Magnetic **Mallet**™

Clinical Evaluations

Volume 1 - 2012/2017

Luglio 2018 - Rev. 00

www.magneticmallet.it // info@metaergonomica.it // T. +39 0331 890280

Doctors

Dr. Roberto Crespi
Dr. Giovanni Battista Bruschi
Dr. Lajos Gáspár
Prof. Werner Zechner
Dr. B. Rajkumar

Dr. Roberto Crespi

Clinical Professor in Dentistry at San Raffaele University, Milano, Italy and Marconi University, Rome

Degrees:

- Post Graduate in Patology
- European Master in Science in Oral Surgery.
- Medical Doctor, Dental Doctor - Università degli studi - Pavia
- Winning the William R. Laney Award 2015
- Member of the Editorial Board of The International Journal of Oral and Maxillofacial Implants (JOMI)
- Quintessence Publishing Co, Inc, Illinois (USA).
- Member of Editorial Board of Clinical Implant Dentistry and Related Research.
- Member of Editorial Board of Case Reports in Dentistry Journal
- Referee del Journal of Periodontology.
- Referee di Histology and Histopathology.
- Author of more than 80 papers published all over the wolrd and 6 books published by Quintessence Editor

Dr. Giovanni Battista Bruschi

Specialist in Dental Surgery at CSO (Centro Specialistico Odontoiatrico in Rome)

Degrees:

- Post Graduate in Oral surgery and Dental Prosthesis
- Medical Doctor, Dental Doctor - Università La Sapienza - Rome
- Perofessor assistant of Prof. Martignoni at Prosthesis dept of Boston
- University School of graduate dentistry.
- Author of several scientific articles published in the foremost scientific journals and coauthor of 3 books on Oral surgery and Sinus lift.

Dr. Lajos Gáspár

Head of Gáspár Medical Center
University Educationa center - Budapest

Graduation:

Semmelweis University of Medicine, Budapest, Dental Faculty, 1978

Special board exams:

- 1980 Dentistry
- 1985 Oral and Maxillofacial Surgery
- 1993 Military Medicine
- 2005 Conservative Dentistry and Prosthetics
- 2005 Dentoalveolar surgery
- PhD Thesis. 1990 Introduction the CO2 laser in oral surgery and dentistry

Publications/Editorial Activities:

- 170 articles in laser and in dentistry
- 12 books
- 16 book chapters

more than 800 presentations at Universities, Congress and International events

Special Honors/Professional Associations:

- President of the Biomedical Optics Committee of Academy of Sciences Hungary
- Secretary General of the Hungarian Medical Laser and Optics Society
- National Representative (Hungary) of World Federation Laser Dentistry WFLD (ISLD)
- Society Oral Laser Application SOLA (ESOLA).

Prof. Werner Zechner

Deputy. Head of Department of Oral Surgery
Bernhard-Gottlieb-Universitätsklinik Ges.mbH

Doctorate for Dr.med.univ.1995

Doctorate for Dr.med.dent. 1999 Medizinische Universität Wien - Universitätszahnklinik

Zahnheilkunde, Univ.Prof.DDr. Implantate, Knochenaufbauten, Orale Chirurgie

Venia docendi for the entire field of dentistry, oral and maxillofacial medicine 2003:

Habilitation topic "Investigations on the bony healing of different implant surfaces and healing methods"

Multiple international and national scientific awards:

European Association for Osseointegration (EAO) - Best Research Award,

International Scientific Award of the Germans (DGI), Austrian (ÖGI) and Swiss Society (SGI) for Implantology

Study visits abroad:

- University of California at San Francisco - USCF (Prof, Dr. L. Rosenberg)
- Dissertation in cooperation with the University of Pennsylvania (Prof. Dr. S. Kim)
- Bony implant healing: Eppendorf Germany Clinic at Prof Dr.mult. K. Donath
- Navigated Implantology: University of Leuven, Belgium (Prof. Dr. Van Steenberghe)

Research and lecture activities focusing on:

- Implant surfaces and procedures and CAD / CAM template guided implantology to optimize function and aesthetics.
- Head of the working group "Navigated Implantology" of the Department of Oral Surgery of the Medical University of Vienna in cooperation with the implant prosthetic department
- Author of numerous international scientific articles and book contributions
- International speaker for implantology, navigation and bone augmentation.

Dr. B. Rajkumar

Professor & Dean BBDCODS
Prof & Head, department of Conservative dentistry & Endodontics at BBDCOCDS, Lucknow

- Chairman: Academy of Dentistry International (India Chapter)
- Chairperson (Scientific): IACDE International conference held at Dubai,UAE.
- Pioneer in use of C-Arm technique in the field of Endodontics & Implant dentistry in India.
- Keynote speaker at FODI National conference, Delhi PG Convention at Kasauli . Famdent Delhi Convention.
- International Speaker on panels of Coltene Whaldent.

International Professional Trainings:

- Completed Certified Course on Biomineralization at Turku Dental Biomaterials Summer School, Seili Island, Finland 2016.
- Completed Certified training at Mirsopeat Academy of Microscope Enhanced Dentistry at Tuscon, Arizona, USA in 2007.
- Trained in Oral Implantology (Frailit Dental Implants) at Germany & Holland.
- Trained in Dental LASERS (Biolase) at New Jersey (U.S.).
- International Assignment: -Observership at University of New Castle Upon Tyne, U.K.
- Memberships:Federation of Operative Dentistry of India, Indian Endodontic Society, Indian Society of Prosthodontic, Restorative and Periodontics & Indian osseointegration society.
- Editorial Board Member: Banaras Hindu University official journal, Indian journal of restorative dentistry journal.
- Reviewer in Journals: IACDE Journal, Dental Research Journal
- Scientific publications: 51+ Publications (in National & International reputed Journals)

Dr. Roberto Crespi
Dr. Giovanni Battista Bruschi

Advantages using **Magnetic Mallet**

01

Clinical
Evaluations

2018

Advantages using Magnetic Mallet

The bone expansion techniques, conceived to increase bone volume using the native bone delegated to host the implant and the bone expander to stabilize the implants in type 3 and 4 bone structures, are well documented and accepted techniques considered valid and reliable by both clinicians and literature. The critical point of these techniques is that the protocol provides the use of a surgical hammer to guide the instrument in the alveolus creation for the bone implant.

