Resonance frequency evaluation on immediate loading implants with angled abutments: case series

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Summary

***Aim*: Immediate loading of implant-supported prosthesis is a predictable and standardised therapy for rehabilitation of partially and totally edentulous patients. The present case series evaluate implant success rates by measuring resonance frequency on immediate loading implants with angled abutments.**
***Materials and methods*: A prospective study was performed on five partially edentulous patients. Twenty-six *Neoss ProActive Tapered*® (Neoss Ltd. Harrogate, UK) implants were inserted: 22 in the maxillary bone and 4 in the mandibular bone. The *Osstell* ISQ® (Osstell; Integration Diagnostics, Göteborg, Sweden) was used to evaluate implant stability. Implant Stability Quotient (ISQ) measurements were performed in three stages: at time of implant insertion (t0), after three (t1) and 12 (t2) months. The ISQ values were recorded after implant installation of *Access*® (Neoss Ltd. Harrogate, UK) during the different stages.**
***Results*: A six month- follow-up showed implant survival of 96%. Twenty-four implants were osseointegrated, a maxillary implant was lost and one other implant was excluded from the study. The values of ISQ ranged between 53-88 ISQ (average 66 ± 6.1 ISQ, median 67 ISQ) at t0, 51-80 ISQ (average 70 ± 5.8 ISQ, median 70 ISQ) at t1 and 53-80 ISQ (average 70.8 ± 5.7 ISQ, median 72 ISQ) at t2.**
***Conclusions*: The 24 successful implants out of 25 in 5 patients demonstrate how using 4-6 implants guarantees sufficient anchorage for a fixed prosthesis and adequate distribution of the prosthetic load on the maxillary and mandible bones, without causing implants failures.**

Key words: resonance frequency, immediate loading implants, angled abutments.

Introduction

Immediate loading of implant-supported prosthesis is a predictable and standardized therapy for rehabilitation of partially and totally edentulous patients; it shows high rates of survival and success, both for the implants and for the prosthesis.
In a 2003 paper, Aparicio et al. analyzed advantages and disadvantages of immediate load technique. They considered the various factors that could affect outcomes (patients' selection criteria, quality of bones, fixture length, surface and shape features, surgeon skillfulness, implant primary stability, occlusal load) and recognized primary stability as the main goal (1).
Also in 2003, Malò et al. described a surgical protocol, the "*All on Four*" method, for rehabilitation of four-implant mandibular arches: two in the frontal side and two in the backside. This method showed a reduction in treatment times, patient discomfort and biological costs (2). Subsequently, the "*All on four*" has been extended to the maxillary bone, resulting in 98% of implant survival after a 5 years follow-up (3).
According to a photoelastic analysis on the peri-implant stress levels *in vitro*, bone around 45° angled implants is more exposed to an occlusal overload in comparison to bone around smaller angulations implants. Small stress differences have been reported around fixtures angles of 0°, 15° and 30°; the regions around the fixtures 'coronal third emerged as the most stressed (4).

Angled abutments mediate prosthetic rehabilitation of angled implants so that abutments axes of the same arch result as parallel as possible.
The most used angled abutments in literature are *Multi Unit Abutment (MUA®)* (Neoss Ltd. Harrogate, UK), *Access*® (Neoss Ltd. Harrogate, UK) and *Low Profile*® (Neoss Ltd. Harrogate, UK).
According to a literary review, the clinical performances of the angled abutments are equal to those of the straight abutments. The stress produced by extra-axial load increases with abutment angulation, yet no consensus has been reached about the precise inclination that leads to implant failure.
During implant success evaluation, it is essential to distinguish between mandibular and maxillary bone. Indeed, a retrospective study on early load with full-arches prosthesis resulted in no implant loss in the mandible, even using only 4 implants, against a 10.6% implant loss in the maxillary bone (5). Another study on full load arch prostheses shows a success rate of 97% for mandibular implants and 87.5% for maxillary ones two years after surgery (6).
The successful installation of immediate loading prosthesis with a full-arch in the maxillary bone depends on the observation of adequate criteria: patient selection, implant choice, correct surgical technique and correct prosthesis realization (7).
Given the limited number of existing studies on the topic (8), the present case series aims to evaluate the success of immediate-loading implants with angled abutments by measuring resonance frequencies.

