LETTER TO THE EDITOR

INFLUENCE OF CLINICIAN'S SKILL ON PRIMARY IMPLANT STABILITY WITH CONVENTIONAL AND PIEZOELECTRIC PREPARATION TECHNIQUES: AN *EX-VIVO* STUDY

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To the Editor,

Osseointegration was defined as a direct and functional connection between bone and an artificial implant. This discovery paved the way for the development of modern dental implantology over the last 50 years (1). Success of dental implants is strictly related to their primary stability (PS). The implant body design and the thread geometry significantly influence PS, as well as the surgical technique. PS is influenced also by bone quality, particularly by cortical thickness, and even by implant surface treatment (2). However, the quality of surgical osteotomy, potentially affecting PS, could be influenced by the clinician's surgical experience (3). The main rules for dental implant success include a careful and little traumatic technique for implant bed preparation to avoid bone overheating and obtain sufficient PS without excessive cortical compression (4). Several surgical protocols have been proposed for implant site preparation. The traditional technique involves the use of calibrated rotating drills. The advantages of this protocol are efficiency, reliability and ease of use. Recently, piezoelectric technology has proved to be a valid alternative to traditional methods. Piezoelectric surgery uses ultrasounds to perform selective osteotomies, with the aim to preserve nerves, vessels and soft tissues. The precision of cutting, the cavitation effect which improves intra-operative visibility and a faster bone healing response are the main features of ultrasonic surgery (5). Vercellotti et al. in 2014 analyzed 3579 implants placed after piezoelectric preparation with a 1-to-3-year follow-up (6). In this multicenter case series study, a piezoelectric device was identified as a valuable tool for implant site preparation showing only 2.26% failure rate after up to 3 years of follow-up. Several studies analyzed potential differences between traditional and piezoelectric techniques, evaluating insertion torque (IT) and implant stability quotient (ISQ). A clinical study by Stacchi et al. suggested that ultrasonic implant site preparation showed a limited decrease of ISQ values and an earlier shifting from a decreasing to an increasing stability pattern, when compared with traditional drilling technique (7). However, in this study, PS resulted similar between piezoelectric surgery and traditional technique at baseline. Analysis of the factors affecting implant success have been extensively reported in the literature; however, research conducted on the effects of clinical experience has been very limited.

Key words: cadaver study; dental implantology; experience; implant stability; piezoelectric surgery

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The aim of this study was to evaluate PS of implants (in terms of IT and ISQ values) placed into fresh human mandibles by clinicians with different levels of experience using two different site preparation protocols (twist drill *vs* piezoelectric surgery).

MATERIALS AND METHODS

The study was conducted during a hands-on implantology course on fresh non-frozen human cadavers. The study protocol was approved by the Institutional Review Board of reference for the Center of Anatomy and Cell Biology - Medical University of Vienna, authorizing to use the bodies for teaching and medical research (protocol number 161008 – approved on October 31, 2016). All experiments were conducted in full accordance with ethical principles, including the World Medical Association Declaration of Helsinki.

One month before the course all the participants received a survey about their clinical abilities. Considering the survey results, trainees were divided into 3 groups: a basic experienced group (they had never used these surgical techniques or had placed less than 50 implants – Group 1), a medium experienced group (placed from 150 to 300 implants – Group 2) and a highly experienced group (more than 500 implants – Group 3). Two clinicians were randomly selected with basic experience, two with medium experience and two with high experience.

A total of 60 implants (Neoss ProActive Tapered, Neoss, Harrogate, United Kingdom) were inserted in 12 human fresh non-frozen cadaver mandibles: 30 implants placed in sites prepared with traditional technique and 30 implants in sites prepared by piezoelectric technique (Fig. 1). Each surgeon placed 10 implants, 5 for surgical technique in similar mandible sites.

Each mandible, fully or partial edentulous, was analyzed clinically and radiologically (MRI images available for consultation at the Institute of Anatomy of Medical University of Vienna) in order to determine the presence of sufficient bone height and width to receive 4.0 Ø x 9 mm length tapered implants. Neoss ProActive Tapered implants are conical (4.0 Ø x 9 mm in this case), in pure titanium, with a treated surface (blasting, etching).