The shock produced by the surgical hammer can develop a very annoying and sometimes prolonged vertiginous syndrome in the patients. To avoid or very significantly reduce these symptoms, the Magnetic Mallet has been launched on the market by Sweden & Martina the last year. A magneto- dynamic device consisting of a handpiece energized by a power supply which controls strength and timing of application.

The purpose is to couple a bone expander to the handpiece and to transmit, to the tip of the instrument, an adjustable shockwave, calibrated in forces and time of application. The Magnetic Mallet, compared to the classical surgical hammer, produces a more powerful energy with high accelerations applied in a very short time. In this way it's possible to induce a bone plastic deformation able to absorb the whole shock wave, thus avoiding to create inertias affecting the rest of the skull.

Shock waves generated, using the surgical hammer in the traditional technique and using the Magnetic Mallet, have been measured on natural models:

1) With the surgical hammer the shock wave generated was of 40 DaN (Deca Newton) (40 kg) for a time of 300 µs. Most of the obtained energy did not accomplished in the bone plastic deformation, but it affected the whole maxilla mass.

2) The shock wave generated by Magnetic Mallet was of 130 DaN (130 kg) with a light point of 80 µs. The bone plastic deformation was thus greatly facilitated and enabled the total energy absorption, so that a minimal and negligible acceleration on the jaw mass remained.

The device perfectly performs the function which it was designed for : to make more acceptable for the patient the maneuvers performed to divide the bone structure when it is necessary to extend it to create an adequate surgical alveolus, both in position and adequate thickness of most critical alveolar walls (vestibular and oral ones), in order to accommodate the implant.

Until now, according to the protocol, these maneuvers were made using sharp instruments and / or instruments able to move the bone structure in the desired position, beating them with a surgery hammer. These maneuvers transmit a vibration to the entire bone structure supporting the jaw which is at the base of the skull, to the nose and, basically, to the otolith system. As a possible consequence of these maneuvers, sometimes a long and tedious dizziness may arise.

With the Magnetic Mallet, using the different instruments it is equipped with, it is possible to perform the maneuvers to expand both horizontally and vertically the native bone structure of the patient in the site or the sites that should receive the implants, with a considerable control and a high threshold of acceptability by the patient.

The device also manages to be very useful in complex extractions. In fact, after having made a coronotomia of the element to be extracted, whether it is included or normo positioned, and after having carried out the separation of the root, using the appropriate instruments, it's possible to slide the root towards the emergency coronal, even in the presence of a curved apex. Normally, the extraction is completed with a minimal damage to the lamina dura of the socket. In addition, these maneuvers away the chance to produce fractures in the root apex. Its features make it extremely interesting to perform minimally traumatic extractions. The maximum respect of alveolar anatomical structures also allow a much more predictable therapeutic choice, which aim is to arm the system coincidentally to the extraction of the natural element.

We present two clinical cases treated with the Magnetic Mallet.

First case : Saddle edentulous maxilla with vertical and horizontal bone reduction

Fig. 1

Aspect of the edentulous ridge prior to the preparation of the incision; there is the decalcified root of 14 which will be replaced by a post-extractive immediately restored implant.

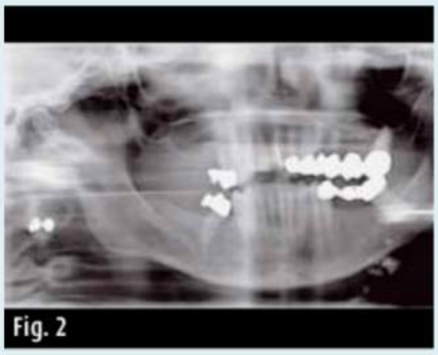


Fig. 2

Pre-surgery ortho-panoramic. In the upper right-hand edentulous area the line, which defines the position of the cortex and bordering the coronal sinus cavity, is easily legible.

Extraction and implant placement for 1.4 in the alveolus of the palatal root. Due to the presence of infection and bone dehiscence at the level of the root vestibular, the insertion at the level of the septum is avoided. The root was mobilized with the right instruments, coupled to the Mallet. The extraction was accomplished with careful preservation of the hard edges.

The preparation of the implant site and the lift of the crestal sinus floor was made with the bone expander coupled to the Magnetic Mallet.

Fig. 3

Implants placed in the position of # 14 , # 15 and # 17 with the mounter still in place. Both the expansion and the implant placement were carried out with the Magnetic Mallet.

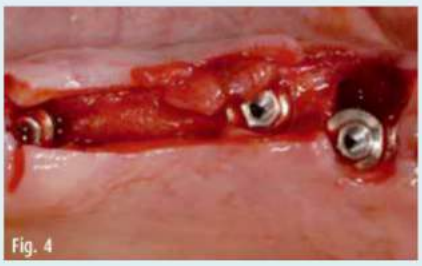


Fig. 4

Implants stabilized in the surgery alveolous.

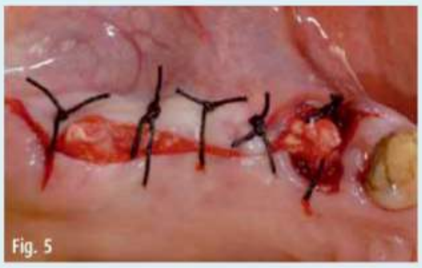


Fig. 5

A collagen sponge was used to fill the remaining vestibular space in the alveolus of # 14, thus avoiding bleeding in the central area of the incision. The sutures are intended to stabilize the apical and buccal flap position and no traction is present.

Fig. 6

Appearance of the tissues before the second -stage surgery. The central portion of keratinized mucosa is healed by secondary intention.

