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Resonance Frequency Analysis of Dental Implants Placed Into the Sinus Lifts: at Stage1 and Stage 2 Surgery

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Summary

Measurement of primary stability of dental implants using resonance frequency analysis is found to be a reliable and evidence based method. It is believed that a higher value indicates a better stability and so a better prognosis for the implant. This kind of relation can also be expected from implants inserted in sinus lifts. This study proves that the values with a lower amplitude by time reach a higher value and those with higher initial resonance frequency value tend to decrease to somewhat lower values. That is, the secondary stability of the implant does not depend completely on primary stability value.
Key words: sinus lift - resonance frequency analysis - ISQ values - implant stability

**Somanathan R. V., Šimůnek A., Bukač J., Brázda T., Kopecká D.:
Rezonanční frekvenční analýza dentálních implantátů zavedených do sinus liftu: I. a II. chirurgická fáze**

Souhrn: Měření primární stability dentálních implantátů rezonanční frekvenční analýzou je spolehlivá a vědecky ověřená metoda. Zdá se, že vyšší hodnoty ukazují na lepší stabilitu, a tím i lepší prognózu implantátu. Toto pravidlo by mohlo platit i u implantátů v sinus liftu. Předkládaná studie dokazuje, že pokud má implantát v sinus liftu primárně nižší hodnoty ISQ, během vhojování implantátu se tyto hodnoty zvyšují. Naopak primární stabilita implantátů s vysokými počátečními hodnotami ISQ se během vhojování oslabuje. Z toho vyplývá, že sekundární stabilita implantátu přímo nezávisí na primární stabilitě.
Klíčová slova: sinus lift - rezonanční frekvenční analýza - hodnoty ISQ - stabilita implantátu

Čes. Stomat., roč. 106, 2006, č. 4, s. 111–114.

INTRODUCTION

Replacement of teeth by dental implants is a proven treatment modality. Success of the implant in the jaw can be determined by assessing the extend of osseointegration achieved by the fixture. Johannson and Albrektsson (1987) introduced the removal torque test to describe the stability and fixation of threaded implants [8]. But this destructive test fails to achieve clinical implication. Donath and Breuner in 1982 described a technique to estimate the osseointegration using histomorphometric analysis of undecalcified sections of intact bone implant interface [8]. This is a more accurate test but can be used only for experiments. Periotest device was regarded not accurate, reproducible and less sensitive. Later in 1997, Meredith developed resonance frequency analysis (RFA) [6]. It is a non-invasive, evidence based, reliable method to evaluate implant stability and osseointegration [1, 2, 6, 11]. RFA measures stability by applying a microscopic bending load through an L-shaped transducer attached to fixture or prosthetic abutment with a retaining screw. The piezoelectric crystal generates a transducer beam and the resistance to vibration of the transducer to the surrounding bone can be detected using a frequency response analyzer. The response measured is the resonance frequency (RF). It depends on two parameters; the degree of stiffness of the system including transducer components and implant components and the level of bone surrounding the transducer. Because the stiffness of

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implant components and transducer are constant, it is the stiffness of implant bone interface which is measured [8]. The original measurements are made in hertz (Hz), but for universality of the measurements each hertz values are calibrated against each transducer and are converted to implant stability quotient (ISQ).

The purpose of this prospective pilot study is to assess the ISQ of implants placed into the sinus lift after nine months of healing of the sinus lift and then after six months after implantation, at the second stage surgery. The statistical dependence between the two values was the major concern.

METHODS

Twelve patients (7 males and 5 females of ages 42 to 67, mean age 54.7) who received two stage sinus lift surgery were involved in the study. All those who were enrolled smoked less than 15 cigarettes per day, had no debilitating diseases and had a minimum of 3 mm of bone below the maxillary sinus. All patients were examined for bone height by panoramic X-ray and in case of suspected compromise in the quantity of bone, a reformatted computer tomogram was used to finalize the decision.