Surgical procedures

The two surgical techniques were performed on similar sites of the same edentulous area for a better standardization. Twelve human fresh non-frozen cadaver mandibles were used to assure the same experimental conditions for all operators. Traditional technique was performed using a surgical motor drill (ChiroproL, Bien-Air Dental SA, Biel/Bienne, Switzerland), using the drilling protocol recommended by the manufacturer. Instructions were provided to clinicians regarding implant bed preparation in order to ensure a standardized approach. Drilling was performed with an in-and-out movement without stopping the handpiece motor until the drill reached the desired depth (9 mm). Motor setting was the same for all groups: drilling speed of 800 rpm with irrigation. Drills were replaced after ten uses as recommended by the manufacturer.

Drilling for Neoss ProActive Tapered implant (4.0 Ø x 9 mm length) in type II bone started with the first 1.5 mm diameter drill, then 2.2 mm diameter pilot drill, 3.0 mm diameter tapered drill, 3.4 mm tapered drill and finished with the countersink Ø4.0T (Fig. 1 A). Piezoelectric technique was performed using Piezosurgery Touch with an Implant preparation kit pro (Mectron, Carasco, Italy) for each skull. Site preparation protocol started with IM1S insert, followed by IM2P (2.0mm diameter). P2-3 tip was then used to optimize preparation concentricity and, finally, IM3P (3.0 mm diameter) and P3-4 were used (Fig. 1 B).

In order to make sure that the osteotomies had the same final diameter, the clinician fitted a 3.4 mm tapered drill into the site after completing piezoelectric preparation. Execution of the two techniques was monitored by an expert tutor for Group 1, who followed the surgical operation sequence and checked the instructions of the manufacturer's protocols.

At the end of site preparations, implants were inserted (Fig. 2 A) with the same surgery motor drill (ChiroproL, Bien-Air Dental SA, Biel/Bienne, Switzerland). Whenever implant placement stopped, the insertion was completed manually.

PS evaluation

Evaluation of PS was performed by measuring IT and RFA. Final IT value was measured using a manual torque gauge (Dial Torque Screwdriver FTD100CN, Tohnichi Mfg, Tokyo, Japan) and was recorded in Newton x centimeter (Ncm) (min. 20, max. 100 – grad.

2). Each placed implant resulted in a single value at the end of the insertion, and mean values were collected by groups and compared. Resonance frequency analysis (RFA) was determined in ISQ values with the PenguinRFA device (Integration Diagnostics Sweden AB, Gothenburg, Sweden). This instrument measures the resonance frequency of a customized autoclavable titanium MultiPegTM with a non-contacting technique. The MultiPeg was screwed inside the implant, and magnetic waves produced by PenguinRFA simulated the stress of the prosthetic load. Measurements were taken as follows: the probe was laterally oriented in relation to the transducer and ISQ values were recorded for each fixture in two directions (mesio-distal, bucco-lingual). Every single measurement was repeated at least twice and the highest value was taken as reference for the statistical analysis (Fig. 2 B). The time required to perform surgical site preparation was recorded with a digital chronometer by an independent operator.

Statistical analysis

Statistical analysis was performed with the software STATA version 14 (STATA Corp., Texas, USA). A two-way ANOVA test was used to evaluate differences within groups and the impact of the operator on the stability parameters. Multiple comparisons were performed using Student's *t*- test. Significance level was set at $p=0.05$. Data were expressed as mean value ± S.D. and ranges were calculated for each group.

RESULTS

In this study 60 implants were placed in edentulous mandible using two different surgical techniques: 30 were placed following traditional drill protocol and 30 after ultrasonic site preparation. Clinicians were divided into three groups according to their experience (group 1 basic, group 2 medium, group 3 expert). Each group placed 10 implants preparing the sites with traditional twist drills, and 10 implants using piezoelectric surgery. Mean values of IT, ISQ and time are reported in Table I.

IT analysis

Mean IT of implants placed after traditional site preparation was 42±10.5 Ncm in group 1, 49.8±7.3 Ncm in group 2 and 50.8±8.0 Ncm in group 3. IT exhibited statistically significant differences between group 1 and group 2 ($p = 0.02$) and between group 1 and group 3 ($p = 0.01$). No differences were detected between group 2 and group 3 ($p = 0.33$) (Fig. 3 A).

