like sinusoidal pulse oscillation continuously excites the implant to record the mechanical vibrations of the intermediate zone of the implant and bone (13, 14).

The research was conducted in two phases

Phase I

The first phase included the preparation of implants sites in bone with standard surgical technique using the drill as recommended by the manufacturer's protocol. After that, the implants are embodied in the bones at the 5mm depth, which provides conditional percentage contact of implants and bone of 50% (Figure 1). All implants are set to prepared bearing mechanic by using the force of 35 N/cm^2 fixed on phisiodispenser Bien Air Chiropo 980.

SmartPegs are placed on the implants and, according to the recommendation from the manufacturer, primary stability is measured from four different directions with the help of an Osstel mentor instruments, with mean value being the reference value. (Figure 2)

In this way, we simulated immediate placing of implants in cases when surface of implants has no full contact with bone wall side of post-extraction alveoli.

Phase II

The second phase of the study included the preparation of the implant site and their placing at its full length of 10 mm, which provides conditional contact between the implant and the bone of 100%.

SmartPeg is placed on the implants and according to the recommendation from the manufacturer, primary stability is measured from four different directions with the help of an Osstel mentor instruments, with mean value as the reference value. (Figure 2)

SmartPegs are placed on the implants and primary stability is measured from four different directions with the help of an Osstell mentor instruments, with mean value as the reference value.

Statistical analysis

The Student's t-test was used for statistical data analysis and comparative analysis of the average value of the primary stability between self-tapping and non self-tapping implants.

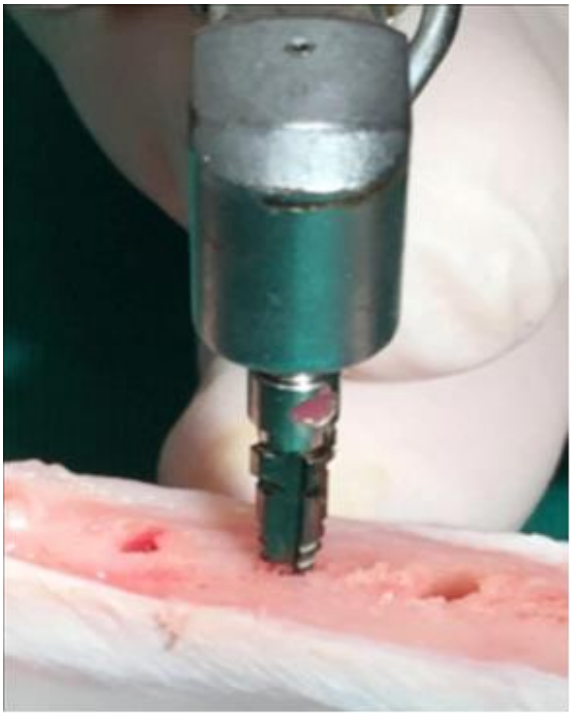


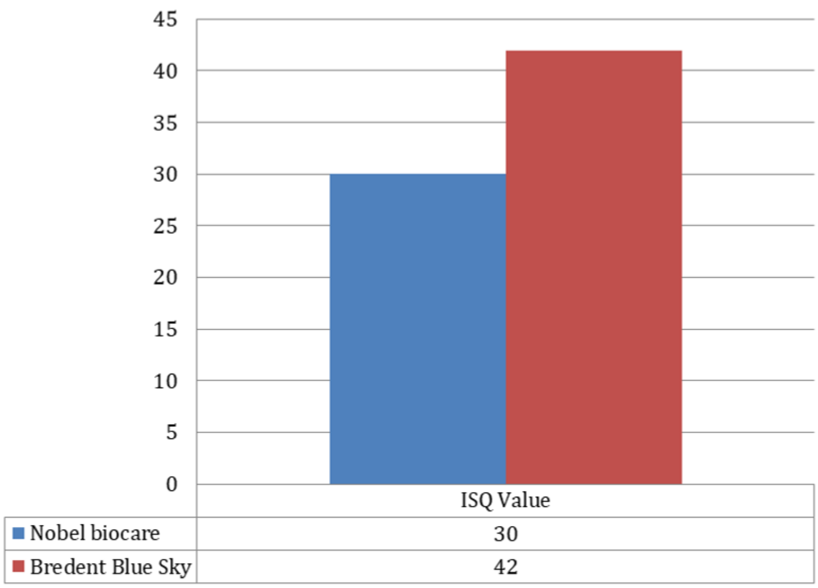
Figure 1.

Figure 2.