Clinical series

Study design

The study was a case series designed to evaluate the success of immediate-loading of twenty-six post-extractive implants: 22 in the maxillary bone and 4 in the mandibular bone. A mandibular implant was excluded from the study because angled abutment was unnecessary. Twenty out of twenty-five implants were inserted in post-extraction alveolus while the remaining five in native bone. The inserted implants, *Neoss ProActive Tapered*® (Neoss Ltd. Harrogate, UK), consist of commercially pure titanium grade 4.
The *Osstell* ISQ® (Osstell; Integration Diagnostics, Göteborg, Sweden) device was used to evaluate implant stability. The *SmartPeg™ (Osstell)* is a small, high-precision disposable aluminium bar screwed onto the implant (or angled abutment) during measurements. The ISQ measurements were performed at the time of implant insertion (t0), after 3 (t1) and 12 (t2) months.
Cone-beam CT and OPT were employed for patients' clinical, prosthetic and radiographic assessments.
All patients underwent oral hygiene sessions; they were further instructed to perform oral hygiene during pre-surgical phase.

Study population

The participants were 5 partially edentulous patients: 2 males and 3 females aged between 58 and 74 years (average of 66 ± 8 years). They were selected according to the following exclusion criteria:

- Systemic disorders (thrombocytopenia, coagulopathy, hepatopathy, immunosuppression, diabetes, prolonged cortisone therapy, chemotherapy, iv bisphosphonate treatment, radiotherapy, myocardiopathy)
- Smoking habits
- Bruxism
- Temporomandibular disorders
- Severe dental or skeletal malocclusions.

And the following inclusion criteria:

- need for a full-arch bridge maxillary and/or mandibular supported by 4 or 6 implants
- minimum implant length of 10 mm
- torque of insertion equal to or greater than 35 Ncm
- prosthesis connected to all the implants
- occlusion with long and wide centric.

All the examined patients were healthy; 4 of them took antihypertensive drugs.

Surgical and prosthetic procedures

In order to assemble the articulator-mounted plaster models and construct the surgical template, the intermaxillary connections must be transferred. A facebow has to be employed if an occlusal vertical dimension (OVD) increment is required or if the connections between the two maxillary arches are absent.
In patients with stable occlusion (at least 4 pairs of antagonist teeth) alginate impressions were taken and intermazillary relationship was recorded by occlusion wax. Gypsum models were placed in the articulator; the resulting surgical template guided implants insertion in the correct prosthetic position and aided the choice of the correct *Access*®.
In patients with unstable occlusion (less than 4 pairs of antagonist teeth), intermaxillary relationship and vertical occlusion dimension (OVD) were registered using a facebow.
Avulsion of every compromised dental element was performed; in the same session, 4 or 6 implants were inserted both in native bone and in post-extraction sites. The implant insertion sites were planned based on TC assessment. The chosen areas were the ones with greater bone volume, which did not require a preventive bone regenerative surgery.
The maxillary implants have been placed in 1.2, 2.2, 1.4 / 1.5, 2.4 / 2.5 regions; the mandibular ones in 3.2 / 3.3, 4.2 / 4.3, 3.4 / 3.5, 4.4 / 4.5 regions. The two posterior implants had a mesio-distal inclination of 25-30°, while the two anterior ones inserted in the premaxilla and in the parasymphysis region were straight.
The protocols suggested by Neoss served as a reference for implant sites preparation. The surgical template guided the implants' position and inclination. The implants were inserted using a torque of 35 N/cm

at least. A transparent resin mask helped choosing the *Access*® angle correctors, which had to be directly screwed onto the implant head to parallelise the axes of the implant emergencies.
The resonance frequency analysis made with *Osstell*® ISQ device measured the primary implant stability at zero time. The ISQ values of anterior implants were measured by placing the probe in mesial, distal and vestibular position; for the posterior implants, the ISQ was taken in the buccal palatal and mesial position. Following this, the *SmartPeg™* was removed and the titanium prosthetic cylinders that act as transfers were installed above the *Access*®. The surgical template was used as an open tray to take a silicone impression.
The occlusal contacts were checked with an articulating paper. The patient was invited to maintain in the maximum intercuspidation position (ICP) throughout the swallowing technique. A bite-type silicone was injected between the mask and the vestibule: it blocked the intercuspidation position, polymerized and then was removed. The ICP impression was used to construct the temporary prosthesis. The temporary resin strengthened by glass fibers was produced based on the implants' emergencies and the wax teeth assembly, and after 24 hours was delivered to the patient.
At the end of the surgical phase, antibiotic and anti-inflammatory therapy was prescribed and a soft diet was recommended for at least 30 days.
The patients were summoned back after 3 months and 12 months after surgery. The final prosthesis was delivered after 6-8 months from the temporary prosthesis implant.
After the temporary prosthesis removal, the peri-implant mucosa healing process was evaluated and the ISQ values of each implant were measured.