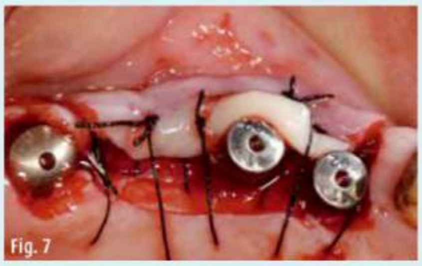


Fig. 7

A partial thickness flap creates the access to the cover screws. After having tightened the screws, the flap healing was buccally and apically repositioned.

Fig. 8

Pillars in place. Appearance of the emergency.

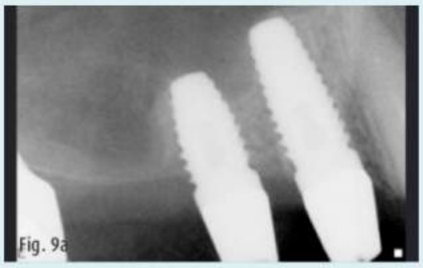


Fig. 9a

Fig. 9b

Intraoral control x-ray on 8 months load.

Second clinical case: lower-jaw horizontal expansion in the distal to the mental foramen

A three elements on two implants bridge was planned in position 44 and 46. In position 46 the expansion was carried out using the Magnetic Mallet.

Fig. 10

Right mandibular edentulous ridge. Magnetic Mallet is used for the ridge expansion in position # 46. The element # 45 was temporary kept, as a natural pillar.

The crest is reduced in buccal-lingual thickness. A horizontal expansion with simultaneous implant insertion was planned.

Fig. 11

The ridge was prepared with a partial thickness and the periosteum conservation. The crest is prepared for the expansion through a first cut in mesiodistal direction and it is defined by means of two release intra-ossesus cuts in distal and mesial position.

Fig. 12

Expansion mechanically completed by the implant, stabilized in the alveolus. The implant is a Premium 4.2 x 13.

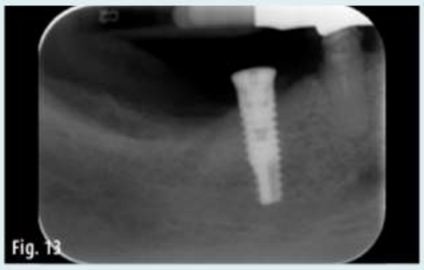


Fig. 13

Post –surgery X-ray with the healing screw tightened to 20 Nc .

Fig. 14

The healing by secondary intention for both hard tissues and the gingival tissues is favored. The flap is apically and buccally repositioned.

Fig. 15

Removal of sutures, four days after surgery. The central portion, that will heal by secondary intention, shows the space filling with fibrin. This kind of healing will produce a stable over time regeneration of keratinized tissue, as a final result.

Fig. 16

Prosthetic abutments, milled according to the AMA technique. There are three pillars since the mouth has been completely rebuilt on artificial pillars.

Fig. 17

X-ray control with positioned prosthetic abutments.

Fig. 18

Buccal view of the prosthetic abutments. Note the emergency implant, the keratinized mucosa band and the muco- gingival line positioning.

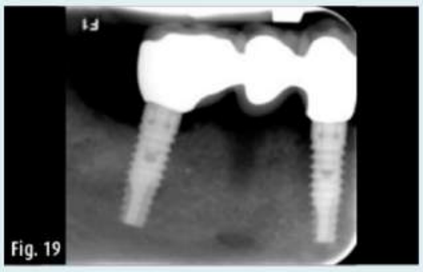


Fig. 19

X-ray with permanent prosthesis in place about a year after occlusal loading.

Dr. Lajos Gáspár

Magnetic Mallet in bone-shaping and implantology (Our most recent experience)

02

Dr. Lajos Gáspár (Gáspár Medical Centre)

Magnetic Mallet in bone-shaping and implantology (Our most recent experience)

Magnetic Mallet (MM) is a new technique all over the world, having been developed since 2012, in which shaping the bone is possible by replaceable osteotomes, chisels, implant bed shapers, bent pieces placed in the handpieces of bone-modelling equipment controlled electromagnetically.

Bonwill was the first to apply magnetic mal-let in stomatology, who had it patented under the name of electromagnetic dental mallet on 21 July 1873. The aim of the device one and a half centuries ago – in case of hammered gold fillings – was to achieve even and mild mechanical hitting effects of predictable forces, which made the dentist's work signifi-cantly easier, increased the precision and, at the same time, the efficacy of making fillings. The oral surgical / implantological applica-tion of the modern magnetic mallet of the 21st century was reported by Crespi in 2012, describing his experience while carrying out sinus lift. He compared the procedures with traditional hammers and osteotomes with the potential ways of application of the new magnetic mallet (Crespi 2012).

The equipment of magnetic mallet consists of a central unit, on which the force of me-chanical blows can be adjusted. A sterilisable handpiece is joined to it, into which various replaceable tips can be fitted. The mallet can be operated by a pedal (Meta Ergonomica 2015).

In the device, the hitting force of MM is adjust-able: 75-90-130-260 kp. This means multiple (6-7 fold) efficacy compared to the maximal force of 40 kp of traditional hand mallets.

The fastest blow that one can carry out with traditional mallets comes to about 350-400 microseconds, whereas the duration of a hit by MM is 1/4 or 1/5 of that. The impulse of hitting is extremely fast: about 80-100 mi-croseconds. Due to the extremely short pe-riod and to the inertia of living organisms to fast impulses, despite the relatively great force of hitting, patients can experience just minimal discomfort. They can feel consider-ably lower blow than in the case of traditional mallets and chisels. Dizziness following sur-gery caused by the hits by traditional mallets, probably resulting from the move of the audi-tory ossicles, can be avoided.

