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CLINICAL REVIEW

USE OF PIEZOSURGERY IN IMPLANT DENTISTRY

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Abstract

Piezosurgery is a new and modern innovative method of bone surgery in implantology.
The purpose of this review was to present, through a literature review, the clinical applications of piezosurgery in implant dentistry and outline their advantages and disadvantages compared to conventional surgical systems.
The main advantages of this technique are precise cuts, absence of thermal damage and preservation of soft tissue structures. Thanks to the use of piezoelectric surgery, increased efficiency the preparation of the site for the implant, bone grafting, elevation of the sinus floor, splitting of the edentulous crest, lateralization of the inferior alveolar nerve. The reduced blood loss the risk of complications is minimized.

Keywords: *implantology, piezoelectric device, piezosurgery, maxillary sinus elevation, bone grafting, osteotomy, edentulous ridge splitting*

Introduction

Treatment success in implant dentistry, periodontology and oral surgery must take into account more precise biologic criteria. These criteria include: using atraumatic surgical procedures; limiting risks to surrounding tissues; an improving visibility, haemostasis and postoperative conditions.
Most instruments available today have not met all above criteria in helping the clinician during treatment process. Manual mechanical instruments like saws, burs, and/mallets and chisels available today in many ways are modifications of old technology.
Currently, piezosurgery is widely used in oral surgery and implantology, various devices are available.[1] Piezoelectric bone surgery, also simply known as piezosurgery, is a new technique for osteotomy and osteoplasty utilizing an innovative ultrasonic surgical apparatus.
In today's dentistry, it is desirable to have in one's disposal a surgical precision instrument tailored in every aspect of periodontal and implant surgery of hard tissues.[2]
Furthermore, an instrument that helps to create a visual acuity during surgery, minimise the trauma to the bone and surrounding tissues and help in reduced postoperative complications and optimal healing process.[3] The Piezosurgery device has been developed to overcome the limits of precision and intra-operatory

safety existing in traditional bone cutting instruments. Piezosurgery allows the clinician to obtain high predictability and low morbidity in bone surgery. The technique of working with a piezoelectric device is based on the use of microvibrations at a certain ultrasonic frequency modulated by sound waves.[4]

The joint work of sound and ultrasonic frequencies (25–30 kHz) creates a mechanical shock wave, which oscillates in a linear way, with vibration amplitude (horizontal 20–200 µm, vertical 20–60 µm).

Since cutting soft tissues requires frequencies of more than 50 kHz, only mineralized tissues are cut with the vibration amplitude of the tip of the piezoelectric device. This reduces damage to the nerves and membranes of the sinus, and the reduction in the risk of overheating is due to the occurrence of a cavitation effect in the irrigation solution due to mechanical micro-movements with a frequency of approximately 25–30 kHz.

Due to their characteristics, the microvibrations allow a selective cut of only mineralized structures without damaging soft tissues, which remain undamaged even in case of accidental contact. The micrometric vibration ensures precise cutting action and at the same time maintains a blood-free site because of the physical phenomenon of cavitation. The micrometric vibration makes the instrument manageable and permits major intra-operative control with a consequent increase in safety especially in anatomically difficult areas.

In 2001, Piezosurgery® was introduced, an instrument that combines ultrasound and piezoelectric effect.[5]

Piezosurgery approach to hard tissue surgery was developed in the 1980's. It is derived from basic principles of "piezoelectricity" discovered by Jacques and Pierre Curie in the late 19th century. The idea of bone cutting was also assessed by Horton et al 1975, 1981 using ultrasonic modulated frequency.[6]

Further advances were made by Torella et al (1998) and Vercellotti et al (2001) that have perfected and adapted to clinical needs.[7-9]

Cavitation effect is a result of vibrations at the tip of the instrument (2-3mm from the tip). The air bubbles formed vibrate with their source, increase in size and explode. This phenomenon, which has antibacterial properties, is called cavitation. It depends on the frequency not the amplitude of the ultrasonic vibration.

These three key factors above surpass any instrument available today as a one tool that is inseparable in my practice in areas of implant dentistry, as well as periodontal surgical procedures and minor oral surgery.