Six out of the twelve sinus lifts were done with a composite graft. It a mixture of autogenous bone from the maxillary tuber with β-tricalciumphosphate (Cerasorb®, Curasan AG GmbH, Kleinostheim, Germany) in the ratio 1:8-1:5, respectively. The rest of the sinus lifts were done only with β-tricalciumphosphate . The lift was allowed to heal for nine months and then hydroxyapatite coated, Impladent® implants (Lasak, Prague, Czech Republic) were inserted using a manual torque wrench. The first ISQ reading (ISQ1) was taken (Osstell™ device, Integration Diagnostics AB, Sävedalen, Sweden). The flap was repositioned and sutured over the implants as a two stage surgery. After six months of healing, during the second stage surgery, the second ISQ was measured (ISQ2). For each measurement the transducer was placed perpendicular to the long axis of the alveolar process and secured with a tight screw to 10-15 Nm torque as per manufacturer instructions. Based on ISQ values implants were divided into 3 groups. Group A included those with ISQ falling in the range 71-77, Group B between 64 and 70 and Group C those between 59 and 63. All procedures were done under local anesthesia, on outpatient basis and sterile conditions. Patients were given details of the surgical procedure and the study and were made to sign surgical release forms. All treatments were done in compliance with Helsinki Declaration 1994.

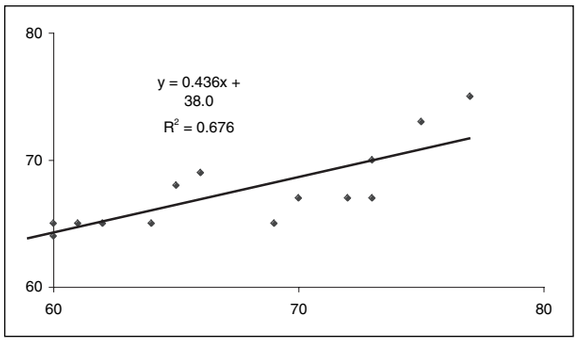
Statistical study included regression analysis to find out any relevant relation between ISQ1 and ISQ2.

RESULTS

All surgeries were done with no complication and RFA was measured. Out of the 16 implanted fixtures all were successfully osseointegrated after a 6 months healing interval. Implant success rate was found to be 100%. ISQ1 ranged from 59 to 77 and ISQ 2 from 64 to 75 (table. 1). Using regression analysis it was seen that ISQ2 depends on ISQ1 (graph. 1). The intercept was 38.0 and the regression coefficient was found to be 0.436. Implants in group A after 6 months decreased from 74.0 to 70.4 on an average and in group C increased from 60.1 to 64.3. The change in group B was not statistically significant.

Table 1. Initial and final ISQ values from implants in sinus lifts

ISQ1	ISQ2
77	75
75	73
73	70
73	67
72	67
70	67
69	65
66	69
65	68
64	65
62	65
61	65
60	65
60	64
59	64
59	64
Mean 66.56	Mean 67.06



Graph 1. Dependence of ISQ2 on ISQ1.

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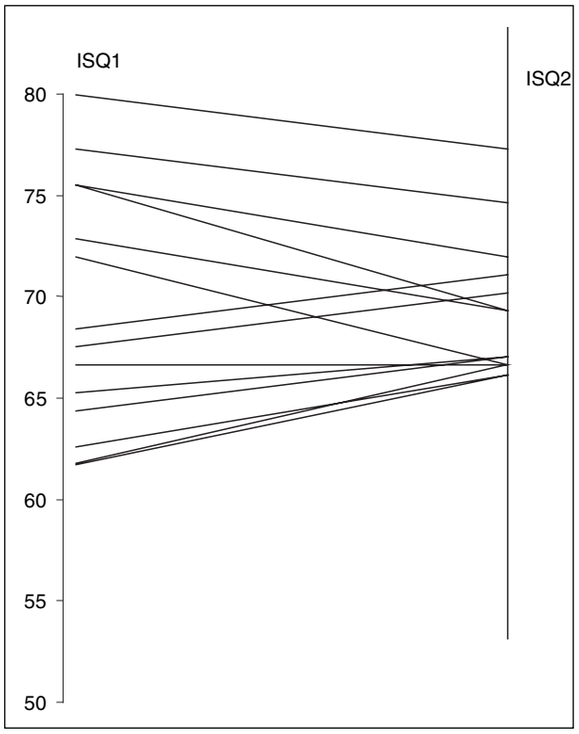
DISCUSSION

Initial implant stability obtained after implant insertion is regarded as critical for the prognosis of the implant [8]. According to Huang, implants with better initial stability would osseointegrate better and would result in higher secondary stability [3]. They therefore require reduced healing period than those with low initial stability [3].