The fastest blow carried out by a tradition-al mallet comes to about 350 microseconds, whereas that by MM is one-fourth or one-fifth of it. It can be ascribed to its extremely great acceleration that, because of the iner-tia of the skull, the mechanical force of the

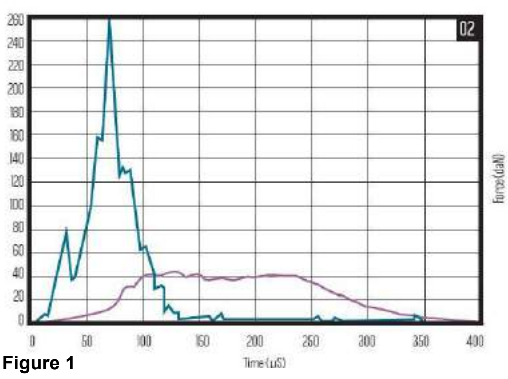


Figure 1

Figure 1: *By MM the force of a blow is 6-7-fold larger than that of the traditional chis-el-hammer, at grade 4 it can reach the value of 260 Newtons compared to that of the traditional tool with a maximal force of 40 Newtons. The force of blow can be set at grades 1-2-3-4. In everyday work, normally, grade 2 is initially suited; the application of grades 3 or 4 is needed more rarely, just in the case of pronouncedly hard bones.*

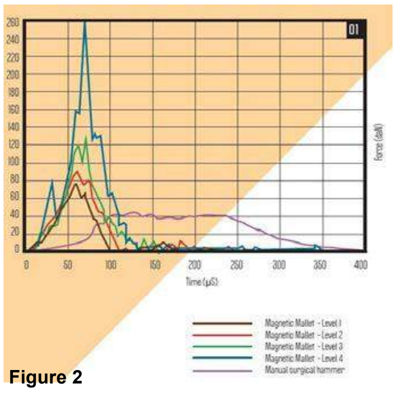


Figure 2

Figure 2: *The correla-tion between force of blow and duration of blow. By MM, the duration of blow is 1/4 of the maximum speed of the traditional mallet and chisel. This means that MM is four times faster than the traditional instrument. This explains the fact that the shaking caused by an MM blow is not or hardly felt by the patient – due to its fast-ness. At grades 1-2-3-4 the maximal achievable force is 75 N, 90 N, 130 N, 260 N, respectively.*

Figure 3

Figure 4

blow – in the vast majority of cases – is primarily directed to the plastic change of the shape of the bone and it is just a small part that moves the skull.

On the contrary, a considerable part of the relatively slow handpiece is directed to moving the skull and just a smaller part to the change of the shape of the bone. In other words, the energy of MM almost entirely promotes the creation of a plastic effect (bone-shaping) with just a slight change in kinetic energy.

By contrast, a handpiece of slow blows produces far more kinetic and less plastic energy resulting in less change in shape.

Similarly to the handpiece of the micromo-tor, the handpiece of MM can be autoclaved and there are various replaceable tips at our disposal, in two sets – straight and curved ones. Among them there are chisel tips, applied for bone splitting, but they are suited for bone cutting as well. There are narrow, flat tips, blades for displacement of roots and teeth.

For the preparation of implant sockets there is a whole series of expanders, implant sock-

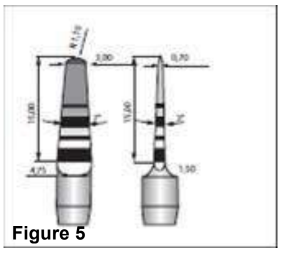


Figure 5

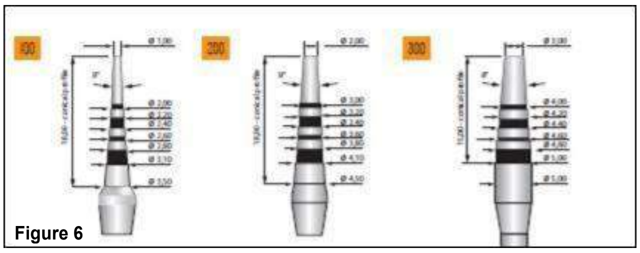


Figure 6

et formulating tips at our disposal. Bone expanders with diameters of 1-2-3 and 2.3-3.3-3.6 mm are suited for both the preparation of implant sockets and bone condensation. As a third set, machine handpieces and tips to remove crowns and bridges can also be ordered.

To sum up the characteristics of MM procedure: the very short – 0.1 sec – tiny little hit-ting effect on the bone of controllable depth and force is to be underlined; the device can be held in one hand, so the other hand of the operator is free; it creates excellent visibili-ty. It is a minimally invasive bone-shaping device, which is capable of separating bone tissues without any bone mass loss, there are no shavings (Csonka 2014/, Csonka 2014/2, Arduini 2014).

Force of application can be adjusted in four scales: 75-90-130-260 kp, thus the force of blow is 6-7 fold compared to tradition-al mallet-chisels. Blow is extremely fast of short impulses – 4-fold compared with the blow of traditional mallets. Owing to this 0.1 second hitting impulse, the head of the patient receives the blow just partially as it cannot follow the fast impulse and is „inert".

A further great advantage of the MM tech-nique is the fact that it does not require any cooling fluid and when splitting by MM during the preparation of the implant sock-et, the usually little and less viable bone mass is not „washed out". In contrast to ro-tary instruments and piezo, due to the fact

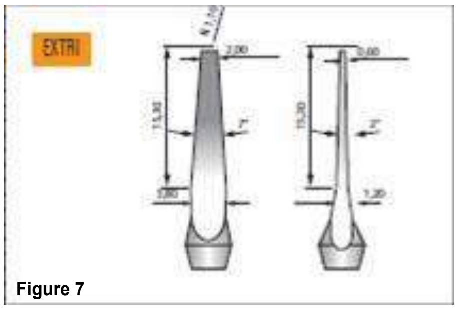


Figure 7

Figure 3: *A series of tips for chiselling, splitting and preparation of implant sockets. The set contains straight piec-es, another set contains bayonet bent tips. This latter set can be applied in the molar region of the oral cavity as well; at an appropriate angle it can be used for both the lower and the upper jaw bones.*

Figure 4: *Magnetic mallet (MM) equipment. The device consists of a central unit in the frontal part of which blows of 4-degree forces (1-2-3-4) can be adjusted. A sterilised handpiece cord can be attached to it, as well as a pedal. Pressing down the pedal once results in one blow. To produce a series of blows, the pedal should be pressed down and let up rhythmically. Continuous pressing of the pedal produces only a single blow.*