Applications Implant surgeries [10,11]

1. Implant site preparation
2. Extraction for immediate implant placement
3. Bone graft harvesting
4. Alveolar ridge expansion
5. Sinus lift procedures
6. Nerve mobilization for implant prosthetic issues
7. Removal of implants

The controlled three-dimensional ultrasound microvibrations, the piezosurgery technique opens up a new age for osteotomy and osteoplasty in Implantology, Periodontology, Endodontics, and surgical Orthodontics.[12]

- Micrometric Cut: Precise cutting actions with an excellent surgical tactile control
- Selective Cut: Minimizing of the risk of adjacent soft tissue damage
- Cavitation Effect: Maximum intra-operative visibility

Piezoelectric bone surgery, also simply known as piezosurgery, is a new technique for osteotomy and osteoplasty utilizing an innovative ultrasonic surgical apparatus.[13]

The precise nature of the instrument allows exact, clean, and smooth cut geometries during surgery. Postoperatively, excellent wound healing is observed. It is apparent that the range of application of piezosurgery is not limited to minor operations. Because of its highly selective and accurate nature, with its cutting effect exclusively targeting hard tissue, its use may be extended to more complex oral surgery cases, as well as to other interdisciplinary problems.

Piezosurgery technique was created and developed in response to the need to reach major levels of precision and safety in bone surgery, as compared to that available by the usual manual and motorized instruments.[14,15]

The absence of macro-vibrations makes the instrument more manageable and allows greater intra-operative control with a significant increase in the cutting safety in the more difficult anatomical cutting zones. The oscillation at the tip with saline jet created an effect of cavitations effect giving the operator maximum visibility, even in most difficult excess area encountered during surgical procedures. This creates a visual acuity, combined with micrometric precision cuts, offers safety, comfort to both the patient and the operator in delicate surgical scenarios.

This precise and atraumatic technique however requires a learning curve and training to understand the perfect balance using hand pressure and vibrating tip of the instrument.

The piezosurgery technique differs considerably from a drill orientadet clinician, where considerable force is required to “mechanically cut the bone” piezosurgery is more closely resemble in laser surgery from user angle rather than from handpiece pressure concept of bone cutting.

The difference in time requirement for surgical procedures using the piezosurgery instrument in comparison with the conventional drill is negligible. Naturally there are always imitations, however adjunct clinical tool, it definitely sets new standard in most aspects of surgical dentistry. The clinical examples provided will help the clinician to perhaps look at a different angle of clinical applications and indications of piezosurgery.

Contraindications

Electrical implants such as pacemakers, in either the patient or the clinician.

Preparing implant osteotomies in fresh extraction sockets using piezosurgery

Although literature states that tooth extraction must be atraumatic during implant placement, the accepted protocol for method of atraumatic extraction in contemporary implant dentistry especially where immediate implant placement is indicated, needs to be addressed in detail.[16]

Vigorous tearing of the periodontal membrane using conventional tooth extraction measures can lead to alteration of the delicate bundle bone and blood supply disruption, created by twisting and apical movement during forceps extraction. This procedure is even more applicable where the roots are brittle and deeper positioned in the alveolar socket.[16]

Figure 1. Sectioning of the tooth (intra-alveolar in-fracture): no disruption to the socket

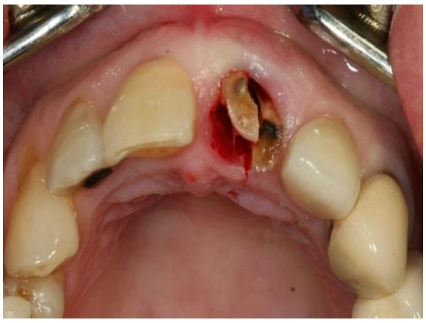


Figure 2. Ultrasonic tip gently cuts the PDL fibres surrounding the root and the socket: the tooth is easily mobilised, can easily continue apically 7-10mm to mobilise the roots using periotomes

Figure 3. Tooth is removed in sections to preserve the delicate labial cortical bone and it’ vascular supply: preserving the regional anatomy. Gingival margin has remained intact. Note limited bleeding during extraction

Preparing implant osteotomies in fresh extraction sockets using piezosurgery has the following advantages[3,17];

1. Notching the apical third of the wall at exactly correct 3D position, which is very simple compared to drill-orientadet. Surgeon, as there is no sslipping of the bur along the incliding palatal bone.
2. This also leads to no damage to delicate buccal cortical plate that we are trying to preserve.[18]
3. Cavitation effect gives an excellent visual acuity.

