

Is Jumping Distance Grafting, Necesseray for Extra Primary Stability? a Cadaveric Study

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Abstract

Aim : Long-term success of dental implants depends on successful osseointegration and adequate peri-implant bone support. Primary stability, defined as the mechanical stability achieved at the time of implant placement, is considered a key factor for the initiation of osseointegration. In immediate implant placement, the anatomical structure of the extraction socket and the graft material used for socket augmentation may influence primary stability. Therefore, the aim of this study was to evaluate the effect of different graft materials on primary implant stability in immediate implant placement procedures.

Material& Method: This study was conducted at the RMK AIMES Laboratory of Koç University Hospital. A total of 10 fresh-frozen cadavers, regardless of sex, were included in the study. Twenty 3.75×11.5 mm Nuvo ConicalFIT implants (JJGC S.A., Curitiba, Brazil) were used. The maxillary anterior teeth (#11 and #21) were extracted, and implant osteotomies were prepared in the right and left anterior maxilla of each cadaver. The peri-implant gaps were augmented using autogenous grafts harvested from the maxillary tuberosity region and xenografts. Primary stability measurements were recorded before and after graft placement.

Results: Both xenograft and autogenous graft placement increased the primary implant stability after the immediate implant placement. In the xenograft group, mean ISQ values increased from 60.85 ± 7.62 to 66.60 ± 7.00 ($p = 0.009$). Likewise, in the autogenous graft group, mean ISQ values increased from 60.95 ± 5.89 to 67.60 ± 7.01 ($p = 0.041$). Although the increase was slightly greater in the autogenous graft group, no statistically significant difference was found between the two grafting materials ($p = 0.171$).

INTRODUCTION

Dental implants are widely preferred for the rehabilitation of missing teeth caused by periodontal diseases, dental caries, and oral infections in order to restore function and esthetics. Dental implants demonstrate high success rates, with survival rates reported to reach up to 95% over a 5-year follow-up period¹. One of the most important criteria for the success of dental implants is the achievement of osseointegration within the surrounding bone and the maintenance of adequate peri-implant bone volume and density over the long term².

For successful osseointegration, the achievement of primary stability during the surgical procedure is of critical importance. Primary stability refers to the mechanical engagement of the implant within the surrounding bone at the time of placement, and this mechanical retention constitutes the biological foundation required for the initiation of osseointegration³. Primary stability is influenced by multiple factors, including bone density and quality, implant design, implant diameter and length, surgical preparation technique, and the characteristics of the graft material if it used. Particularly in immediate implant placement procedures, the anatomical configuration of the extraction socket and grafting of the peri-implant gap play a decisive role in achieving primary stability. Therefore, comparative evaluation of

the effects of different graft materials on primary stability in immediate implant placement is of considerable clinical importance⁴.

Historically, dental implants were placed in a delayed manner several weeks or months after tooth extraction to allow bone healing within the socket. However, in recent years, immediate implant placement has gained increasing attention due to its advantages, including preservation of alveolar bone, improved implant positioning, enhanced esthetic outcomes, and psychosocial benefits for patients. In addition, immediate implantation may eliminate several disadvantages associated with delayed protocols, such as prolonged treatment time, multiple clinical appointments, alveolar bone resorption, and migration of adjacent teeth into the edentulous space⁵⁻⁸. Although immediate implant placement is considered a reliable and predictable treatment modality, selecting an implant that perfectly matches the dimensions of the extraction socket is not always feasible. Implants placed immediately after tooth extraction often do not establish complete contact with all four socket walls, resulting in a gap, particularly between the buccal bone wall and the implant surface. To enhance primary stability and achieve improved osseointegration, this horizontal defect area, also referred to as the "jumping distance," is commonly filled with graft material^{9,10}. For this purpose, various bone regenerative biomaterials, including autografts (autogenous grafts), xenografts, alloplastic grafts, and allogeneic grafts, have been utilized to preserve alveolar ridge volume and promote new bone formation^{6,7,11}. Autogenous grafts are harvested from the same individual receiving the graft and have long been considered the gold standard in bone regeneration procedures. Allografts are derived from individuals of the same species and are available in frozen, freeze-dried, and demineralized freeze-dried forms, which may be used as particles, gels, or putties. Their major advantage is the elimination of the need for a second surgical donor site. Alloplastic grafts are synthetic biomaterials that contribute to bone defect repair and exhibit varying resorption rates depending on their chemical composition and surface characteristics. Xenografts, on the other hand, are materials obtained from different species in which organic components have been completely removed, providing a natural scaffold structure and calcium source without inducing significant immunologic reactions^{7,12}.