Figure 5: *Bone-cutting chisel tips are available in several sizes with depth-indicating lines, which show the depth of splitting during work. The division, similarly to implantological drills, indicates depths of 6-8-10-12 mm on the operating instrument tips.*

Figure 6: *Implant-sock-et preparation, expansion series with depth-indicating lines. The thinnest piece in the set is of a diameter of 1 mm (with a needle-like tip), then come the piec-es with tips in increas-ing order (2 mm, 3 mm, 3.3 mm), similarly to the series of implant-bone sockets. The pieces of the expansion series prepare root-shaped implant sockets.*

Figure 7: *Tooth-and tooth root-removing tips are made with dif-ferent profiles. Among them there are straight, flat chisel-shaped ones, there are hol-lowed, round-surface ones - both wider and narrower.*

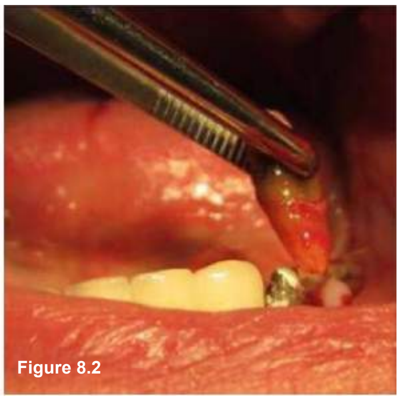


Figure 8.1: *A 61-year-old woman – removal of left lower teeth 5-6 by MM. Loosening tooth 5 by an MM extraction tip.*

Figure 8.2: *Lifting out the loosened tooth is possible with tweezers.*

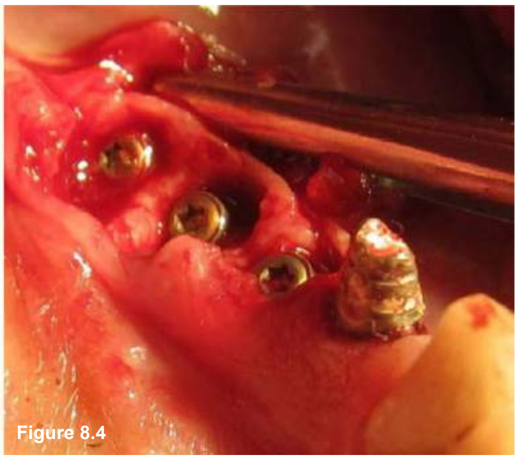
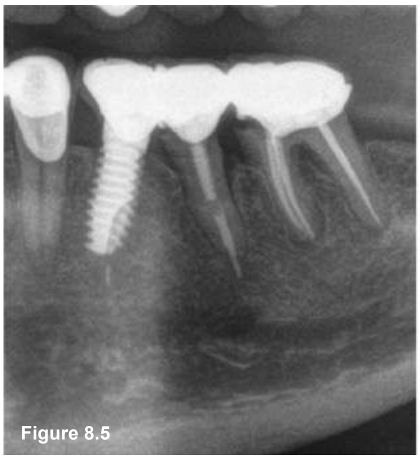


Figure 8.3: *Following minimally invasive removal of teeth by MM, the destruction of soft tissues and bone struc-tures is minimal.*

Figure 8.4: *Immediat implantation; we insert 3 pieces of Straumann implants into the alveoli prepared by MM.*



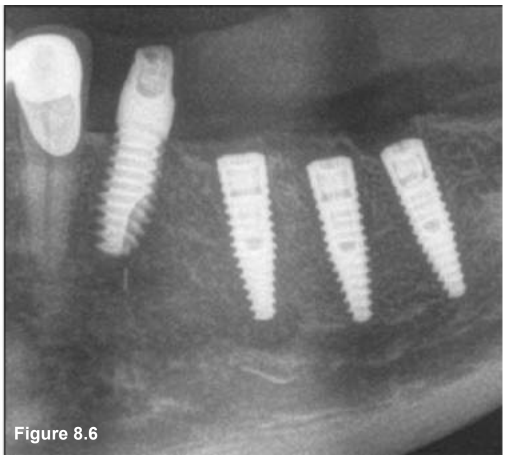


Figure 8.5: *X-ray taken before tooth removal.*

Figure 8.6: *X-ray taken following implantation.*

that cooling is not needed, the substances (minerals) inevitable for starting ossifica-tion and osseointegration and that are nor-mally found in a „living" bone, are not rinsed out. The bone is slightly bleeding and shows signs of life. Following the application of MM, the blood in the surface of bone is abundant and is of living colour, compared to the state after bone-shaping by a micro-motor or piezo, where, in many cases, the surface is whitened and is „washed out". The bone expanders of MM, the so-called root-form expanders are suited for the preparation of bone sockets which corre-spond to the outer shape of most root-form implants. In the case of implants with cut-ting edges, implants can be usually screwed into the bone socket formulated by MM ex-panders.

If it is necessary, the bone socket formulat-ed by MM expansion can be further refined and shaped with the final drill and / or thread cutter of the given system of implants by the help of a handpiece – a ratchet spanner (without any cooling fluid).
By the help of the double-curved instruments,

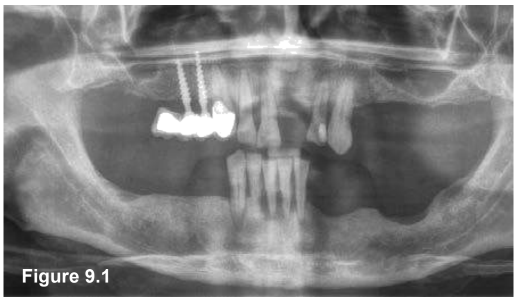


Figure 9.1


Figure 9.2

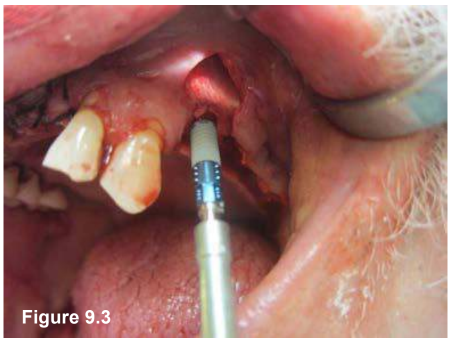


Figure 9.3


Figure 9.4

Figure 9.1: *Male patient of 63, who lost his upper and lower sets of implants, inserted previously , 5 years ago. X-ray images taken before operation.*

Figure 9.2: *Preparation of an implant socket by MM osteotome*

Figure 9.3: *Insertion of a Straumann implant*

Figure 9.4: *The 3 im-plants in the mouth*

Figure 9.5: *X-ray check-up of the inserted implants (21-24-25-26)*

the site of the alveolar ridge in the position of the second molar in the lateral region can be reached.