Nalbandian S. Use of Piezosurgery in implant dentistry. *Bulletin of Stomatology and Maxillofacial Surgery*. 2023;19(2):51-62. doi: 10.58240/1829006X-2023.19.2-51

4. Osteotomy bed can be prepared and reshaped by almost splitting and forming the palatal bone (provided it is 3-4mm) into newly fully formed osteotomy site. This procedure also condenses bone improving the primary stability.[19]
5. This is a fast, if not faster procedure than conventional drill osteotomy.

Sinus lift transcrestal approach using piezosurgery

Prosthetic rehabilitation is based on accurate diagnosis and treatment planning. Systemic and local conditions compatible with implant placement and sinus floor elevation procedures must be assessed; the absence of signs and symptoms of sinus diseases, as confirmed by clinical examination and radiographic assessment prior to the maxillary sinus floor augmentation.

The sinus lift was initially introduced as a lateral approach by Tatum in 1976[20] and subsequently published by Boyne in 1980.[21] Surgical techniques for sinus floor elevations using the transcrestal approach where fundamentally rely on the fracture or perforation of the sinus floor by means of osteotomes.[22-27]

However, both bur-driven and osteotome procedures present advantages and limitations. Osteotomes may increase the density of the soft maxillary bone while tenting the Schneiderian membrane by the hydraulic pressure of the bone graft pulled into the sinus. Where the implant site preparation is realized by the use of a trephine drill this trephined core of autogenous bone in many cases helps the vertical bone augmentation during the elevation of the sinus floor. Controlling the pressure of osteotomes is difficult that can result in penetration of sinus, membrane perforation and graft entry into the sinus. The problem is when a thick layer cortical bone remains at the sinus floor; the osteotome technique may require vigorous traumatic malleting during sinus floor elevation. Benign paroxysmal positional vertigo (BPPV) has been as post-surgery complication.[4]

The use of burs with different working lengths provides a controlled perforation of the sinus floor, restraining the action of the cutting edge to the native bone and limiting the risk for perforation of the sinus membrane. However, the tactile sensitivity of piezosurgical tips and visual acuity provided by cavitation effect gives that added confidence during clinical procedures, creating 90% of osteotomy; bone spreading and elevating sinus floor, reducing sinus floor perforation. In edentulous patients with insufficient bone volume and therefore reduced ridge height, sinus floor elevation is often the most appropriate solution for implant placement. Although the lateral window is probably the most commonly used technique, other techniques have been described, including crestal access. If there is 4mm or more vertical height of existing bone, a simultaneous placement of the implant is usually performed, as there is adequate bone to stabilize the implant while the bone graft matures. Where there is a perforation of the membrane, the procedure is delayed 2-3 months, in most cases. Sinus floor carefully dissected using piezosurgery tips as well as preparing the osteotomy site simultaneously. Internal sinus lift crestal approach-Hydro pneumatic pressure using saline subjected to piezoelectric cavitation.[28]

Using piezosurgery simultaneous osteotomy, sinus lifts and implant placement in prosthetically optimal position residual bone height (i.e., the distance from the bone crest to the sinus floor) ≥4 mm. A 3-4mm diameter osteotomy is performed in crestal bone at the site of implant placement to stop inferior to the Schneiderian membrane to avoid perforation. This is probably requiring a considerable learning curve and is the most technique sensitive aspect of the entire procedure. Graft material of choice is then placed in the osteotomy. Blunt Instruments are used to gently place graft material in the sinus, using the membrane to maintain the graft. Piezosurgery provides easy access and maximum tactile sensitivty to the operator contemplating any sinus lift procedures. This is especially important in delicate, difficult acess area in the posterior regions of maxilla.