MATERIAL & METHODS

Ethical approval

for this study was obtained from the University of Health Sciences Hamidiye Non-Interventional Scientific Research Ethics Committee (Decision No. 7/10-2026). All methods were performed in accordance with the relevant guidelines and regulations. All cadavers used in this study were donated bodies obtained through the Science Care Body Donation Program, with documented informed consent for donation for scientific research and educational purposes obtained from the donors or their legally authorized representatives. This study was conducted at the RMK AIMES Laboratory of Koç University Hospital. A total of 10 fresh-frozen cadavers, regardless of sex, were included in the study. The cadavers were provided free of charge by the RMK AIMES Laboratory, and the Ostell Mentor 3 device used for

primary stability measurements belonged to the personal inventory of İsmail Doruk Koçyiğit. The dental implants (Nuvo ConicalFIT), implant surgical kit, and physiodispenser required for osteotomy preparation were supplied free of charge by the implant manufacturer. Preoperative and postoperative radiographic imaging could not be obtained due to laboratory limitations. Cadavers included in the study were over 18 years of age, possessed maxillary anterior teeth (#11 or #21), had sufficient bone volume for implant placement in the related region, and exhibited no pathological findings in the surgical area.

Study Design

A total of 20 Nuvo ConicalFIT implants measuring 3.75×11.5 mm (JJGC S.A., Curitiba, Brazil) were used in the study. Following extraction of the maxillary anterior teeth (#11 or #21) in 10 fresh-frozen cadavers, implant osteotomies were prepared in the right and left anterior maxilla according to the manufacturer's drilling protocol under isotonic saline irrigation at 800 rpm and 35 Ncm torque. Two dental implants of identical diameter and length were placed in each cadaver. Osteotomy widths were prepared according to implant diameter, while implant placement depth was standardized at 2 mm subcrestal to the alveolar crest level (Fig. 1). Implants were inserted at 35 Ncm torque and 30 rpm without saline irrigation (Fig. 2A-B).

First, primary implant stability was measured before grafting material placement in the jumping distance area with using the Ostell Mentor 3 device (Fig. 3). Measurements were obtained from three different directions (mesial, distal, and buccal), and the mean ISQ values were recorded for each implant.

Autogenous bone grafts harvested from the maxillary tuberosity region were applied to the buccal peri-implant defect area (Fig. 4A-B). Primary stability measurements were then repeated using the same protocol. After implant placement into the extraction socket, the jumping distance was filled with xenograft, followed by repeated RFA measurements (Fig. 5).

Thus, primary stability values obtained under three different conditions were compared in order to evaluate the effect of different graft materials on primary implant stability. Implant osteotomy preparation and implant placement procedures were performed by one clinician, whereas all stability measurements were conducted by a second independent clinician.

STATISTICAL ANALYSIS

In this study, primary stability measurements were repeatedly obtained from the same samples before and after graft application. Descriptive statistics for continuous variables were presented as sample size (n), mean, median, minimum–maximum values, and standard deviation (SD). Due to the limited sample size (n = 10) and the non-normal distribution of the data, non-parametric statistical methods were preferred.

Since the primary stability measurements obtained before and after graft application represented paired observations, comparisons were performed using the Wilcoxon Signed-Rank Test. This analysis was

used to evaluate the direction and magnitude of the effect of graft application on primary stability. In addition, “post–pre” difference values (Δ primary stability) were calculated for each sample in order to quantitatively assess graft-related changes.