Outcomes measures and results

The obtained ISQ values reflect the stability level on the universal ISQ scale, from 1 to 100. Three measurements were recorded for each direction tested but only the highest value was considered. The ISQ values were recorded after implant installation of *Access*® (Neoss Ltd. Harrogate, UK) during the different stages: during surgery (t0), after 3 (t1) and after 12 months (t2) from insertion. The values of ISQ ranged between 53-88 ISQ (average 66 ± 6.1 ISQ, median 67 ISQ) at t0, 51-80 ISQ (average 70 ± 5.8 ISQ, median 70 ISQ) at t1 and 53-80 ISQ (average 70.8 ± 5.7 ISQ, median 72 ISQ) at t2.
Analyzing the variation tables of the ISQ value over time, we note an increase at t1 and a slight increase or stabilization at t2. In Tables 1, 3 and 5 some implants slightly drop the ISQ values from t0 to t1 and an increase them from t1 to t2. In Tables 1, 2 and 5 ISQ values higher than 75 recorded at t0 fall at t1, then stabilize or return to growth in the ISQ control performed at t2. In Tables 2, 3 and 4 three out of twenty-five implants have shown a different trend: lower ISQ values at t1, which stabilized at t2 in Tables 2 and 4 while further decreased at t2 in Table 3. In Tables 1, 3 and 4, three implants with ISQ values lower than 60 at t0 showed a marked increase in the ISQ value at t1 and t2, conforming to the ISQ values of the other implants present in the respective Tables.
The patient 2 was supplied with prosthesis in both the maxillary bone and the mandible, thus we could draw two distinct tables to monitor the different osseointegration of the maxillary and mandibular implants over time. The ISQ values trend is described above in both Tables. If the mandibular implant with abnormal ISQ val-

Table 1. The variation table of the ISQ value over time in patient 1.

PATIENT 1														
				T0			T1			T2		
SITE	IMPLANT	ACCESS	V	M	D/P	V	M	D/P	V	M	D/P
1.5	3.5 X 13	20°	72	65	65	52	66	64	71	72	73
1.2	3.5 X 11	30°	88	73	68	72	62	72	77	77	77
2.2	3.5 X 11	30°	65	69	67	68	68	68	68	72	72
2.4	3.5 X 11	20°	53	65	53	58	63	58	67	70	67

Table 2. The variation table of the ISQ value over time in patient 2.

PATIENT 2												
			T0			T1			T2		
SITE	IMPLANT	ACCESS	V	M	D/P	V	M	D/P	V	M	D/P
1.6	3.5 X 11	10°	52	52	52	X	X	X	X	X	X
1.4	3.5 X 11	10°	70	70	63	72	72	72	73	73	73
1.1	4 X 11	20°	62	67	67	77	77	77	65	71	71
2.2	3.5 X 11	30°	62	65	65	72	72	72	65	69	69
2.4	4 X 11	30°	66	66	61	71	72	71	76	76	76
2.6	4 X 11	30°	63	70	63	77	77	77	74	74	74
3.3	4 X 13	10°	67	69	69	77	80	80	77	80	80
4.2	3.5 X 11	10°	72	72	72	63	63	63	62	62	63
4.5	4 X 10	30°	71	79	72	76	80	76	80	76	76

Table 3. The variation table of the ISQ value over time in patient 3.

PATIENT 3															
					T0			T1				T2			
SITE	IMPLANT	ACCESS	V	M	D/P		V	M	D/P		V	M	D/P	
1.5	4 X 11	30°	68	67	68		73	73	73		73	73	73	
1.2	3.5 X 13	10°	58	58	58		63	67	63		68	70	72	
2.2	3.5 X 13	20°	67	60	68		64	64	64		60	63	63	
2.5	3.5 X 13	10°	58	58	58		69	69	69		71	71	71	

Table 4. The variation table of the ISQ value over time in patient 4.