Figure 4. Sinus floor carefully dissected using piezosurgery tips as well as preparing the osteotomy site simultaneously

Figure 5. Internal sinus lift crests al approach-hydro pneumatic pressure using saline subjected to piezoelectric cavitation

Figure 6. X-rays before implant placement

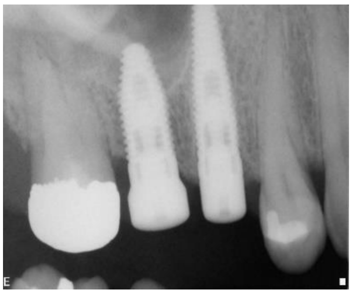


Figure 7. X-ray after implant placement

Figure 8. Optimal prosthetic platform for individual implant supported PFM crowns

Figure 9. PFM crowns with implant support after fixing

Sinus Lift-Latreal window approach using piezosurgery

The lateral window surgical procedure involves the removal of the bony window of the anterior wall of the maxillary sinus. Perforation of the Schneiderian membrane can occur both during the removal of the bone window and during the elevation itself.[29,30]
If perforation occurs and bone grafting is completed, there is a risk of an inflammatory complication that may require further surgical interventions, including revision of the maxillary sinus. Therefore, it is very important to avoid any perforation. A precise cutting device that does not perforate the Schneiderian membrane is preferred over conventional methods. The hydropneumatic pressure of the applied elements, through a cooling solution, helps in dissection of the maxillary sinus membrane. More articles have been published on the use of a piezoelectric device for sinus augmentation with a lateral window.[31-36] The use of a piezoelectric device reduces the incidence of membrane perforation in surgeons with limited experience. Piezosurgery provides easy access and maximum6tactile sensitivty to the operator contemplating any sinus lift procedures " you can feel the bone at the tip of your instrument".

Split alveolar ridge using piezosurgery for narrow ridge

Edentulous site enhancement (ESE)[6] is a systemic regenerative approach that improves the anatomy of the edentulous site en mass, independent on any specific implant system and applicable in most clinical situations, irrespective of aesthetic requirements.[16,37] ESE approach helps uses implant and prosthetic components to restore ideal bone and mucosal contours, since ideal bone scaffolding and mucosal dimensions are provided optimal outcome.


Figures 10; 11. 2.5mm width narrow ridge

Figure 12. Split thickness flap[1] to maintain periosteal blood supply to the ridge crest ridge width 2.5mm

Figure 13. No bone flap-vertical bony incision

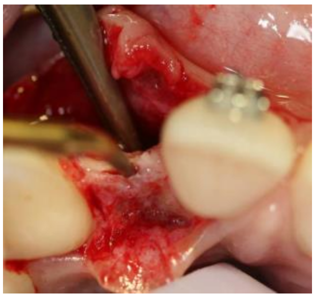


Figure 14. Careful piezosurgery assisted osteotomy splitting and expanding the ridge from 2.5mm to 4.2mm to house 3,5mm diameter implant

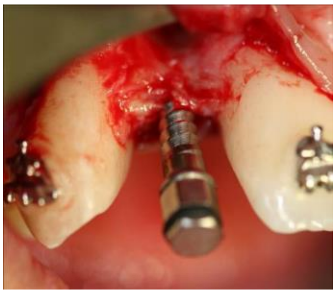


Figure 15. Meisinger rotary osteotomes shaping the implant osteotomy

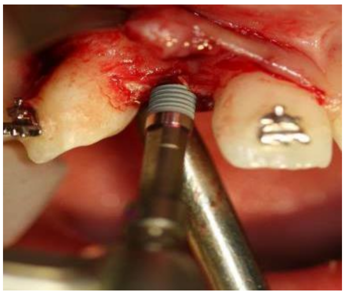


Figure 16. Implant placement at 32 Ncm: good primary stability obtained

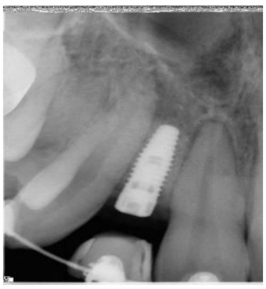


Figure 19. X-rays after implant placement

Figure 20. X-ray after provisional crown fixin

Figure 21. Long-term provisional crown 18 months post op

Split alveolar ridge is a recognized surgical technique that allows the implant to be inserted into a narrow and atrophic alveolar ridge. With insufficient width of the alveolar ridge, the technique of splitting the edentulous ridge can be applied. For this procedure, the lingual plate is separated from the buccal plate of the edentulous ridge. Alveolar ridge splitting is possible with piezosurgical approach. Case reports and studies demonstrate the successful use of a piezosurgical device.[38-40]

Bone separation with a piezoelectric device is possible even in difficult bone situations thanks to precise and well-defined cutting abilities without macro vibrations. Narrow 2.2- 2.5mm ridge expansion using combination of piezosurgery assisted osteotomy and Meisinger rotary osteotomes: ridge expansion and shaping the implant osteotomy is solution. Crestal split augmentation technique involved a surgical osteotomy that was followed by alveolar crest split and augmentation after buccolingual bony plate expansion, prior to implantation. A minimally invasive approach allows toreduce the surgical trauma and postsurgical discomfort. The complete vascular supply is maintained, the bone resorption is reduced, and the connective epithelium does not undergo postsurgical retraction, achieving the full maintenance of the residual keratinized gingiva.