To compare these difference values between different graft approaches, the Mann–Whitney U test was applied, as the analysis involved two independent groups. This analysis enabled evaluation of the relative effects of different graft materials on increases in primary stability. Statistical significance was set at $p < 0.05$. Results with $p > 0.05$ were considered statistically non-significant but were additionally interpreted in terms of potential clinical trends. All statistical analyses were performed using IBM SPSS Statistics 22 software.

RESULTS

This cadaveric study included 10 fresh-frozen human cadavers which a total of 20 dental implants placed in the anterior maxilla following extraction of the maxillary central incisors. Primary stability was assessed using resonance frequency analysis (RFA) under three different conditions: without grafting, after xenograft application and after tuber-derived autogenous bone grafting.

Descriptive statistics for all groups are presented in Tables 1 and 2.

Table 1 : Statistical analysis of primary stability values measured before and after xenograft placement in the extraction socket.

							Wilcoxon test	
	n	Mean	Median	Minimum	Maximum	ss	z	p
PRE- XENOGRAFT PLACEMENT	10	60,85	61,50	44,00	72,00	7,62	-2,6	0,009
POST-XENOGRAFT PLACEMENT	10	66,6	69	47	71	7		

Table 2 : Statistical analysis of primary implant stability values before and after placement of an autogenous tuberosity graft into the extraction socket.

							Wilcoxon test	
	n	Mean	Median	Minimum	Maximum	ss	z	p
PRE- TUBER GRAFT PLACEMENT	10	60,95	61,00	48,00	69,00	5,89	-2,04	0,041
POST-TUBER GRAFT PLACEMENT	10	67,60	69,50	48,00	72,00	7,01		

1) WITHOUT XENOGRAFT PLACEMENT (Primary Stability) vs. AFTER XENOGRAFT PLACEMENT (Primary Stability)

Descriptive findings:

-Pre-xenograft: n=10, Mean=60.85, Median=61.50, Min–Max=44.00–72.00, SD=7.62

-Post-xenograft: n=10, Mean=66.60, Median=69.00, Min–Max=47.00–71.00, SD=7.00

Statistical results (Wilcoxon):

-z = -2.60, p = 0.009

Primary stability values after graft placement increased significantly compared to pre-graft levels ($p < 0.05$). The negative z-sign depends on how the difference is defined in SPSS; however, descriptive statistics clearly indicate an increase (Median 61.5 → 69).

This finding suggests that graft placement (or the surgical/bone bed conditions performed alongside the graft) creates a biomechanical environment capable of enhancing primary stability. Clinically, this increase in primary stability may be associated with outcomes such as improved implant–bone contact and mechanical locking, thereby reducing early-stage micromobility. However, it should be noted that the increase in stability may depend not only on the graft material but also on accompanying factors such as the prepared osteotomy, bone quality, implant design, and timing of measurement.

2) WITHOUT TUBER GRAFT (Primary Stability) vs. AFTER TUBER GRAFT (Primary Stability)

Descriptive findings

-Pre-graft: n=10, Mean=60.95, Median=61.00, Min–Max=48.00–69.00, SD=5.89

-Post-tuber graft: n=10, Mean=67.60, Median=69.50, Min–Max=48.00–72.00, SD=7.01

Statistical results (Wilcoxon)

z = -2.04, p = 0.041

Primary stability values after the tuber graft placement are also significantly higher than before the graft placement ($p < 0.05$). Descriptive statistics show that the increase is evident at both the mean and median levels (Median 61.0 → 69.5).

The significant increase in primary stability following the tuber graft suggests that this approach may offer a clinical advantage, particularly in supporting mechanical stabilization. The ~8–9-point increase in median values may correspond to a perception of safer initial stability in clinical practice. However, the p-value of 0.041 is at the “borderline significance” level; therefore, given the limited sample size (n=10) and

potential individual variations, it is recommended that this finding be supported by studies with larger samples.

