Is Piezoelectric Surgery the New Gold-Standard in Oral Surgery and Implantology?
A Scientific Literature Review

Troedhan Angelo - MD, DMD, PhD
Specialist Craniomaxillofacial Surgery, Specialist Dentistry
V.Prf. Health Science University Vientiane – Lao PDR | Vienna, Austria | dr.troedhan@gmail.com

Ziad Tarek Mahmoud - DDS, MSc
Lecturer of Oral and Maxillofacial Surgery, Faculty of Dentistry, Alexandria University | Alexandria, Egypt | drziadmahmoud@gmail.com

ABSTRACT
Mills, drills, burs and low-frequency oscillating saws were the only tools for bone-cutting for a long time and their use rarely questioned on their biological and physiological effects on bone. With the emergence of new technologies in bone-cutting - such as lasers and piezoelectric cutting devices - more and more experimental and clinical studies shed light on the differences in the bone healing-cycle when traditional instrumentation is compared to these new technologies.

A search in medical and biomedical databases was performed and molecular-biologic, micromorphologic, histologic, experimental and clinical comparative studies were selected, excluding case-reports and unclear methodology. Experimental and clinical findings then were summarized and compared against each other by their micromorphologic, histologic, biologic and clinical effects resulting in a comparative overview with impact to the clinician’s daily routine-work.

At the current state of secure knowledge, scientific literature suggests piezoelectric surgical tools for bone-cutting to provide the highest clinical precision, the least procedural bone-loss, an improved bone-healing and best “ease-of-use”.

KEYWORDS

INTRODUCTION
Surgical procedures in dentistry and Oral and Maxillofacial surgery (such as tooth removal, apicectomies, periodontal surgery, bone-management, guided bone regeneration (GBR), dental implant insertion, orthognathic surgery etc.) are performed traditionally with chisels, burs, osteotomes and low-frequency oscillating saws.

However, rotating or low-frequency oscillating instruments are very difficult to handle when used on cortical and trabecular bone due to its procedural high physical torque-moment. The result is a loss of tactile sensitivity due to the requirement of pressure on the hand-piece, difficulty in the determination of cutting depth and iatrogenic impairment in undesired areas due to a failure in the accurate adjustment of the speed of a rotating bur or oscillating saw, particularly when ultimate precise osteotomies are essential.1 When chisels or osteotomes are used, labyrinthine concussion of the inner ear, positional vertigo or even brain concussion may occur.2,3

Major and unavoidable medical drawbacks of the use of motorized rotary, reciprocal or low-frequency oscillating instruments in bone-cutting are enormous procedural bone losses, significant bone-necrosis due to overheating and the high risk of soft tissue injury to important anatomical structures such as the inferior alveolar nerve or maxillary sinus-membrane and deposition of metal shavings and bacterial contamination.4-7

Burs serrations are quickly filled with the squamous bone removed, which makes them blunt and less effective, resulting in the need to apply increasing pressure on the handpiece which in turn may contribute to excessive frictional heat produced during preparation, leading to post-surgical complications such as bone-necrosis, pain, retarded or prevented healing.8

Although the use of rotating and low-frequency oscillating instruments deliver acceptable clinical results in the everyday surgical practice, their use is always highly traumatic on the microscopic, histologic and molecular
level and their correct application is highly related to the surgeon’s manual capabilities. Rotating burs and low-frequency oscillating saws historically were the only common devices available to cut bone tissue in oral and maxillofacial surgery. By the end of the last century, piezoelectric surgical devices — well known in orthopedic surgery since 1974 — and lasers of different wavelengths (Ne:YAG 1064nm, Ho:YAG 1980nm, Er:YAG 2940nm, ErCr:YSGG 2780nm, CO₂ 9400/10600nm, Excimer-UV 193nm) were introduced to clinical application also in oral and maxillofacial bone surgery.

While piezoelectric surgical tools were specifically and originally developed and designed to cut bone, lasers were used for soft-tissue cutting and only few possible clinical applications and indications are known and verified for osteotomies of jaw-bones and none in orthopedic surgery.