Various sets and complementary tips al-so include bone-cutters, chisel tips, tooth-, root- and superstructure-removing tips. This technique can be primarily used for the preparation of implant sockets and also for bone-condensation in the case of less bone mass and non-hard bone.

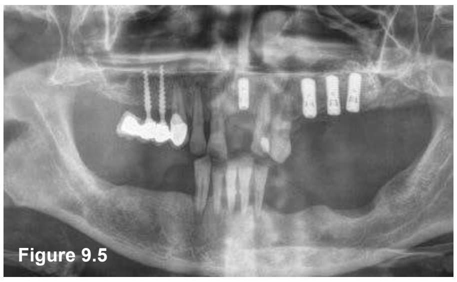


Figure 9.5

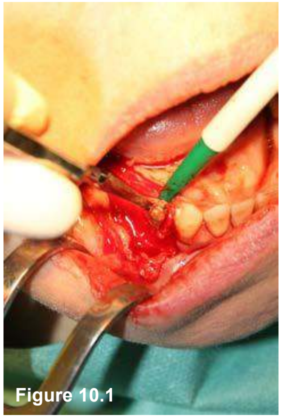


Figure 10.1


Figure 10.2

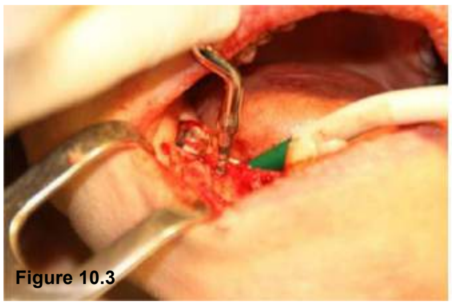


Figure 10.3


Figure 10.4

Figure 10.1: *Removal of tooth 45 is done by magnetic mallet. During the procedure, we gradually introduce the chisel-shaped operat-ing tip between the root and the alveolar wall and at grade 2, step by step, we expand the slit around at the line of the root membrane by tiny blows. Applying it around the tooth it becomes mobile and can be lifted out with-out any decrease in the bone layer of the wall of the alveolus.*

Figure 10.2: *Following removal of the tooth, the narrow crest is split by MM, with the chisel-shaped tip.*

Figure 10.3: *Following splitting the jaw bone crest, the formation of the implant socket is carried out by a series of „root-form" MM tips, beginning with a 1 mm tip, continued with the 2 and 3 mm „root-form" tips.*

Figure 10.4: *The in-sertion of the 3 pieces 3.2-10 SGS LA implants (already placed in) by MM between the split bone plates in the plac-es of teeth 44-45-46.*

Figure 11.1: *Upper edentulous maxilla of a 64-year-old female patient – a state following the removal of 8 implants placed 19 years ago. A thin jawbone crest and minimal bone supply are at our disposal.*

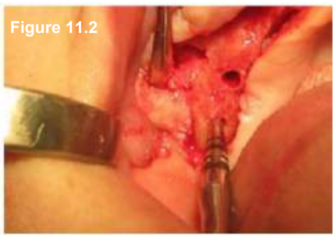


Figure 11.2: *Surgical plan: sinus lift on the right side, placement of 4 pieces, 3.75-10 and 3.75-12 SGS implants by magnetic mallet. Im-plant socket is prepared by magnetic mallet with „root-form" tips of gradually increasing diameters.*

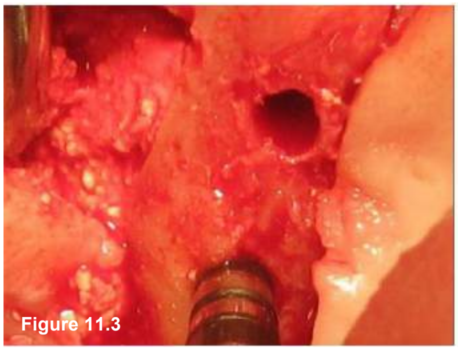


Figure 11.3: *We did not rinse the inside of the bone socket formed by magnetic mallet as no fluid-cooling is needed. The prepared bone surface provides the impression of a dense, „bloody" and living bone tissue. The depth of the implant socket on the lines of tips of MM can be seen as well as on the lines indicating the depth of bone socket on rotary hammer drills. There is no bone loss at the preparation of the implant socket. The ex-panding tips simultane-ously expand, condense and thicken the bone.*

Figure 11.4: *Placement of self-cutting 3.75-10 SGS in the place of 16. With a rachet spanner, by continuous force and control, the implant can be driven into the bone socket prepared by MM.*

Figure 11.5: *The 4 im-plants placed into the right maxilla without any bone loss. We were able to carry out the expansion of the nar-row mandibular crest with just a little bone supply by MM, without breaking or cleaving the edge of the bone.*

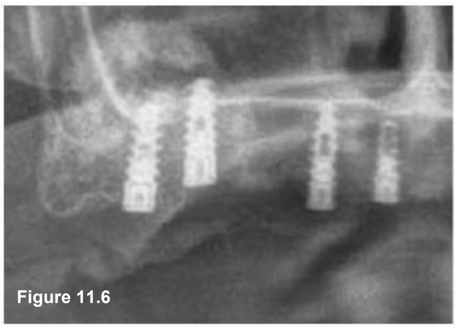


Figure 11.6: *X-ray check-up following surgery. The 4 pieces of placed implants and the result of sinus lift can be seen.*