Overall conclusion (combined interpretation of the two comparisons):

Both paired analyses demonstrate a statistically significant increase in primary stability following graft placement ($p=0.009$ and $p=0.041$). This suggests that grafting procedures may have a positive effect on primary stability. However, the relatively small sample size and the controlled experimental conditions (bone quality, implant size/design, surgical protocol) may limit the direct applicability of the findings to clinical practice.

DISCUSSION

This cadaveric study demonstrated that both xenograft and autogenous bone graft placement significantly enhanced primary stability of the immediately placed implants with mean ISQ increased of approximately 5.75 and 6.65 units respectively. These findings corroborate earlier observations that peri-implant gap management directly influences mechanical retention in fresh extraction sockets. The statistically significant improvements align with biomechanical principles whereby grafting the jumping distance increases frictional resistance at the bone-implant interface.^{3,6}

Primary implant stability is maintained by the interplay between implant macro-design, osteotomy preparation and surrounding bone quality. Resonance frequency analysis measures this three-dimensional anchorage through ISQ values, which reflects the stiffness of the bone-implant complex. In the anterior maxilla, where the buccal bone is often thin, additional support provided by grafting materials can markedly enhance these stiffness values.^{3,4,13}

Immediate implant placement into fresh extraction sockets results in the formation of a circumferential gap known as the “jumping distance”. When this gap exceeds 2 mm, spontaneous bone fill becomes less predictable, thereby increasing the need for grafting procedures to maintain dimensional stability and implant support. In the present study, implants were placed 2 mm subcrestally, allowing adequate access for graft adaptation within the peri-implant defect and potentially improving early mechanical stabilization.^{5,14}

After the extraction, the alveolar ridge undergoes significant dimensional alterations, particularly at the buccal aspect where the thin bundle bone is prone to rapid resorption following the loss of periodontal ligament support. This physiological bone remodeling process results in horizontal and vertical ridge reduction, which can diminish the stability of immediately placed implants. By introducing grafting materials into the jumping distance—the gap between the implant surface and the bony socket wall—the clinician creates an osteoconductive scaffold that stabilizes the clot and may reduce post-extraction ridge remodeling, thereby contributing to maintenance of ridge contour and mechanical support.^{5,10}

Bone grafting materials ensure their stabilizing effect through distinct mechanisms: xenografts primarily provide osteoconductive support and space maintenance, whereas autogenous grafts may additionally contribute osteogenic cells and growth factors. The observed ISQ elevation after both graft types underscores the importance of defect obliteration in preventing micromotion during the critical initial healing phase.^{1,2,5,7,9}

Although autogenous tuber grafts demonstrated slightly greater median stability gains, no statistically significant difference was observed between grafting materials. This finding is consistent with previous studies indicating that both xenografts and autogenous grafts can provide effective short-term mechanical stabilization when appropriately adapted to the peri-implant defect. Nevertheless, the greater variability observed in the autogenous group may reflect differences in characteristics and biologic heterogeneity of autogenous bone.^{2,3}

Resonance frequency analysis remains a reliable and non-invasive method for evaluating primary implant stability in both clinical and experimental settings. In the present study, repeated ISQ measurements enabled objective assessment of the stabilizing effects of different grafting materials while minimizing inter-implant variability.^{3,4}

From a clinical standpoint, the documented increase in ISQ values supports the use of grafting procedures in immediate implant placement to improve primary stability and reduce the risk of early implant micromobility^{4,13}. Enhanced mechanical stabilization may facilitate earlier functional loading and improve treatment predictability, particularly in the anterior maxilla where esthetic and functional demands are high. Previous research studies have also suggested that immediate implant placement can help the preservation of peri-implant soft tissue architecture and favorable esthetic outcomes^{8,11}. Maintenance of crestal bone levels is also considered critical for preservation of the interproximal papilla and peri-implant esthetics¹². Although autogenous grafts possess osteogenic potential, xenografts offer practical advantages, including elimination of donor-site morbidity and more standardized handling characteristics.^{1,2}