Any tissue-cutting laser (Light Amplification of Stimulated Emission of Radiation) produces a coherent light beam of a specific wavelength mostly in the infrared (=heating) spectrum of electromagnetic waves. This infrared “heat-beam” then causes a sudden circumscribed microscopic explosive boiling of cell- and interstitial tissue-liquids (known as “photoacoustic effect”), leading to a thermo-mechanical ablation of soft-tissues and in case of bone, dentin and enamel to the explosive ejection of mineral particles. Once the liquid of the targeted tissue is consumed and fully evaporated, the mere heat of the laser-beam causes heat-coagulation and shrinking of collagen-fibers similar to the electro-coagulation of tissues treated with electric knives and coagulator-devices (“electrotomes”). As consequence, oral soft tissues - composed of approximately 70% watery liquid – endure laser-radiation longer than bone, which contains only approximately 22% watery liquids, before sudden exponential temperature-increase leads to heat-necrosis, microfractures and carbonization of bone and dentin (Fig.1).

This physical mode of action of lasers on different types of body-tissues requires a profound knowledge and a diligent and long training of the surgeon for a safe application. Moreover, lasers must not be used in vicinity of delicate soft-tissue-structures such as sinus-membranes and infraorbital, mental and mandibular nerve since they do not provide any kind of cutting-depth-control, thus limiting their application in oral and maxillofacial bone-surgery significantly.

Piezoelectric devices for bone-surgery-applications are based on the ultrasonic fast and precise unidirectional expansion and contraction of piezoelectric crystals when electric voltage is applied to them. These precise oscillations at a rate of 27 – 32 KHz (27 thousand to 32 thousand unidirectional movements per second) are modulated in their amplitude and extend alternately from 30 – 60 micrometers to preserve the basic collagenous texture of bone (Fig.2).

Obviously, these small and precise unidirectional movements at ultrasonic speeds do not cause any adverse torque-forces due to the physical inertia and thus allow the surgeon a pressure-free and precise guidance of the ultrasonic surgical working tip on and in the bone. A physical effect caused by well-constructed Piezotomes in liquid-containing tissues and surrounded by the cooling saline-solution-flow is the so called “hydrodynamic cavitation effect”, which cannot be seen with the unaided eye because of its speed. Any solid body oscillating in liquids at ultrasonic speeds creates a partial vacuum on the opposite side of the direction of movement, decreasing the boiling-temperature of the liquid to room temperatures effecting into a strong and expanding cool gaseous “cushion” around the oscillating working-tip (Fig.3).
This is why cutting bone with Piezotomes is less a mechanical process like with burs, saws or chisels but more an atraumatic and microscopic precise separation of soft and hard-tissue layers by the separating pressurized gaseous “cushion” around the oscillating tip, gliding through the bone like a Hovercraft glides over water and similar to the photoacoustic effect created by infrared laser-beams. Contrary to laser-beams - which can only focus on one single microscopic spot at a time and which create microscopic gas-bubble-explosions at approximately 100°C or more (overheated gas) - Piezotome-working tips are flat-covered with gaseous bubbles at room-temperatures or below.\(^{(21)}\) (Fig.3)

Moreover, the hydrodynamic cavitation effect also causes less mechanical destruction of blood vessels compared to rotary instruments, which results in an almost bleeding-free surgical site. It also helps to maintain good visibility onto the surgical site by dispersing the coolant saline solution as an aerosol that causes the sparse blood to wash away.\(^{(21)}\) In addition, the hydrodynamic cavitation-effect inheres a disinfecting property similar to infrared lasers, attributed to the fragmentation of bacterial cell walls.\(^{(23,24)}\) A significant decrease of risk of intrasurgical dispersion of infections into the surrounding bone is the result compared to rotary instruments.\(^{(6,7)}\)

**BIOLOGIC & PHYSIOLOGIC EFFECTS OF PIEZOELECTRIC BONE-SURGERY APPLICATION**

**HISTOCHEMICAL EFFECTS OF APPLICATION OF ULTRASOUND ON SOFT AND HARD TISSUES**

In general medicine, orthopedic surgery and traumatology the positive effects of ultrasound-application to significantly enhance healing processes are well known since the last century. Ultrasound application enhances significantly the production of Interleukin 8 (IL8), Fibroblast Growth Factor (FGF) and Vascular Endothelial Growth Factor (VEGF), promoting a faster and richer vascularization of the healing site both in soft and hard tissues as well as the growth of the organ-specific collagenous fiber-pattern which is the very basic structure of every organ, also bone.\(^{(25,26)}\) Especially when applied to healing bone the application of ultrasound increases bone volume, osteoid thickness and mineral apposition rate significantly resulting in a better and faster bone-healing\(^{(27)}\) and is widely used in general medicine, orthopedic surgery and traumatology.