PATIENT 4															
					T0			T1				T2			
SITE	IMPLANT	ACCESS	V	M	D/P		V	M	D/P		V	M	D/P	
1.4	4 X 11	20°	69	69	69		70	70	70		64	74	73	
1.2	3.5 X 13	30°	63	68	68		69	69	69		68	75	75	
2.1	4 X 13	20°	70	70	70		70	70	70		72	72	72	
2.4	4 X 11	20°	64	68	66		56	51	57		53	53	53	

Table 5. The variation table of the ISQ value over time in patient 5.

PATIENT 5															
					T0			T1				T2			
SITE	IMPLANT	ACCESS	V	M	D/P		V	M	D/P		V	M	D/P	
1.5			66	66	70		71	71	70		75	75	74	
1.2			64	64	48		69	69	69		71	71	71	
2.2			70	70	70		70	70	70		72	72	72	
2.5			78	71	71		71	71	71		72	72	72	

ues at control t1 and t2 is neglected, the recorded ISQ values in the mandible are higher than those in the maxillary bone.

Twenty-four implants were osseointegrated whereas a maxillary implant was lost one month after immediate loading procedure (patient 2). A six months follow-up showed implant survival of 96%.

Discussion

The ISQ measurements performed at t0, t1 and t2 indicate that implant stability increases over time. This result can be due to both new bone formation around implant turns and bone mineralization increase in the bone-implant interface. Many studies monitored ISQ values shifts over time since implant placement (9-28). Three maxillary implants with ISQ values below 60 at t0 showed a marked increase in the ISQ value at t1 and t2. Huwiler et al.'s study states that the increase in ISQ value is higher in type IV bone and lower in type I bone 6 weeks after implant insertion (15). In Sim and Lung's 2010 paper, ISQ value of type II bone slightly decreases after 2 weeks but always remains above 70 ISQ, while ISQ value of type III and IV bone continuously grows until it reaches slightly lower values than those recorded in type II bone after 12 weeks (17).

In the present case, an anomalous trend was measured on three implants: their ISQ value progressively decreased, suggesting some kind of impairment; however, they remained clinically stable. Temporary prosthesis occlusal control revealed an occlusal overload on those three anomalous implants: the pre-contact was immediately corrected.

Further, the ISQ values measured on the three mandibular implants can be associated with a better bone quality of the implant insertion site (15, 17).

The different angulation *Access*® devices lead to an ISQ value average decrease if compared with the ISQ measured without intermediate components between *SmartPeg™* and implant. The 0° *Access*® reports an average decrease of 1.74-5.01% of the ISQ value; the *Access*® 10° an average decrease of 5.07-6.63%; the *Access*® 20° a decrease average of 6.79-7.93%; the *Access*® 30° an average decrease of 7.2-8.73%.

Several Authors have searched for an ISQ threshold clinically useful to differentiate early successes and failures. Guler et al. state it is impossible to identify this value (12, 13). On the other hand, Andersson et al. affirm that a substantial ISQ value decrease recorded three month after surgery can predict implant failure. According to Fischer et al., an ISQ value lower than 44 indicates imminent failure in 100% of cases (29). Huwiler et al. report similar results: failed implants ISQ

values declined from 68 at t0 to 45 after a week (15). Both Andersson et al. and Sennerby et al. discourage immediate loading on implants with an ISQ value of 60: the failure rate ranges around 6.5% (5, 30).
Eventually, the first measurement is important to understand subsequent data. Measurements repeated with the transducer in the same position allow a meaningful comparison of data.

Conclusions

The present case takes into account immediate loading implants with full-arch fixed prosthesis placed in post-extraction sockets. The implant survival rate after 12 months reaches 96%.
The 24 out of 25 successful implants in 5 patients show how using 4-6 implants (mostly 11-13 mm long) guarantees sufficient anchorage for a fixed prosthesis and adequate distribution of the prosthetic load on the maxillary and mandible bones, without causing implants failures. In conclusion: in maxillary bone and mandible's post-extraction alveoli of totally edentulous patients, it is possible to insert 4-6 immediate loading implants equipped with angled abutment and full-arch fixed prosthesis. Further clinical studies will be needed to establish the long-term predictability of this rehabilitative treatment.