Several limitations should be considered when evaluating the results of the present study. Because a cadaveric model was used, biologic processes such as bone remodeling, vascularization, and long-term osseointegration could not be evaluated. In addition, the relatively small sample size and single-time-point measurements limit the ability to reflect the dynamic healing conditions seen in clinical settings. Another limitation is that, only central incisor sites were evaluated, which may limit the generalization of the findings to other anterior regions with different anatomical characteristics.

Future clinical studies with larger sample sizes and long-term follow-up are necessary to further clarify the effects of xenograft and autogenous grafting on primary implant stability, peri-implant bone preservation, and long-term osseointegration outcomes in immediate implant placement.

CONCLUSION

Within the limitations of this cadaveric study, grafting of the peri-implant gap significantly enhanced primary implant stability in immediate implant placement. Both xenograft and autogenous bone graft placement demonstrated favorable effects on ISQ values, with no statistically significant difference observed between grafting materials. Although autogenous grafting showed greater variability, both approaches provided improved mechanical stabilization at the time of implant placement. Further clinical studies are needed to evaluate the long-term effects of the grafting protocols on osseointegration, primary stability and implant success.

Declarations

Funding

No funding was used in this research.

No financial support was received for the conduct of this study.

The authors declare that they have no conflict of interest.

✘ The authors declare that they have no financial interests or personal relationships that could have appeared to influence the work reported in this paper.

✘ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contribution

İsmail Doruk Koçyiğit was the principal investigator and supervisor of the study. He was responsible for the study design, data collection and evaluation, and overall supervision and coordination of the study. Bensu Esin and Rukiye Ceren Beker performed the experiments, contributed to data collection and analysis, and drafted the manuscript. Tahsin Tepecik contributed to the evaluation and interpretation of the experimental results and to the writing of the manuscript. All authors reviewed and approved the final manuscript.

Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Figures

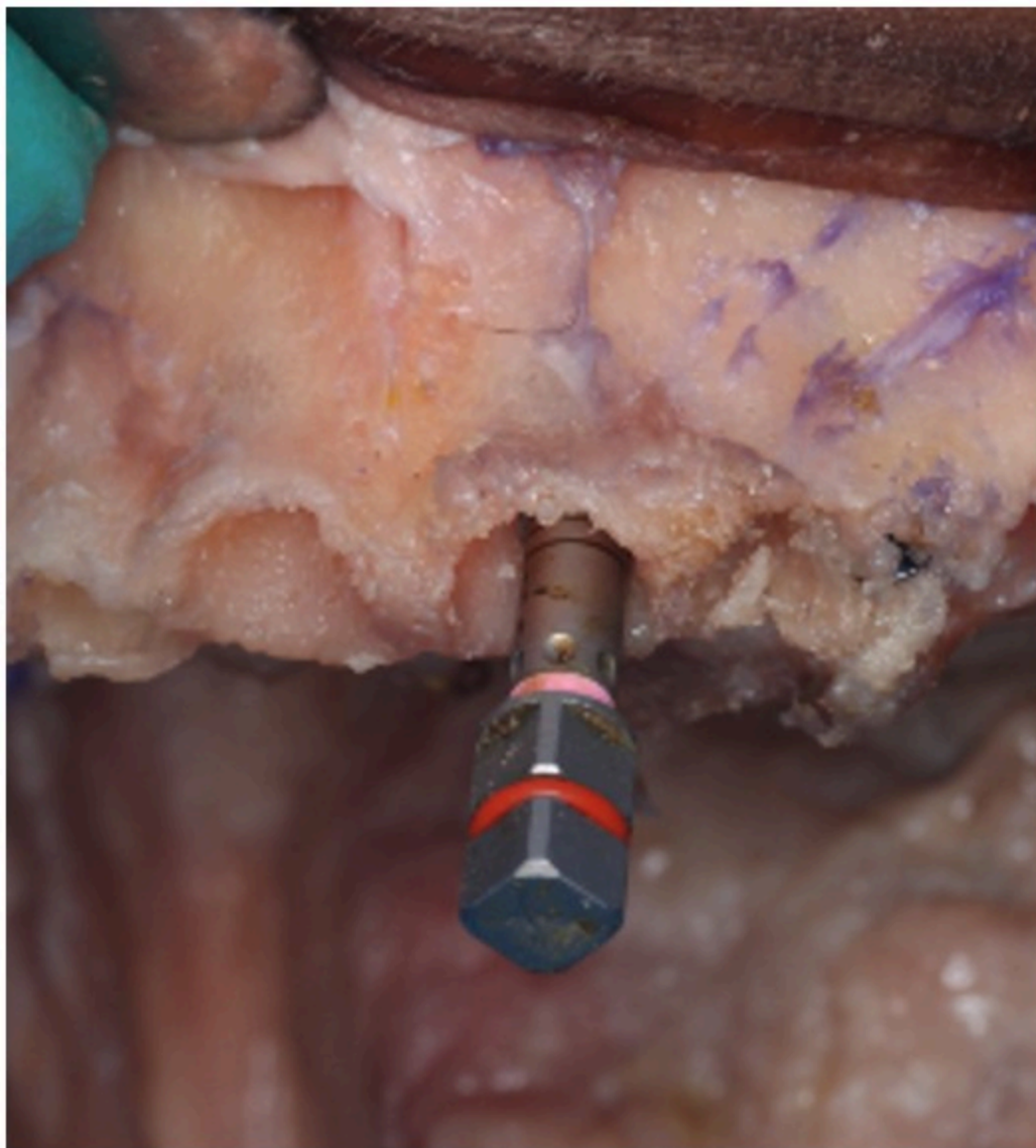


Figure 1

Standardized implant placement at a depth of 2 mm below the alveolar crest.