Figure 12.1: *Persistent left lower first milk incisor 71 of a 38-year-old man. Underdeveloped alveolar ridge around the milk tooth. The al-veolar ridge is concave, from the edge of the ridge towards the base of the mandible it gets narrower and narrower. High risk patient.*

Figure 12.2: *Careful splitting, then the prepa-ration of the bone socket on the thin bone is carried out by MM. Starting width of bone on the ridge is 4 mm.*

Figure 12.3: *Following careful and gradual*

Figure 12.4: *Placement of crown on the implant*

8

Figure 13.1

Figure 13.2

Figure 13.1: *Osteoporosis around the mesial root of the right lower tooth 7 in the panoramic X-ray image caused by inflammation, which is the actual cause of the toothache. The distal root is knee-shaped.*

Figure 13.2: *Removal of ankylotic tooth 47 by MM. We loosen it with the chisel-shaped tip out of the bone socket. Following loosening, we chop the tooth up with a turbine, then continue to move it and lift it out of the alveolus.*

Major fields of application of magnetic mallet (MM)

1. Tooth and root extraction

1.1. MM-assisted removal of tooth and root;

1.2 Removal of tooth and root and instant placement of implant by MM;

1.3. Delayed placement of implant into the alveolus, by MM.

2. Bone condensation and expansion by MM

2.1. Bone condensation;

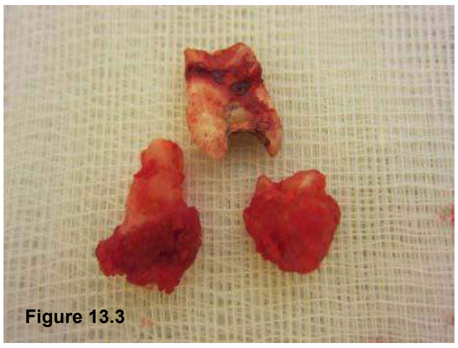


Figure 13.3

Figure 13.3: *Spherical-ly ossified ankylotic fragments at the tips of the removed roots. Because of this, their removal with traditional tools is not possible. By MM, their extirpation from their bone nests were able to be carried out without any nerve injury.*

Type of intervention	Male	Female	Total
Removal of tooth and immediate implantation	27	44	71
Bone condensation	28	55	83
Horizontal expansion of the bone	27	39	66
Vertical expansion of the bone	4	7	11
Removal of impacted tooth	7	11	18
Sinus lift	5	15	20
Összesen	98	171	269

Table 1: *Distribution of interventions by magnetic mallet based on type of surgery.*

Patients	Number of patients	Number of implants
Male	98	189
Female	171	240
Total	269	429

Table 2: *Distribution of patients by their gender in case of implants pla-ced by magnetic mallet.*

2.2. Horizontal bone expansion;

2.3. Vertical bone expansion.

3. Sinus lift by MM

3.1. Transcrestal sinus lift;

3.2. Sinus lift completed with local bone management;

3.3. Sinus lift performed simultaneously with tooth extraction.

4. Other applications of MM

4.1. MM-assisted orthodontic treatment

4.2. MM-assisted root apex resection

4.3. MM-assisted impacted, retained tooth root removal

4.4. Removal of crowns, bridges and implant parts

Type of implant	Number of implants
SGS	319
Straumann	59
MIS	51
Denti	3
Paltop	8
Összesen	429

Table 3: *Distribution of implants placed by magnetic mallet based on their types.*

Patients and methods

Magnetic mallet was applied for 269 patients at Gáspár Medical Center between 01.10.2014 and 30.04.2016. In the interventions, 98 male and 171 female patients were operated on. (Gáspár 2014, Gáspár 2016).

During tooth and root removal we used thin, blade-shaped tips prepared for the equipment, with which, in the gap between the

Table 4: *Distribution of implants placed by magnetic mallet on the basis of jaw bones.*

Jaw bone	Number of implants / %
Maxilla	279 64%
Mandible	150 36%
Total	429 100%

Table 5: *Distribution of implants placed by magnetic mallet on the basis of their tooth groups.*

Localisation	Number of implants / %
Front	103 24%
Premolar	137 32%
Molar	189 44%
Total	429 100%

tooth or the root and the bone, going inward by rhythmic blows, transecting the fixing el-ements, we can detach the fibres fixing the tooth. Reaching the appropriate depth, in some cases with tooth forceps, with a light motion, we can lift out the root. In other cas-es, the tooth can be moved to such an extent that we can take it out of the alveolus with tweezers.

While extracting the tooth, we can preserve the bone edges but we can also treat the soft tissues with special care. Papillae can remain

