Implant stability evaluation by resonance frequency analysis in the fit lock technique. A clinical study

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Summary
Surgical procedures for the application of implants in the lateral-superior sectors are affected by the availability of the residual bone. When this condition is lower than 5 mm it is recommended that techniques involving two therapeutic phases, a reconstructive and an applicative one, as reported in the international literature, are adopted. The authors propose here a new method with the potential to apply implants simultaneously with the reconstructive phase.

The aim of this longitudinal retrospective study was to evaluate the stability of implants applied with the fit lock technique in the upper maxillary in us with bone availability lower than 4 mm by measuring resonance frequency at different follow-up periods. The same measurements, carried out on 30 implants, were analysed with specific statistical procedures. The results indicate that the stability of the implants inserted with the fit lock method increases progressively over time in a statistically significant manner. The stability recorded after one year from the insertion (ISQ T2) is significantly higher than that recorded after six months (ISQ T1), and this is significantly higher than that recorded at the time of implant placement (ISQ T0). The implants inserted in the maxillary zones with scarce bone availability and applied with this technique showed a similar stability as reported with other techniques.

In light of the results, the authors confirm that the primary stability represents the basic requirement to guarantee a correct healing of the implant and demonstrate that the fit lock technique also allows reaching this condition when bone availability is minimal.

Key word: resonance frequency analysis, bone grafting, dental implants.

Introduction
The pneumatization of the sinus is a frequently occurring phenomenon in absence of dental elements, causing a vertical reduction of bone availability and limiting the implant placement for prosthetic rehabilitation (1). The approach strategy to this anatomical zone has always been debated, both in the case of a surgical approach and concerning the possible post-surgical complications (2-5).

From the international literature, it is clear that in cases where bone availability is less than 4 mm, as in the classification IV of Misch, a first reconstructive-regenerative phase is indispensable, followed by a second surgical phase for the implant placement (6, 7). This should be done with the goal of implant primary stability, which according to long term studies have a success similar to the implants inserted in normal bone conditions (8).

Some authors consider the possibility of placing the implants at the same surgical time by using extra-oral autologous bone graft (from hip or fibula) in order to obtain the primary stabilization (9). Other authors (Vollmer, Lang, Engelke) proposed resorbable plaques from extrasinus osteosynthesis, but not for the primary implant stability (10-12).

However, as reported by some authors, the survival is also affected by the quality and density of the bone, which is reduced in these zones and thereby can affect the stability (13, 14).

The authors have proposed the fit lock technique, which allows the implants to be placed simultaneously with residual bone thickness less than 4 mm, while harvesting intraoral autologous bone (15). Given the long term results, a longitudinal study has been conducted on 11 patients treated with this technique while using a new implant design to guarantee better stability of the graft also in cases of insufficient bone density.

The aim of the study, retrospective and longitudinal, is to evaluate by resonance frequency across the follow-
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up periods the degree of the stability of the implants applied with the fit lock technique in the upper sinus with bone availability lower than 4 mm. The stability measurement has been carried out by resonance frequency analysis with Osstell Mentor (Osstell instrument, Integration Diagnostics AB, Gothenburg, Sweden) at time 0 (T0) of implant placement, after 6 months (T1), and after 12 months (T2), upon progressive load. The recordings were carried out with double directional measurement (vestibular oral or oro vestibular and mesiodistal or disto-mesial) on the Smart Peg (Type 49) as reported by the company indications, and the value reported in Table 1 is the arithmetic mean of the two (21, 22).

Materials and methods

About 50 patients were visited between January 2011 and January 2012 for implant-supported rehabilitation of the posterior-superior sectors at the Municipal Japanese University Hospital of Santa Cruz de la Sierra, Bolivia and at the Department of Odontostomatologic Sciences, Sapienza University of Rome. All patients were studied following our clinical-implantologic protocol for prosthetic rehabilitation. During this period 11 patients were selected according to the following exclusion and inclusion criteria.

Exclusion criteria:

- Low oral hygiene,
- Acute or chronic synusitis of the maxillary sinus,
- Patients with high risk factors,
- Patients under Cadwell Luc treatments,
- Patients under radiotherapy,
- Patients with a bone height above ≥ 4 mm.
- Inclusion criteria:
  - Bone height ≤ 4 mm (X-ray assessment),
  - Bone availability for harvesting at the ramus-symphysis donor site,
  - Patient’s consent to participate in the clinical study,
  - Patient’s consent to undergo regular clinical follow-up.

From the initial 50 patients 15 were excluded, 20 did not give consent, 4 did not undergo the follow-up. The remaining sample consisted of 11 patients. This final sample was composed by 6 men, mean age 58.2, and 5 women, mean age 59.8. In total there were 15 sinus elevations and 30 implant placements.

The allocation of the 30 implants was as follows: 2 in area 14; 2 in area 15; 6 in area 16; 5 in area 17; 1 in area 24; 2 in area 25; 7 in area 26; 5 in area 27. All implants were of 11.5 length and 4.0 mm diameter (Tab. 1).

The Tekka implants were evaluated with measures of resonance frequency during the follow-up periods using Osstell Mentor (Osstell instrument, Integration Diagnostics AB, Gothenburg, Sweden) at time 0 (T0) of implant placement, after 6 months (T1), and after 12 months (T2), upon progressive load. The overall results reported in Table 1 show the loss of only two implants in position 24 and 27 on the same patient, due to a post-surgical infection occurring 15 days after placement. No complications occurred for the remaining 18 implants across the study period.

The evaluation of the data across the three follow-up periods showed a distribution that significantly deviated from normality. From the graphs it can be seen that two of the selected variables (ISQ T0 and ISQ T1) have a skewed distribution, although the deviation from normality is statistically significant depending on the test (Diagrams a-b-c).