These proven physiologic facts were verified in experimental and clinical studies also for the application of Piezotome-surgical procedures in oral and maxillofacial surgery when compared to traditional procedures with rotary burs.\(^{(28,29)}\)

**HISTOLOGIC EFFECTS OF PIEZOELECTRIC SURGERY**

A scanning electron microscopy study comparing the traditional Lindemann-bur with sonic and ultrasonic instrumentation revealed “the use of ultrasonic instruments to result in extremely precise cuts and reduced bone damage. Lindemann bur showed less precision and higher bone damage both in cortical and in cancellous bone. In cortical bone, ultrasonic and sonic cuts showed nicely opened bone vascular canals, while Lindemann bur showed many canals closed by abrasions, exfoliation and cracks by dragging attrition. In cancellous bone, ultrasonic cut showed intact trabeculae and trabecular spaces free of debris, while sonic cut showed more debris accumulation in trabecular spaces. Lindemann bur showed huge quantity of bone debris that filled trabecular spaces.”\(^{(30)}\)

A direct ex vivo histologic comparison of bone healing after cutting bone with rotary burs and two different piezoelectric devices (Piezotome I and Piezotome II, both ACTEON/France) revealed a highly significant improvement of bone healing regarding bone-fill and bone mineral density in the osteotomy-gap in favor of both Piezotomes.\(^{(31)}\)

Obviously, above all, the use of piezoelectric bone-cutting-devices macroscopically leads to significant less procedural bone-loss when compared to rotary instruments or lasers. (Fig. 4)

**CLINICAL AND MEDICAL EFFECTS OF APPLICATION OF PIEZOELECTRIC SURGICAL TOOLS**

**PATIENT MORBIDITY**

The TKW-Research-Group – specialized in clinical research and development of ultrasonic surgical tools and applications – were the first to investigate the practical clinical implications of the experimental results in a multicenter split-mouth study on the removal of impacted third molars.\(^{(32)}\)
With the results of this first randomized clinical split-mouth study the authors were able to prove the enormous clinical impact the application of pure Piezotome-surgery provides for patients compared to the use of rotary instruments by a postsurgical reduction of swelling of more than 50% (Fig. 5) and pain (Fig. 6). The initially doubted results of this clinical study were later on verified by numerous clinical studies with the same or a similar study-design.\textsuperscript{33-37}

**SOFT TISSUE PRESERVATION**

Prior to experimental and clinical studies in dentistry and oral and maxillofacial surgery neurosurgeons discussed and evaluated the superior preservation of critical soft tissues such as the spinal cord and brain tissue when...
piezoelectric bone surgery is used with an ever increasing use of Piezotomes in spinal and skull-base surgery.

**Mucoperiostal Flap Preparation**

Every oral surgical procedure starts with the preparation of a mucoperiostal flap, up to now performed with conventional mucoperiostal elevators. What is often forgotten is the fact, that only a fully intact periosteum (as the sole carrier of bone-regeneration by osteoblast-induced mineralization of the initial callus-formation) provides the requisites for an undisturbed bone healing or a fast mineralization of the augmentation-site in GBR-procedures.

Experimental research lately revealed a significant improvement of microcirculation in the periosteum and a significant higher functional capillary density after surgery when mucoperiostal flaps are prepared with piezoelectric devices in comparison to traditional mucoperiostal elevators. The experimental results later on were verified by microscopic clinical studies proving the clean and uninjured separation of the periosteum from the bone when Piezotome-surgical preparation is performed.

**Preservation of Critical Soft-Tissues in Dentistry, Oral and Maxillofacial Surgery**

As mandatory in neurosurgery also the dentist and oral surgeon by all means has to preserve the full function of critical soft tissues such as the mandibular, mental and infraorbital nerve as well as the periosteum of the sinus-membrane for successful sinuslift-procedures. Comparative clinical studies (Piezotomes versus rotating burs, oscillating saws and chisels) proved the superior safety and preservation regarding an unaffected function of the mandibular/mental nerve in critical osteotomies adjacent to the mandibular nerve at removal of impacted third molars, cyst enucleation, complex osteotomies for bone-augmentation and in orthognathic surgery.