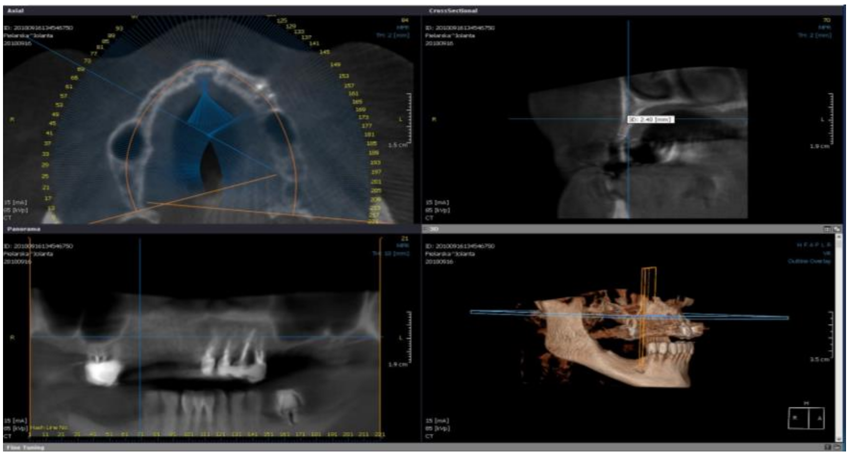


Figure 22. CT Narrow ridge 2.1mm site 15 Class IV (Cawood & Howell 1988)

Figure 23. Mid-crestal incision: note the narrow ridge 2.5mm -3.00mm

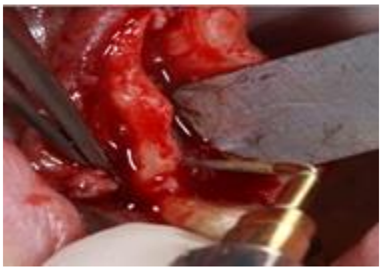
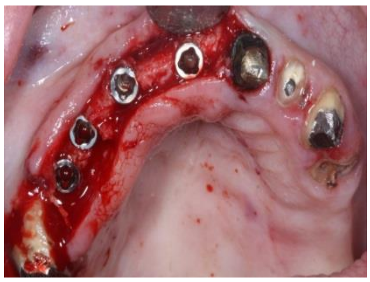


Figure 24. Osteotomy by piezosurgery. The Piezosurgery OP5 insert at initial site of the proposed osteotomy

Figure 25. IM2A 2mm Osteotomy Inserts



Figures 26, 27, 28. Maxillary Implant placement & Provisionalisation

Nalbandian S. Use of Piezosurgery in implant dentistry. *Bulletin of Stomatology and Maxillofacial Surgery*. 2023;19(2):51-62. doi: 10.58240/1829006X-2023.19.2-51

Figure 29. Intraoral condition before crestal ridge expansion piezosurgery split augmentation technique

Figure 30. 14 days Post Op: Ridge expansion and placement of 7 fixtures

Disscusion

Healing of the implant within the biologic envelope is a natural tissue engineering that helps to generate native bone to the implant surface. Enhancing implant survival as it is within the native bone. The main advantages of using piezoelectric devices are precise and selective cuts, no thermal damage and preservation of soft tissue structures. This highly predictable surgical procedure is the result of precise and conservative use of piezosurgery assisted osteotomy and bone spreaders that allows the implants to be placed at the same time: reducing treatment time, overall cost and number of surgical procedures, especially in the maxillary atrophic ridge.[41-43]

Through the use of piezoelectric surgery, implant site preparation, bone grafting, sinus floor elevation, edentulous ridge splitting, or inferior alveolar nerve lateralization are technically feasible.[44]

The use of piezosurgery in areas with very dense cortical bone may have limited cutting capacity and may not work as efficiently as burs and thus may not be suitable for all types of implant site preparation.