Implants placed after piezoelectric preparation protocol showed the following mean IT values: 48.0±8.7 Ncm in group 1, 49.4±8.1 Ncm in group 2 and 51.6±7.9 Ncm in group 3. Analysis of IT values did not demonstrate statistically significant differences between group 1 and group 2 ($p = 0.31$), between group 1 and group 3 ($p = 0.11$) and between group 2 and group 3 ($p = 0.20$). Comparison between piezoelectric technique and traditional technique showed a statistically significant difference for IT values only in group 1 ($p = 0.029$). No differences were detected in groups 2 and 3 ($p > 0.05$) (Fig. 3 B).

ISQ value analysis

After traditional preparation, mean ISQ was 60.7±8.4 in group 1, 75.3±3.1 in group 2 and 81.3±3.4 in group 3. ISQ values were statistically different between the 3 groups. Specifically, group 1 showed ISQ values lower than those of group 2 ($p <0.01$) and group 3 ($p <0.01$) and group 2 showed ISQ values lower than those of the group 3 ($p <0.01$) (Fig. 4 A). Similar results were obtained for implants inserted after piezoelectric site preparation: mean ISQ was 65.0±4.7 in group 1, 75.1±4.3 in group 2 and 81.7±1.5 in group 3. ISQ value was significantly lower both in group 1 compared to groups 2 ($p < 0.01$) and 3 ($p <0.01$), and in the group 2 compared to the group 3 ($p <0.01$) (Fig. 4 B). Comparing the two surgical techniques, only group 1 showed a statistically significant difference in favor of piezoelectric surgery ($p <0.01$).

Time analysis

Mean time required for surgery using traditional technique was 492.1±13.9 s in group 1, 297.9±14.0 s in group 2 and 187.7±5.7 s in group 3. Mean time required for ultrasonic implant site preparation was 650.7±14.5 s in group 1, 518.6±16.2 s in group 2 and 427.3±9.0 s in group 3. Both for piezo and traditional techniques, the time was longer in group 1 compared to group 2 ($p < 0.01$) and to group 3 (p

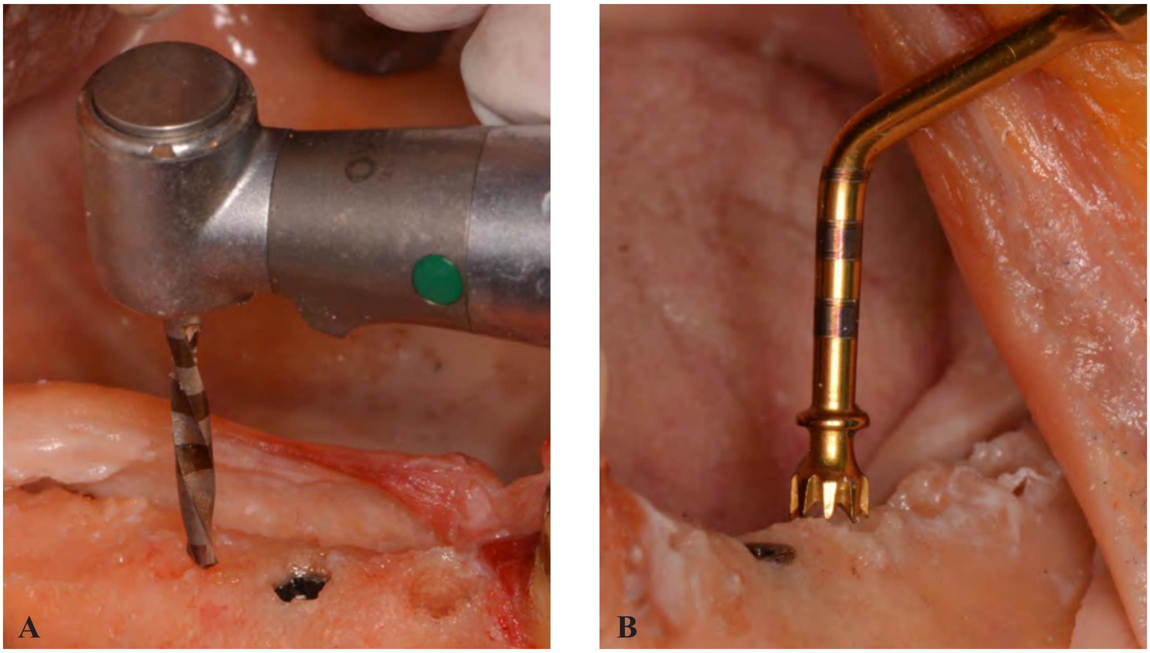

Fig. 1. *A) Traditional implant site preparation with 3.0 Ø tapered drill.* ***B****) Implant site preparation with piezoelectric surgery.*