![Manibular Nerve](image)

(Fig. 8) Depiction of the fully intact mandibular nerve after engulfing cyst-tissue removal with Piezotome

![Application of piezoelectric bone-cutting devices in orthognathic surgery (BSSO). A: lingual vertical osteotomy, B: mesio-distal ascending and distal buccal osteotomy, C: completed SSO with almost no bleeding.](image)
The unpunctured/unruptured preservation of the periosteum of the sinus-membrane is mandatory for prevention of postsurgical infectious sinusitis and successful subantral mineralized bone-regeneration (sinuslift). Clinical studies prove piezoelectric devices with special diamond coated tip-designs to significantly reduce the incidence of accidental iatrogenic membrane perforations among surgeons with limited experience. With piezoelectric surgical procedures the perforation rate of the sinus-membrane can be reduced from 24 – 56% with rotary instruments to 5%.

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(Fig. 10)

Mandibular Nerve/Inferior Alveolar Nerve - Lateralization (MNL/IANL)

A good alternative to vertical bone-augmentation in the lateral mandible (vertical bone distraction-osteogenesis, vertical block-grafting) - which in clinical studies and systematic reviews present a high short and long-term failure-rate would be the mandibular nerve/inferior alveolar nerve-lateralization (MNL/IANL). However, due to the lack of a clear view onto the surgical site, the lack of depth control with rotary and/or low-frequency oscillating saws and the enormous risk to unrecoverable damage the mandibular nerve this procedure is rarely performed and if, only by highly experienced and specialized surgeons.

With the introduction of piezoelectric surgical devices and clear surgical protocols the risk of a permanent damage of the mandibular nerve and the period of neurotmesis or hypaesthesia can be decreased significantly both by the excellent visibility of the surgical site, the perfect depth control of the osteotomies and the superior soft tissue safety of piezosurgical instruments.

(Fig. 11)

Transcrestal Hydrodynamic Ultrasonic Cavitational Sinuslift (tHUCSL-INTRALIFT)

As further improvement both in ease of application, predictability and soft-tissue safety and as an alternative or entire replacement of lateral approach sinuslift the tHUCSL-INTRALIFT was introduced in 2007. This minimal invasive transcrestal sinuslift-procedure allows a fully scalable subantral augmentation both for mesio-distal extension and augmentation-height in every anatomical situation and least possible complication rate (2.69%) as was proven in a prospective clinical multicenter-study.

The high success-rate of the INTRALIFT also in the hand of the not so experienced surgeon is based mainly on the transcrestal approach with diamond coated ultrasonic tips and precise separation of the sinus-membrane from the bony antrum-floor by the cavitation effect, leaving...
Surgical-protocol-scheme of transcrestal Hydrodynamic Ultrasonic Cavitational Sinus Lift (tHUCSL-Intralift, 2-stage surgery). A: minimal invasive crestal flap, B: opening of the bony sinus-floor with diamond-coated ultrasonic tip TKW 2, C: preparation of the receptacle for TKW 5 tip with diamond-coated TKW 4-tip, D: hydrodynamic-hydraulic separation of the sinus-membrane from the bony antrum-floor with TKW 5-tip, utilizing the cavitation effect, E: application of bone-graft material through the 3mm-diameter osteotomy (if primary stability can be achieved by an individual implant system, implant can be inserted simultaneously), F: in cases of 2nd-stage implant insertion implant-site-preparation with drills or ultrasonic tips, G: primary stable implant insertion.

Even in case of an iatrogenic puncture of the sinus-membrane at preparation of the transcrestal approach, the INTRALIFT mostly can be performed successfully without further rupture of the sinus-membrane. Meanwhile – because of its predictability, ease of application and standardized surgical protocol – the tHUCSL-INTRALIFT is established as sinus-lift-procedure of choice in clinical biomaterial and implant-research.

Piezotome Enhanced Subperiostal Tunnel Technique

By its clean and predictable separation of periosteum from bone, keeping the full osteogenic potential of the periosteum intact, lately a well-known technique for vertical and lateral bone-augmentation was revived: the subperiostal tunnel technique, again yielding predictable and constant results and least risk of failure. (Fig. 15)

HARD TISSUE PRESERVATION

As depicted in Fig. 4, piezoelectric ultrasonic bone-cutting allows highest possible precision in design and depth of any kind of osteotomy with proven significant advantages regarding atraumaticity, speed and predictability of bone healing. By its explicit precision piezoelectric surgical tools allow a significant expansion of existing
surgical protocols in bone-surgery which were restricted to certain bone-dimensions due to the massive procedural bone-loss with rotary instruments until now.