References

1. Aparicio C, Rangert B, Sennerby L. Immediate/early loading of dental implants: a report from the Sociedad Española de Implantes World Congress consensus meeting in Barcelona, Spain, 2002. Clin Implant Dent Relat Res. 2003;5(1):57-60.
2. Malò P, Rangert B, Nobre M. "All-on-Four" immediate-function concept with Braemark System implants for completely edentulous mandibles: a retrospective clinical study. Clin Implant Dent Relat Res. 2003;5(Suppl 1):2-9.
3. Maló P, de Araújo Nobre M, Lopes A, Francischone C, Rigolizzo M. "All-on-4" immediate-function concept for completely edentulous maxillae: a clinical report on the medium (3 years) and long-term (5 years) outcomes. Clin Implant Dent Relat Res. 2012 May;14(Suppl 1):e139-150.
4. Begg T, Geerts GAVM, Gryzagoridis J. Stress patterns around distal angled implants in the all-on-four concept configuration. Int J Oral Maxillofac Implants. 2009 Jul-Aug;24(4):663-671.
5. Andersson P, Degasperi W, Verrocchi D, Sennerby L. A Retrospective Study on Immediate Placement of Neoss Implants with the Early Loading of Full-Arch Bridges. Clin Implant Dent Relat Res. 2015 Aug;17(4):646-657.
6. Grunder U. Immediate functional loading of immediate implants in edentulous arches: two-year results. Int J Periodontics Restorative Dent. 2001 Dec;21(6):545-551.
7. Peñarrocha-Oltra D, Covani U, Peñarrocha-Diago M, Peñarrocha-Diago M. Immediate loading with fixed full-arch prostheses in the maxilla: review of the literature. Med Oral Patol Oral Cir Bucal. 2014 Sep 1;19(5):e512-517.
8. Burak Özcelik T, Ersoy E, Yilmaz B. Biomechanical evaluation of tooth- and implant-supported fixed dental prostheses with various nonrigid connector positions: a finite element analysis. J Prosthodont. 2011 Jan;20(1):16-28. Doi: 10.1111/j.1532-849X.2010.00654.x.
9. Mozzati M, Arata V, Gallesio G, Mussano F, Carossa S. Immediate postextraction implant placement with immediate loading for maxillary full-arch rehabilitation: A two-year retrospective analysis. Journal of the American Dental Association. 2012;143(2):124-133.
10. Corsalini M, Genovese K, Lamberti L, Pappalettere C, Carella M, Carossa S. A laboratory comparison of individual Targis/Vectris posts with standard fiberglass posts. Int J Prosthodont. 2007;20(2):190-192.
11. Mussano F, Rovasio S, Schierano G, Baldi I, Carossa S. The effect of glycine-powder airflow and hand instrumentation on peri-implant soft tissues: A split-mouth pilot study. International Journal of Prosthodontics. 2013;26(1):42-44.
12. Guler AU, Sumer M, Duran I, Sandikci EO, Telcioglu NT. Resonance frequency analysis of 208 Straumann dental implants during the healing period. Eur J Oral Implantol. 2013 Apr;39(2):161-167.
13. Monje A, Suarez F, Garaicoa CA, Monje F, Galindo-Moreno P, García-Nogales A, Wang HL. Effect of location on primary stability and healing of dental implants. Implant Dent. 2014 Feb;23(1):69-73.
14. Pettini F, Savino M, Corsalini M, Cantore S, Ballini A. Cytogenetic genotoxic investigation in peripheral blood lymphocytes of subjects with dental composite restorative filling materials. J Biol Regul Homeost Agents. 2015;29(1):229-233.
15. Huwiler MA, Pjetursson BE, Bosshardt DD, Salvi GE, Lang NP. Resonance frequency analysis in relation to jawbone characteristics and during early healing of implant installation. Clin Oral Implants Res. 2007 Jun;18(3):275-280. Epub 2007 Mar 12.
16. Corsalini M, Carella M, Boccaccio A, Lamberti L, Pappalettere C, Catapano S, Carossa S. An alternative approach to the polishing technique for acrylic resin surfaces. Int J Prosthodont. 2008 Sep-Oct;21(5):409-412.
17. Sim CP, Lang NP. Factors influencing resonance frequency analysis assessed by Osstell during implant tissue integration: I. Instrument positioning, bone structure, implant length. Clin Oral Implants Res. 2010 Jun;21(6):598-604.
18. Sençimen M, Gülses A, Ozen J, Dergin C, Okçu KM, Ayyıldız S, Altuğ HA. A clinical study. Early detection of alterations in the resonance. Eur J Oral Implantol. 2011 Aug;37(4):411-419.
19. Shokri M, Daraeighadikolaei A. Measurement of primary and secondary stability of dental implants by resonance frequency analysis method in mandible. Int J Dent. 2013;2013:506968.
20. Corsalini M, Carella M, Boccaccio A, Lamberti L, Pappalettere C, Catapano S, Carossa S.An alternative approach to the polishing technique for acrylic resin surfaces. Int J Prosthodont. 2008;21(5):409-412.
21. Grassi FR, Rapone B, Scarano Catanzaro F, Corsalini M, Kalemaj Z. Effectiveness of computer-assisted anesthetic delivery system (STA™) in dental implant surgery: a prospective study. Oral Implantology. 2017;10(4):381-389. ISSN:1974-5648. Doi: 10.11138/orl/2017.10.4.381.
22. Kalemaj Z, Scarano A, Valbonetti L, Rapone B, Grassi FR. Bone response to four dental implants with different surface topography: a histologic and histometric study in minipigs. Int J Periodontics Restorative Dent. 2016 Sep-Oct;36(5):745-754. Doi: 10.11607/prd.2719.
23. Rapone B, Nardi GM, Di Venere D, Pettini F, Grassi FR, Corsalini M. Oral hygiene in patients with oral cancer undergoing chemotherapy and/or radiotherapy after prosthesis rehabilitation: protocol proposal. Oral Implantol (Rome). 2016 Dic ;9(Suppl 1):90-97. Doi: 10.11138/orl/2016.9.1S.090.