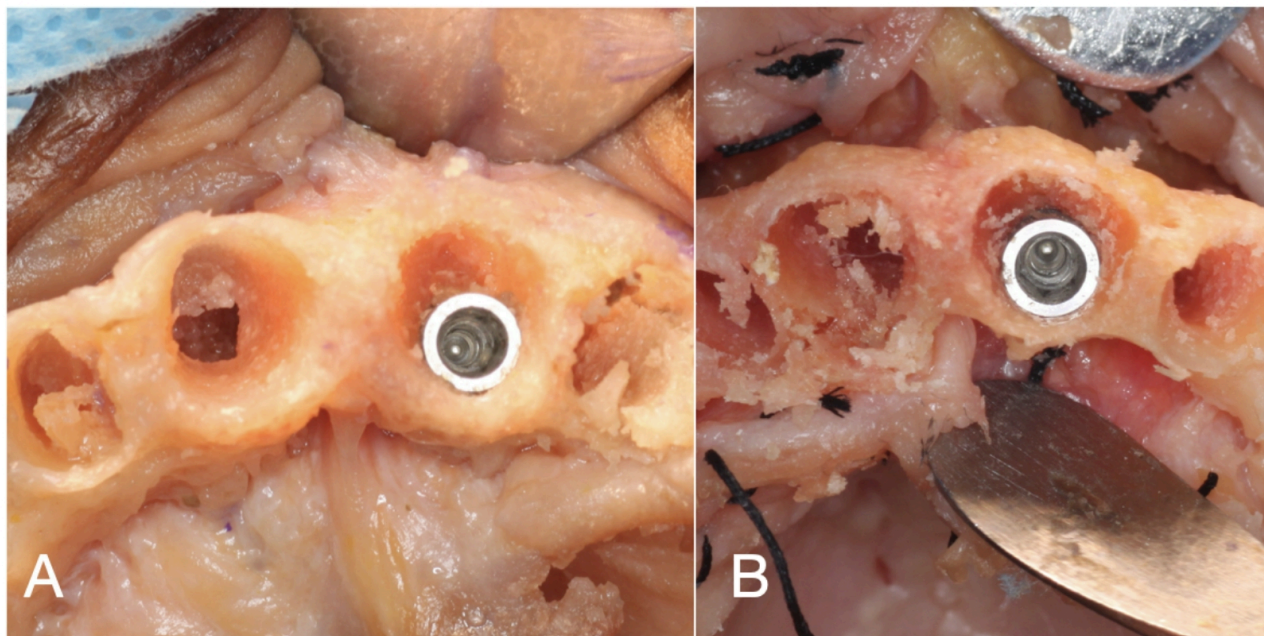


Figure 2

A-2B: Implants placed into extraction sockets before graft placement (xenograft or autogenous tuberosity graft), using an insertion torque of 35 Ncm at 30 rpm