**Routine Oral Surgical Procedures (impacted tooth removal, apicectomies)**

Due to its property to cut bone almost lossless and with precise depth control piezoelectric bone-surgery allows anatomy-preserving surgical procedures. Whereas in most surgeries of removal of impacted third molars tremendous amounts of bone get lost by milling with burs, pure piezoelectric-surgical removal without use of any burs allows a full restitution of the patients anatomy at the end of the surgical procedure avoiding large long-term bone defects in the retromolar area which might cause unpleasant food-retention at chewing. (Fig. 16)

Defective healing of the alveolar crest after apicectomies with rotating burs – especially in the upper front, when later on the tooth finally has to be extracted and a dental implant inserted – is very common. Following a piezo-surgical protocol with an anatomical correct full reconstruction of the resection-site, defective healing can be avoided. When later on the tooth might have to be removed, no additional buccal bone-augmentation procedures will be necessary. (Fig. 17)

**Autologous Bone-block Transplants**

Since possible geometric dimensions and anatomic locations restrict intraoral bone-block harvesting, procedural bone-loss in most cases is unacceptable and might lead to insufficient augmentations. Since with piezoelectric bone-scalpels almost no procedural bone-loss occurs, piezoelectric bone harvesting should be preferred. (Fig. 4)
Piezotome-enabled Distraction Osteogenesis

As reported the main cause of failure in distraction osteogenesis is based on the primary osteotomy, which with rotating and/or low-frequency oscillating instruments does not allow a perfect osteotomy-design as well as leads to the common problems known for application of these instruments on and in bone. On the other side, piezoelectric surgical instrumentation fully avoids these obstacles and allows a perfect and individual design of the bone-block to be distracted.

Vertical Alveolar Crest-Split & Horizontal Distraction

One of the most common diagnosis in the course of dental implant planning is an insufficient alveolar crest-width due to the natural and/or iatrogenic lateral atrophy of the alveolar ridge. Lateral appositional bone-block grafting or - nowadays - the Piezotome enhanced subperiostal tunnel technique allow to increase the width of the alveolar crest but need to be performed in two stages with longer healing periods. Similar to procedures in distraction osteogenesis the narrow alveolar crest can be split vertically and distracted horizontally, mostly with simultaneous implant-insertion, but was limited to crest-width of minimum 3-4mm due to the procedural bone loss with rotating burs or mills and the need to prepare a mucoperiostal flap. Due to the lack of depth-control and imprecision of the vertical osteotomy with rotary instruments accidental fractures of the distracted buccal compacta were reported as well as secondary vertical bone loss of 3mm or more in the healing-period.

With the Piezotome enabled flapless vertical alveolar crest-split and horizontal distraction the indication for crest-splitting can be narrowed down to alveolar crest widths of 1mm.

Monocortical Interproximal Alveolar Ridge Corticotomy for Orthodontic Teeth Movement Acceleration

Orthodontic tooth movement is impaired by the physical presence of the coronary alveolar cortical bone surrounding the neck of the root. Therefore, it becomes necessary to disrupt this cortical bone via surgery to allow a faster orthodontic tooth movement. Following periodontal accelerated osteogenic orthodontics (PAOO) by corticotomy, a transient decalcification-recalcification process of the alveola occurs speeding up the orthodontic movement of teeth. Nevertheless, this surgical technique – performed with rotary instruments...
- needs the reflection of a full thickness mucoperiostal flap, which leads to uncontrolled resorptions and cosmetic deficiencies in the healing period and is very traumatic both for soft and hard tissues as well as for the patient. Therefore, this surgical procedure is at least questionable from the medical standpoint.

With the introduction of the Piezocision-technique now an almost atraumatic buccal corticotomy without reflection of a mucoperiostal flap can be performed\textsuperscript{79-81} providing all advantages for a precise and rapid orthodontic tooth movement while completely lacking the medical and esthetic disadvantages. The risk of lesions of the adjacent periodontal ligaments is considered very low due to the design of the Piezocision-tips for Piezotomes. In case of need of buccal augmentation, the Piezotome enhanced subperiostal tunnel technique can be performed additionally.\textsuperscript{83} (Fig. 21)

**Implant Site Preparation**

Rotary drills remove bone and even when used at slow speeds inhere the risk of damage in the trabecular bone.\textsuperscript{4-8} Repeated use of implant-drills lead to bluntness of the drills and therewith to higher necessary loads on the handpiece, which then might lead to unwanted thermal effects in the bone.\textsuperscript{82}