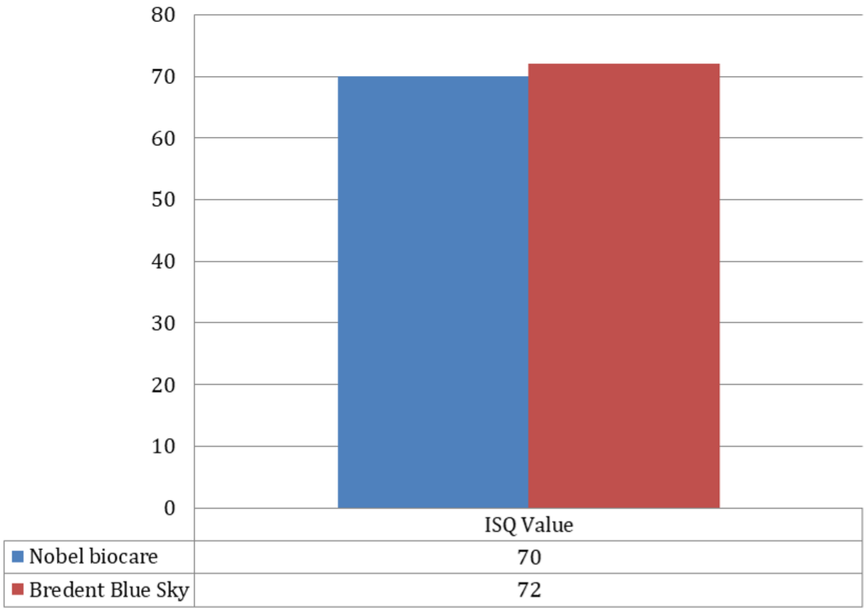
Results

In the first phase of the study, the average value of primary stability in non-self-tapping implants was 30 ISQ (Graph 1). On the other hand, the average value obtained in the self-tapping implants varied significantly compared to non-self-tapping implants, and its value was 42 ISQ. Comparative analysis by Student's t-test showed a statistically significant difference in stability between primary stability between self-tapping and non-self-tapping implants.

In the second phase of the study, approximately the same values have been recorded: i.e. 70 ISQ, on average. The comparative analysis made by Student's t-test showed that there was no statistically significant difference in primary stability between different implantation systems and macro design of implants (Graph 2).



Graph 1. Values of primary stability at a depth of 5 mm



Graph 2. Values of primary stability at a depth of 10 mm

Discussion

Numerous studies have shown that the design of the implant plays an important role in achieving good primary stability. Also, the primary stability depends on the quantity and quality of available bone tissue, depending on the localization and individual dispositions (11, 13, 15, 16). Studies on human cadavers showed that the value of the primary stability of 12 mm length implant into the region of the extracted lower premolars and immediate implants amounted to an average of 69 ISQ (ranging between 64 and 73) (15).

However, a particular problem was to achieve adequate primary stability in the region of the upper lateral sector where is the bone type 3 and type 4 according to the classification of Leksholma and Zarb, bone dominated by spongiosa with a thin cortical layer of compact (11). The researches show that better primary stability can be achieved with the use of self-tapping implants in combination with lateral and apical bone condensation in low bone quality cases (6). In our study, the values of primary stability do not significantly differ compared to macro design of implants when the percentage contact of the implant and the bone was 100%, and when implants were built to their full 10 mm length using standard surgical installation techniques.

Regarding the immediate implant placement, the problem is to achieve adequate primary stability due to the difference in the shape of implants and alveolus of the extracted tooth during, where it is impossible to achieve full contact between the implant and the bone. In self-tapping implants, there are vertical cuts in the apical third that enable the implant without taps. Also, bone splinters, occurring during twisting, were used for greater implant-bone contact (8, 9).

In our study, due to percentage contact between the bone and the implant of 50%, when the implants were built to a 5 mm depth, the obtained values of primary stability are statistically significantly different in self-tapping compared to non self-tapping implants.

Conclusion

Macro design plays an important role in achieving adequate primary stability. This study recorded statistically significant higher values of primary stability in self-tapping compared to non-self-tapping implants in the contact between the implant with the bone of 50% in percentage terms, which in turn recommends this macro design during instalment of immediate implants when the contact of the implant with bone tissue is not complete.

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KOMPARATIVNA REZONANTNO - FREKVENTNA ANALIZA PRIMARNE STABILNOSTI KOD RAZLIČITOG DIZAJNA IMPLANTATA

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Primarna stabilnost implantata označena je kao preduslov i jedan od faktora procjene postizanja uspješne oseointegracije. Više faktora utiče na primarnu stabilnost od kojih su tri najznačajnija: dizajn implantata, hirurška tehnika ugradnje i kvalitet koštanog tkiva.

Cilj ovog rada bio je odrediti uticaj različitog makrodizajna na primarnu stabilnost implantata, kao i procjenu primarne stabilnosti u odnosu na procentualni kontakt površine implantata i kosti.

Studija je sprovedena u *in vitro* uslovima, a kao analog humane kosti u istraživanju su korišćena svinjska rebra kortikalnog sloja debljine 2 mm, cilindrični neurezujući implantati marke Nobel Biocare Replace 3,5x10 mm i samourezujući implantati marke Bredent dimenzija 3,5x10 mm. Primarna stabilnost implantata mjerena je metodom rezonantne frekvencije Osstell mentor aparatom, a za statističku obradu podataka primijenjen je Studentov t-test.

Prosječne vrijednosti primarne stabilnosti nakon tri mjerenja na dubini od 5 mm kod neurezujućih Nobel Biocare iznosila je 30 ISQ. Kod samourezujućih Bredent implantata vrednosti su bile 42 ISQ. Na dubini od 10mm izmjerene su sledeće prosječne vrijednosti primarne stabilnosti: Nobel Biocare 70 ISQ i Bredent 72 ISQ. Studentovim t-testom ($p < 0,05$) utvrđeno je da postoji međusobno statistički značajna razlika u vrijednostima primarne stabilnosti kod različitog dizajna implantata.

Dizajn implantata igra bitnu ulogu u postizanju adekvatne primarne stabilnosti. U ovoj studiji izmjerene su statistički značajne više vrijednosti primarne stabilnosti kod samourezujućih u odnosu na neurezujuće implantate na dubini od 5 mm, što ih preporučuje kod imedijantne ugradnje.

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Ključne reči: *primarna stabilnost, rezonantna frekvencija, implantati*