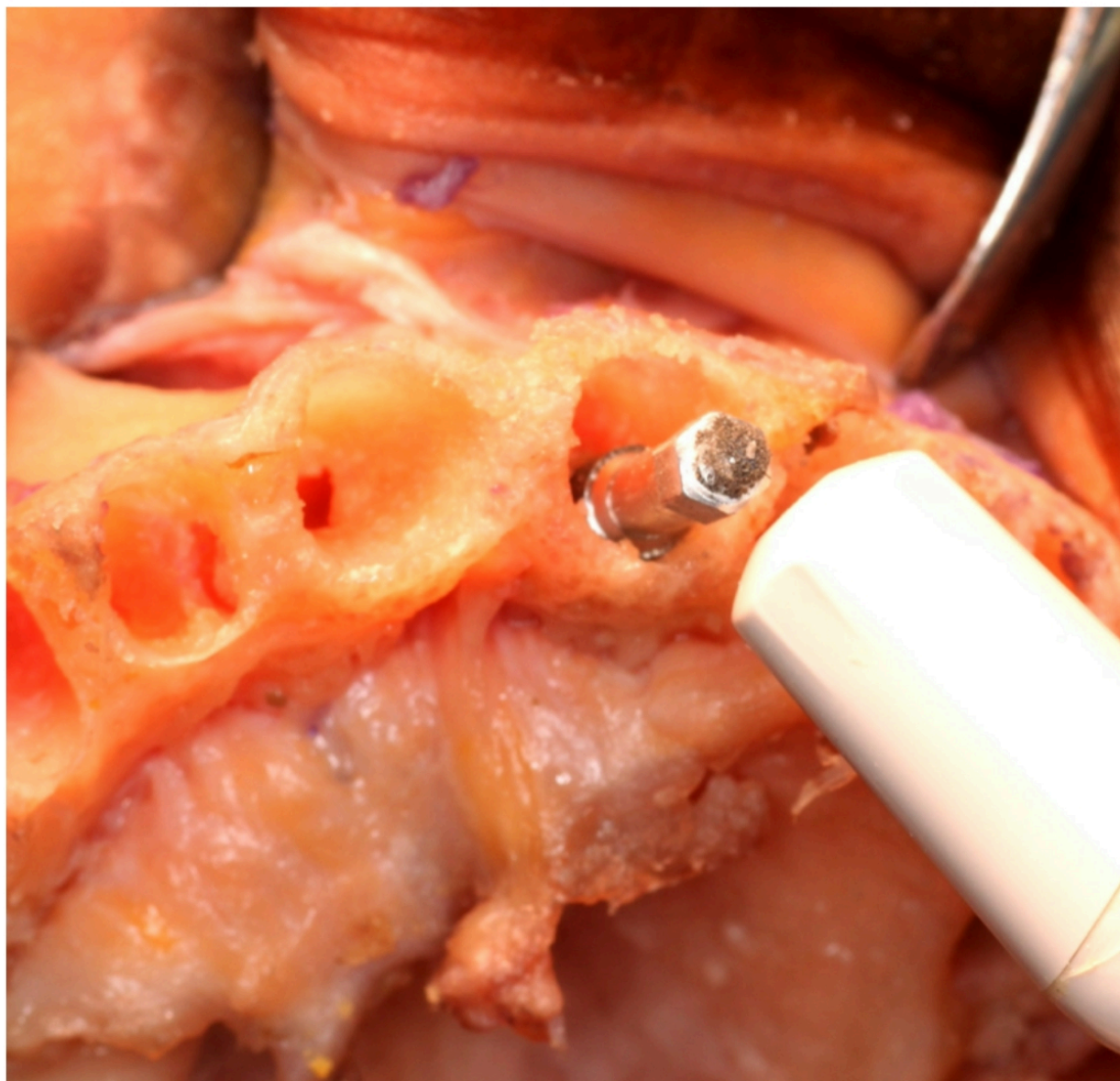


Figure 3

Primary implant stability was measured before grafting material placement in the jumping distance area with using the Ostell Mentor 3 device

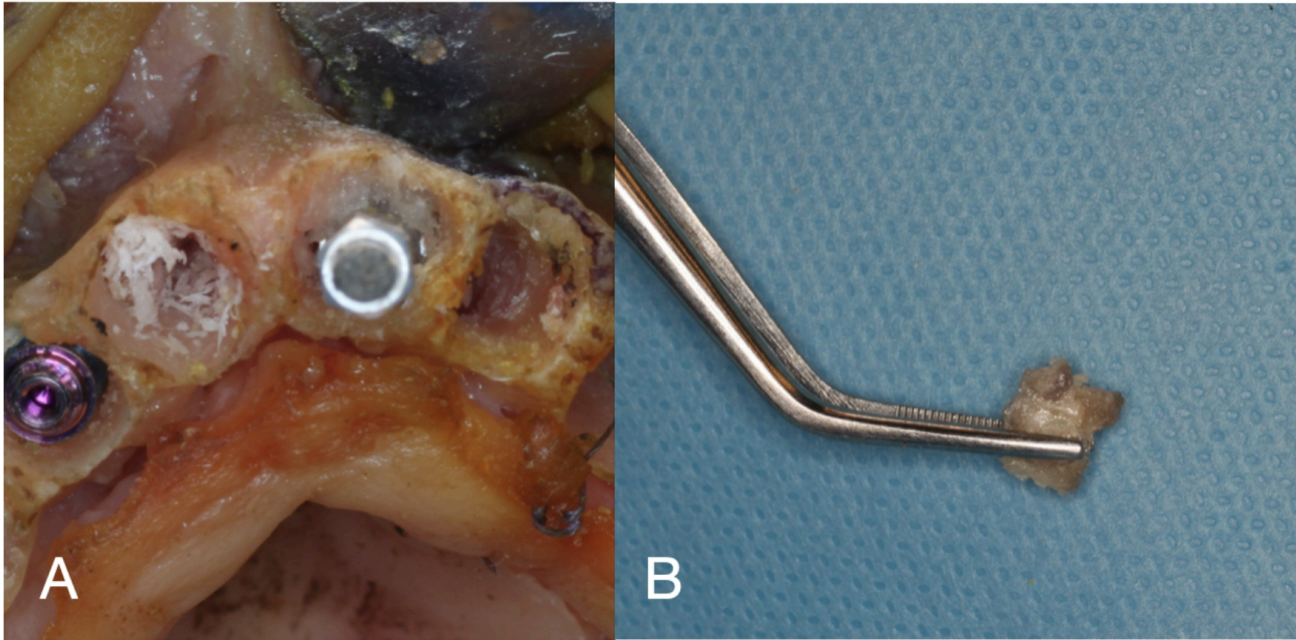


Figure 4

A. Placement of the autogenous graft harvested from the maxillary tuberosity.

Figure 4B. Clinical view of the autogenous graft harvested from the maxillary tuberosity



Figure 5

Placement of xenograft