(Fig. 20) Clinical case following the surgical protocol for Piezotome-enhanced flapless Crest-Split (initial alveolar crest-width: 1mm). A: initial top-crestal mesio-distal mucoperiostal incision. No mucoperiostal flap is prepared, B: initial bone-lossless vertical mesio-distal osteotomy with CS 1 tip, C: initial horizontal distraction with CS 2 tip to allow easy vertical approach for next surgical step, D: mesial and distal buccal relief-osteotomies from inside of the mesio-distal osteotomy in buccal direction, E: step by step horizontal distraction of completed osteotomy with CS 4, 5 and 6 tip to a gap-width of 4mm. the buccal-distracted compact-bone stays fully attached to the periosteum and therewith fully vital, F: state after implant-insertion (Q2-implant) and gap-filling with self hardening biphasic bone-graft biomaterial (easygraft), G: crestal-gingival anatomy mostly allows gap-free tensionless wound-closure, H: final prosthetic result after 3,5 months
Experimental assessment of differences between the use of piezoelectric surgery and a conventional drill concerning neo-osteogenesis and inflammatory reaction after implant-site preparation revealed more newly formed bone with an increased amount of osteoblasts to be visible on the piezoelectric implant site during the early phase (7–14 days). The investigated humoral factors BMP-4, TGF-β2 and IL-10 were increased in the piezoelectric group, while IL-1β and TNFα were not. In conclusion, the piezoelectric device stimulated peri-implant osteogenesis, and a reduction of proinflammatory cytokines.

Therefore, implant-site preparation with piezoelectric surgical devices seems favorable to achieve clinically high primary implant-stability and an enhanced and safer osseointegration. (Fig. 22)

PIEZOTOME-APPLICATIONS IN THE DAILY DENTAL ROUTINE

TOOTH REMOVAL

Once all treatment possibilities to preserve a tooth are exhausted, finally teeth will have to be removed and possibly to be replaced by dental implants. Fractured teeth, roots and ankylosed teeth challenge the dentist to preserve the alveolar bone height and width for a planned later implant insertion. When drills, burs and periotomes have to be used, mostly part of the alveolar ridge has to be sacrificed in order to remove the tooth or its fragments, leading to the need for bone augmentation to enable implant insertion.

An alternative to bone-destructive tooth-removal now is piezoelectric tooth-removal with piezoelectric ligament-cutters. Similar to the preparation of a mucoperiostal flap with Piezotomes43,45 – the periodontal ligament consists of the same Sharpey-fibers attaching the tooth to the bone as the periosteum is attached to the bone46 – the periodontal ligament is precisely cut and the periodontal gap widened by the cavitation-effect without bone-loss, enabling an almost forceless removal of the tooth. (Fig. 23)

CROWN LENGTHENING

In case the root of a tooth with crestal caries or intrabony crestal fracture can still be treated with a pin and a crown, a perfect margin has to be prepared for later impression. In case of crestal caries or a subcrestal fracture, crestal bone has to be removed carefully to allow the later preparation of the crown margins. The minimal invasive removal of crestal bone with rotary instruments challenges the dentist. As a better alternative nowadays, piezoelectric instruments should be used for this task especially in the early period of gaining manual experience. (Fig. 24)
DISCUSSION

Obviously, the use of Piezotomes in the daily dentists as well as oral and maxillofacial surgeons’ clinical routine seems to be preferable since common disadvantages of the use of rotary mills and burs, low-frequency oscillating saws, chisels and infrared lasers Piezotome-surgery seems to outclass traditional instruments and lasers by far on clinical, histologic and micromorphologic level providing precise osteotomies, maximum soft-tissue preservation and improved bone-healing even in the surgical beginners hand and by this seems to be the new gold-standard in dentistry, oral and maxillofacial surgery.

REFERENCES


CONCLUSIONS

In the light of this thorough literature-research and comparison to rotary mills, burs, low-frequency oscillating saws, chisels and infrared lasers Piezotome-surgery seems to outclass traditional instruments and lasers by far on clinical, histologic and micromorphologic level providing precise osteotomies, maximum soft-tissue preservation and improved bone-healing even in the surgical beginners hand and by this seems to be the new gold-standard in dentistry, oral and maxillofacial surgery.

(Fig. 23) Tooth removal with ultrasonic ligament-cutters for Piezotomes. A: removal of an ankylosed root-fragment with LC 1-tip, B: removal of a fractured root-fragment with LC 2-tip.

(Fig. 24) Surgical Crown Extension to allow sufficient supracrestal crown-margin-preparation and impression-taking.
The use of piezosurgery in mandibular cyst enucleation.

Comparing piezosurgery and conventional rotatory surgery