The Friedman non parametric test showed that implant stability (mean and median values) progressively increased over time; ISQ T2 is higher than ISQ T1, and this latter is higher than ISQ T0 (Diagram d). The differences were statistically significant (Diagrams e-f).

Moreover, the post-hoc tests for the three possible comparisons showed the following results: for ISQ T0 vs ISQ T1, z = 3.408; for ISQ T0 vs ISQ T2, z = 3.608; for ISQ T1 vs ISQ T2, z = 2.943. The critical value for significance was always passed.

Discussion and Conclusions

In literature the implant survival in posterior lateral areas (type SA4) - ranges between 90 and 97%.
non treated implants is about 85.6%, while the percentage rises to 95.8% if implants are treated superficially and made rough ones;
- timing of the insertion - the implant can be applied in the same surgical procedure (one-stage surgery) or when the regeneration is complete: in first case the survival rate is 92.17%, while in the second case is 92.93% (23).

These data are influenced by several factors (Del Fabbro, 2004):
- for example, the survival of the only autologous bone is about 87.70%, while in combination with bone substitutes is about 94.88% and when only bone substitutes are used the survival is about 95.98%;
- implant production methodology - the survival of

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Sex</th>
<th>Implant side</th>
<th>Implant misure</th>
<th>ISQ T0</th>
<th>ISQ T1</th>
<th>ISQ T2</th>
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<tr>
<td>1</td>
<td>63</td>
<td>F</td>
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</table>
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Some surgical protocols suggest that, if the bone available is thinner than 4 mm, as in Misch IV classification, first is necessary a reconstructive-regenerative phase and then a second surgical phase of implant insertion (6, 7). These protocols are justified by the fact that, as reported by the authors, the survival of the implant is also influenced by the quality and density of the bone which is reduced in these areas (13, 14). Nedir et al., in 2009, proposed one-stage surgery with simultaneous insertion of implants in patients with atrophic maxilla without grafting, provided that primary stability was guaranteed (24). Later other authors have proposed, in
The described technique seems to ensure a good success rate in cases of Misch IV class with contextual implant placement, with a success percentage of 93.4% one year after placement. The technique allows an immediate stabilization of the implants also due to the new design that improves performance in those cases

a wider caseload, the contextual placement of the implant without filling or with PRF (platelet-rich fibrin), reporting a 100% of success also in cases of lower bone availability (25, 26).

The described technique seems to ensure a good success rate in cases of Misch IV class with contextual implant placement, with a success percentage of 93.4% one year after placement. The technique allows an immediate stabilization of the implants also due to the new design that improves performance in those cases.
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Diagram e. Outcome of the Friedman ANOVA test indicating the overall significance of the time effect.

Table 2. Descriptive statistics of implant stability values (ISQ) at time T0, T1, and T2. The ISQ values (mean and median) progressively increase over time (see also diagram f).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Valid N</th>
<th>Mean</th>
<th>Median</th>
<th>Mode</th>
<th>Frequency of Mode</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Lower Quartile</th>
<th>Upper Quartile</th>
<th>Variance</th>
<th>Std Dev</th>
<th>Coef Var</th>
<th>Standard Error</th>
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<td>47.14</td>
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<td>32.0000</td>
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<td>53.07</td>
<td>52.0000</td>
<td>49.0000</td>
<td>6</td>
<td>43.0000</td>
<td>71.0000</td>
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<td>64.32</td>
<td>65.5000</td>
<td>Multiple</td>
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<td>71.0000</td>
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<td>16.44841</td>
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</tbody>
</table>

Friedman ANOVA and Kendall Coeff. of Concordance (StatisticFalisi) ANOVA Chi Sqr. (N = 28, df = 2) = 52.51429 p = .00000 Coeff. of Concordance = .93776 Aver. rank r = .93545

Diagrams a-b-c. Frequency distribution of implant stability values (ISQ) and outcome of the normality tests (Kolmogorov-Smirnov, Lilliefors, Shapiro-Wilk) at time T0 (a), T1 (b), and T2 (c). See “Materials and Methods” section for details.
Diagram f. Temporal profile of the ISQ values at T0, T1, T2. The small centered squares are medians, the boxes indicate the highest and the lowest quartiles, the vertical bars indicate minimum and maximum values.

with reduced bone density. Compared to similar techniques it appears simpler and reproducible, it does not depend on the operator and allows a lower biological and economic effort for the patient, considerably reducing the time of prosthetic rehabilitation. 

The results suggest that the stability of the implants applied with the fit lock technique increases progressively over time in a significant manner. 

The implant stability one year after placement (ISQ T2) is significantly higher than the stability recorded after six months (ISQ T1), and this latter score is higher than the stability recorded at the beginning (ISQ T0), as evident from the post hoc tests. The ISQ value is in line with other studies concerning reliability, allowing a delayed loading of the implants, and compatible with the biological times (27, 28).

The main disadvantage, as already published, is the impossibility of using implants with a diameter higher than 4 mm, since the graft diameter also can't be more than 8 mm due to anatomical limitations of the antrum, or when for reasons of dental-implant discrepancy, an only graft is required.

This method certainly represents a therapeutic alternative, given the clinical results are comparable to other techniques described in the literature (29, 30).

In light of these results, the authors confirm that the primary stability represents the basic requirement to guarantee a correct healing of the implant and show that the fit lock technique also allows reaching this state in conditions of lower bone availability. 

Because of the low sample size, these results need to be complemented by an istomorphometric analysis and the use of more patients, although to date they represent, together with the previous report, the main published clinical records.

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cal study of seven titanium implants retrieved from humans.