From our results it is evident that all the implants placed in the sinus lift after nine months of healing osseointergrated in six months. The initial measurement of average 66.56 indicates acceptable primary stability (table. 1). In the next six months of healing in the bone the implants gained a competitive secondary stability with those implanted in non augmented areas.

As RFA readings can be implemented in evaluating the success of osseointegration in implants [4, 5, 7], it also refers to the success of sinus lift indirectly. It has been proved in this study that all the implants placed into the sinus lift achieved an optimal ISQ and at the same time showed acceptable histomorphometrical picture of the biopsied area from the grafted sinus using trephine drill [10].

The coefficient of determination (R^2) was found to be 0.646 which means a strong relation between the two values. It is obvious that ISQ2 depends on ISQ1. The calculated regression equation is y=38.0+0.436x, where y stands for the dependent and x for independent variable. The regression coefficient 0.436 is less than one which indicates the type of dependence of ISQ2 on ISQ1. It has been noticed that implants with lower values of ISQ1 (group C) showed a higher value of ISQ2 and those with higher ISQ1 (group A) reached a lower value of ISQ2 (graph. 2). Nedir et al (2004) reported a similar finding in non-augmented areas [7]. They reported an increase in ISQ values with initial value (during insertion) less than 60 and those with initial values between 60 and 69 tend to decrease their values after the first 2 months. In our experiment the values which tend to increase were from 59 to 63 and those found decreasing their values were between 71 and 77. The values in group B didn't show a substantial change and the average of the group in six months remained the same. Therefore it is evident that there is a possibility of a platform of values in which there is the least possible fluctuation or if the implants reach a certain value of stability during their insertion then there is a small chance of change of stability in the future. So there is no need of a high initial stability value to ascertain a better prognosis for the implant, as values with a high magnitude by time reaches a lower value and vice versa. But the lower limit of the value is yet to be determined.



Graph 2. Tendency of ISQ values to converge: the values tend to reach a stable platform near 67.

Table 2. Predicted ISQ3 (Extending the application of the regression equation one more half-year

ISQ2	ISQ3
75	70.74255
73	69.87029
70	68.56190
67	67.25351
67	67.25351
65	66.38125
69	68.12577
68	67.68964
65	66.38125
65	66.38125
65	66.38125
65	66.38125
64	65.94512
64	65.94512
64	65.94512

We may conjecture that this form of dependence may continue and use the assumption that the same equation y=38.0+0.436x holds once more to estimate the values of ISQ3 which would be the values one year after ISQ1 was measured. Such values are indicated in table 2. But this is only a hypothesis requiring a further detailed study. By extending the graph 2 further to 1 year statistically it can be proved that the values

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reach a common point, near to ISQ 67 from whichever value it started, in certain limits (say 59-77).

CONCLUSION

Results of this study support implants in the sinus lift as a successful treatment modality. The values which are of lower RFA (≤ 63) by time reaches a higher value and those with higher initial RFA (≥ 71) tend to decrease to some what lower values. It is possible that all the values reach a particular ISQ value during the course of healing, particular to an implant system.

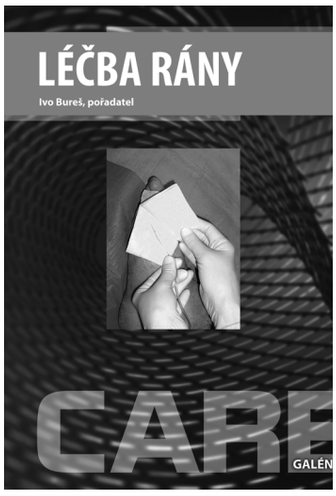
Acknowledgments

This study was sponsored by IGA MH CR (project No. NK 7711- 3/2003).

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Vydal Galén v roce 2006, ISBN 80-7262-413-X, 78 s. formát 150 x 210 mm, brož., barev., 78 str., 60 Kč.
Edice CARE – příloha periodika Florence, číslo 5, ročník II, 2006

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