Fig. 2. *A) Implant insertion.* ***B****) Recording of ISQ with PenguinRFA.*

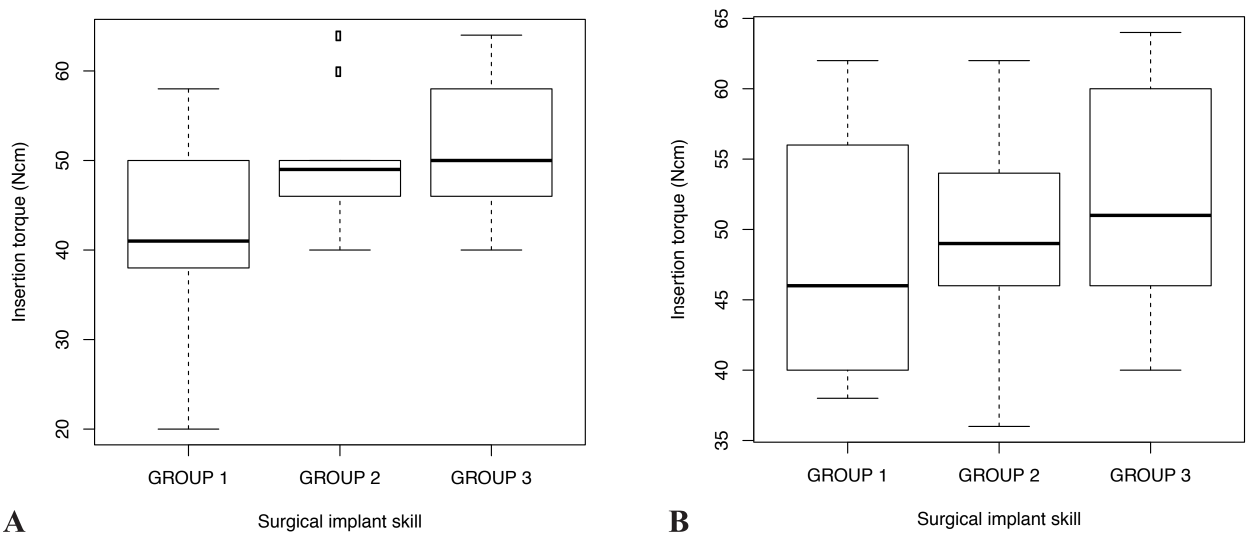

Fig. 3. *A) Boxplot of the distribution of IT according to the different clinician's experience groups related to traditional implant site preparation. **B**) Boxplot of the distribution of IT according to the different clinician's experience groups related to piezoelectric implant site preparation.*