Samples of cortical bone particles were collected using ultrasound or conventional drills. Bone particles were compared using histomorphometric analysis. The study concluded that autogenous bone particles harvested by ultrasound contain vital cells that differentiate into osteoblasts compared to conventional osteotomies.[45]

Postoperative recovery and wound healing after piezosurgery are favorable for achieving optimal bone regeneration. The use of piezosurgery can also benefit the patient by reducing postoperative swelling and trismus, as well as speeding up the healing process. In addition, the absence of piezosurgery-induced osteonecrosis and the positive effects on bone healing and osteogenesis mean that piezosurgery is a valuable tool to have in your dental implant arsenal.

A few histomorphometrical, immunohistochemical, and molecular analysis comparing piezosurgery with conventional drills and oscillating saws observed similar rate of bone healing but slightly more bone formation following piezosurgery.[46] Bone harvested using PS device was found to contain more osteoblast like cells.[47]

Stubinger et al. observed better periosteal microcirculation while using PS device for subperiosteal preparation which could be an incentive for enhanced bone metabolism.[4]

One of the key disadvantages of piezosurgery is time: the piezoelectric scalpel requires repeated application to the bone to gradually deepen the incision and complete the osteotomy. This increase in preparation time inevitably entails financial implications, so slightly higher costs may be required.[48]

This clinical review provides a brief overview of the current literature and describes the advantages and disadvantages of piezoelectric bone surgery in implant dentistry.

The outlook for the use of piezosurgery promises to revolutionize implantology, with most studies agreeing that the piezoelectric device is extremely efficient and accurate and recommend its use. In the near future, piezoelectric instruments will become an integral part of any procedure in maxillofacial surgery and implantology.

With the advent of technological advances, piezosurgical devices will become a promising technique with numerous applications in various disciplines of dentistry.

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ՊԻԵԶՈՎԻՐԱԲՈՒԺՈՒԹՅԱՆ ՕԳՏԱԳՈՐԾՈՒՄԸ ՍՏՈՄԱՏՈԼՈԳԻԱՅՈՒՄ

Սարգիս Նալբանդյան

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Ամփոփում

Պիեզովիրաբուժությունը իմպլանտոլոգիայում ոսկրային վիրահատության նոր և ժամանակակից նորարարական մեթոդ է: Այս գրականության վերլուծության նպատակն է ներկայացնել պիեզովիրաբուժության կլինիկական կիրառությունները ստոմատոլոգիական իմպլանտոլոգիայում և ուրվագծեր դրանց առավելություններն ու թերությունները՝ համեմատած սովորական վիրաբուժական համակարգերի հետ:

Այս տեխնիկայի հիմնական առավելություններն են ճշգրիտ կտրվածքները, ջերմային վնասվածքների բացակայությունը և փափուկ հյուսվածքների կառուցվածքների պահպանումը: Պիեզոէլեկտրական վիրաբուժության կիրառման շնորհիվ իմպլանտի համար տեղանքի պատրաստումը, ոսկրային փոխպատվաստումը, սինուսի հատակի բարձրացումը, անատամ գագաթի ճեղքումը, ստորին ալվեոլային նյարդի կողայինացումը, արդյունավետությունը բարձրացնում է: Արյան կորստի նվազեցման դեպքում բարդությունների ռիսկը նվազագույնի է հասցվում:

ИСПОЛЬЗОВАНИЕ ПЬЕЗОХИРУРГИИ В ИМПЛАНТОЛОГИИ

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Абстракт

Пьезохирургия – это новый и современный инновационный метод костной хирургии в имплантологии.

Цель обзора состояла в том, чтобы представить посредством обзора литературы клинические применения пьезохирургии в имплантационной стоматологии и обозначить их преимущества и недостатки по сравнению с обычными хирургическими системами.

Основными преимуществами данной методики являются точные разрезы, отсутствие термических повреждений и сохранение структур мягких тканей. Благодаря применению пьезоэлектрической хирургии повысилась эффективность подготовки места для имплантации, костной пластики, поднятия дна пазухи, расщепления беззубого гребня, латерализации нижнеальвеолярного нерва. Уменьшается кровопотеря, риск осложнений сводится к минимуму.

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