24. Di Venere D, Pettini F, Nardi GM, Laforgia A, Stefanachi G, Notaro V, Rapone B, Grassi FR, Corsalini M. Correlation between parodontal indexes and orthodontic retainers: prospective study in a group of 16 patients. Oral Implantology. 2017 Apr 10;10(1):78-86. Doi: 10.11138/orl/2017.10.1.078. eCollection 2017 Jan-Mar.
25. Corsalini M, Di Venere D, Rapone B, Stefanachi G, Laforgia A, Pettini F. Evidence of signs and symptoms of Craniomandibular Disorders in Fibromyalgia patients. The Open Dent Journal. 2017;11:91-98. Published online 2017 Feb 14. Doi: 10.2174/1874210601711010091.
26. Grassi FR, Pappalettere C, Di Comite M, Corsalini M, Mori G, Ballini A, Crincoli V, Pettini F, Rapone B, Boccaccio A. Effect of different irrigating solutions and endodontic sealers on bond strength of the dentin-post interface with and without defects. Int J Med Sci. 2012;9(8):642-654. Published online 2012 Sep 24. Doi: 10.7150/ijms.4998.
27. Di Comite M, Crincoli V, Fatone L, Ballini A, Mori G, Rapone B, Boccaccio A, Pappalettere C, Grassi FR, Favia A. Quantitative analysis of defects at the dentin-post space in endodontically treated teeth. Materials. 2015;8,3268-3283. Published online 2015 Jun 4. Doi: 10.3390/ma 8063268.
28. Di Venere D, Corsalini M, Nardi GM, Laforgia A, Grassi FR, Rapone B, Pettini F. Obstructive site localization in patients with Obstructive Sleep Apnea Syndrome: a comparison between otolaryngologic data and cephalometric values. Oral Implantology. 2017 Jul-Sep;10(3):295-310. Published online 2017 Nov 30. Doi: 10.11138/orl/2017.10.3.295.
29. Fischer K, Bäckström M, Sennerby L. Immediate and early loading of oxidized tapered implants in the partially edentulous maxilla: a 1-year prospective clinical, radiographic, and resonance frequency analysis study. Clin Implant Dent Relat Res. 2009 Jun;11(2):69-80.
30. Sennerby L, Meredith N. Implant stability measurements using resonance frequency analysis: biological and biomechanical aspects and clinical implications. Periodontol 2000. 2008;47:51-66.