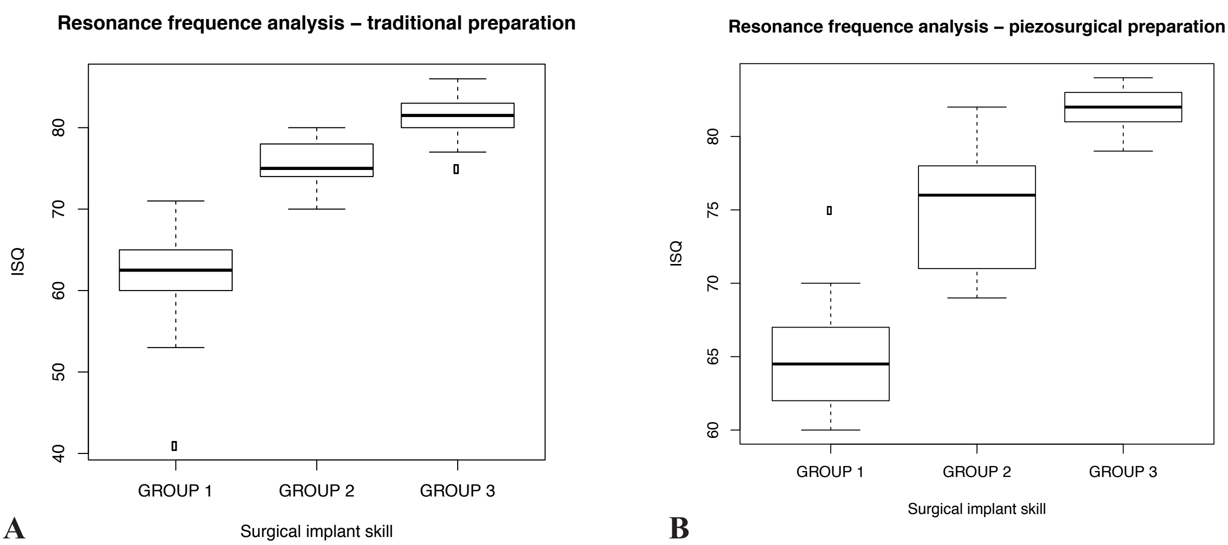

Fig. 4. *A) Boxplot of the distribution of ISQ values according to the different clinician's experience groups related to traditional implant site preparation. **B**) Boxplot of the distribution of ISQ values according to the different clinician's experience groups related to piezoelectric implant site preparation.*

< 0.01), and it was longer in group 2 compared to group 3 ($p < 0.01$). In all three groups, piezoelectric site preparation required a longer surgical time than traditional approach ($p < 0.01$).

DISCUSSION

As PS is one of the prerequisites for achieving successful osseointegration, without doubt the clinician's experience in implant placement is important to prevent failures (8). The insertion of an implant without an adequate PS or poor bone integration commonly leads to implant failure and rarely to its accidental migration (9). There is a lack of research in the literature regarding the effect of the level of experience on PS (3). To the best of the

Table I. *Mean values of IT, ISQ and time.*

Surgical Preparation Technique	Clinicians' experience	IT (Ncm)	ISQ	Time (s)
Traditional	Basic	42.0±10.5	60.7±8.4	492.1±13.9
	Medium	49.8±7.3	75.3±3.1	297.9±14.0
	Expert	50.8±8.0	81.3±3.4	187.7±5.7
Piezoelectric surgery	Basic	48.0±8.7	65.0±4.7	650.7±14.5
	Medium	49.4±8.1	75.1±4.3	518.6±16.2
	Expert	51.6±7.9	81.7±1.5	427.3±9.0

IT: insertion torque; ISQ: implant stability quotient

Authors' knowledge, the present study is the only one to compare the influence of the experience of the clinician on implant IT and RFA in fresh non-frozen cadaver mandibles with conventional and piezoelectric preparation techniques. IT alone is not a predictable value to assess implant PS. IT and RFA were demonstrated to be different and not comparable systems to assess implant stability (10, 11). We found significant relationship between the clinician's experience and IT among the three groups performing implant site preparation with twist drills. There were statistically significant differences between values of group 1 compared with groups 2 and 3 but no difference between groups 2 and 3. Conversely, no significant differences were found analyzing the three groups preparing implant sites using the piezoelectric technique. This result can be explained because of piezosurgical tips being slower and not customized for the implant system. ISQ values resulted significantly related to clinician's experience both in piezoelectric and traditional preparation groups: ISQ was significantly lower in group 1 compared to groups 2 and 3, also in group 2 compared to the group 3. Considering that RFA is more related to the amount of crestal bone surrounding the coronal part of the implant and high ISQ values are related to stiffness of the implant-bone interface, especially in the coronal region (12), the Authors hypothesised that high ISQ values in group 3 could be related to a proper implant vertical position and a better bone/implant contact, especially in the crestal area. The preparation technique had an influence on PS only considering the group of basic experience. Piezoelectric site preparation in group 1 resulted in higher IT and ISQ values than the traditional technique in the same group. This result is probably related to a better control compared with twist drills. Implant osteotomy with piezoelectric surgery needed more time for implant site preparation in all the three groups compared with traditional drilling osteotomy. In conclusion, our results showed that the clinician's experience seems to affect osteotomy preparation and implant placement, resulting in higher IT and ISQ values, especially when the traditional preparation technique was considered. Both experienced and inexperienced clinicians consistently achieved satisfactory PS in terms of IT and ISQ, especially after piezoelectric osteotomy.

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