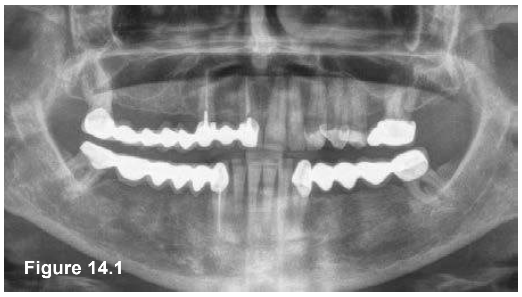


Figure 14.1


Figure 14.2

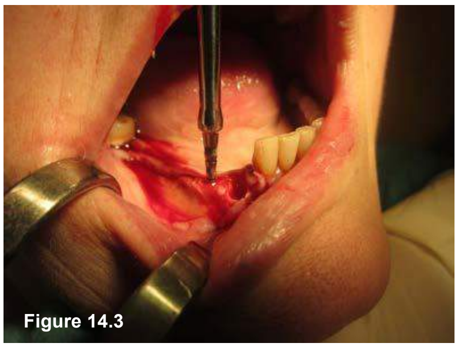


Figure 14.3

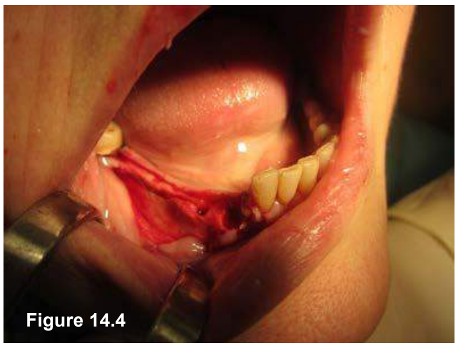


Figure 14.4

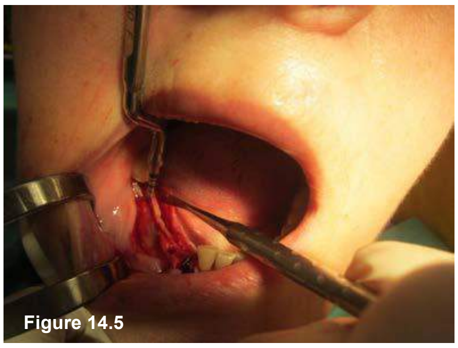


Figure 14.5

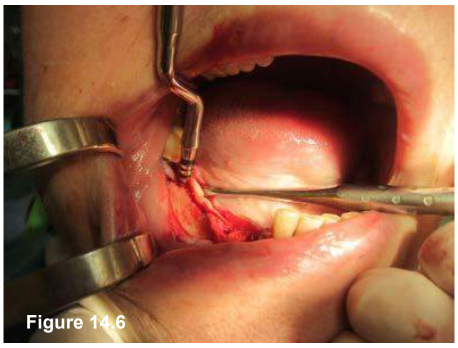


Figure 14.6

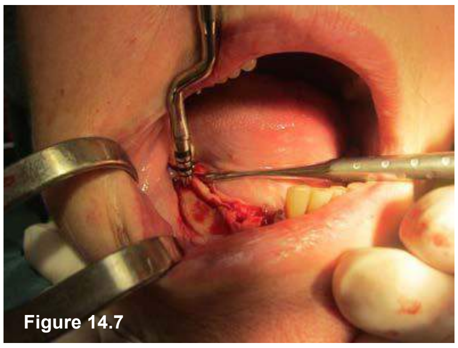


Figure 14.7


Figure 14.8

Figure 14.1: *Panoramic X-ray image of the state before implantation.*

Figure 14.2: *Bone-split-ting by MM chisel tip.*

Figure 14.3: *Formation of implant sockets by MM in the place of tooth 44, first in the alveolar ridge split into 2, first with the 1 mm tip expander.*

Figure 14.4: *The image of the implant socket prepared in the place of tooth 44.*

Figure 14.5: *Starting im-plant socket expansion with a tip of 1 mm in the place of tooth 46.*

Figure 14.6: *Expansion of the implant socket with a 3 mm expander.*

Figure 14.7: *Application of a 3.3 mm expander tip. The depth of the socket can be seen on the lines of the expand-ing tip.*

Figure 14.8: *Placement of a 3.2 10 SGS implant in the place of tooth 44. The implant is driven into the bone socket expanded by MM with a rachet spanner.*


Figure 14.9


Figure 14.10

sound or suffer just minimal compression. Thus, for the conditions of immediate implan-tation, we can ensure the greatest possible preservation of the bone and soft tissues.

In case of multi-rooted teeth, transection of the crown and the neck of tooth can be car-ried out by a rotary instrument or piezo, then, by MM, we treat them as single roots and move them out of the alveolus with the thin blade of MM. Following this, we can prepare an implant socket with MM by horizontal ex-pansion.

For bone condensation, we apply MM tips which condense laterally and, in an order widening upward, we use them one after the other (1 mm, 2 mm, 2.3 mm, 3 mm, etc.). The rather soft, in many cases D4 bone, can be condensed to D3 and D3 quality to D2.

In case of horizontal bone expansion, often in a ridge with a width of 5-6 mm, we can car-ry out widening with MM tips of increasing width without shaving off any of the already little bone mass. In the case of a very thin and quite rigid bone, we start the operation with splitting, then, at an appropriate depth, in a ditch of 10-12 mm, we can further widen the split bone with implant-shaped tips. In the case of a rigid 3-4 mm ridge end, we can start the shaping of the corticalis and the first mil-limetres by piezo, then continue with an MM blade and chisel.

During the removal of impacted and retained teeth, we can access to the site between the tooth and the bone mass and, by expanding the bone slit, we gradually move the tooth out. Meanwhile, we can support the opera-tion by either a piezo or a drill.

Sinus lift is also possible with various special MM tips, as well as thickening the bone lay-er with tips of increasing diameters, applying vertical expansion. Stopping at 1 mm from the sinus base, with the blunt tip, it is possible to lift the bony base of the sinus, then prepare the mucosa and place the implant.

Figure 14.9: *Placement of a 3.2 10 SGS implant into the place of tooth 46. Completion of the thin mandibular crest with titan net and syn-thetic bone.*

Figure 14.10: *The 3 pieces of SGS implants in the right lower quad-rant can be seen in the panoramic X-ray image, following bone splitting and placement of the implant.*


Figure 15.1


Figure 15.2

Figure 15.1: *In the X-ray image cysts can be seen on the upper front teeth.*

Figure 15.2: *Bone fenes-tration by MM, with the chisel-shaped tip at the root apex of tooth 11.*

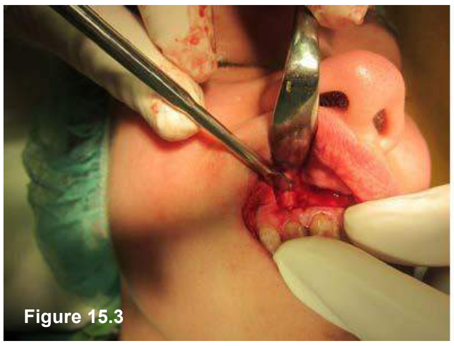


Figure 15.3


Figure 15.4

Figure 15.3: *Cutting down the end of the root apex by MM, with the chisel-shaped tip.*

Figure 15.4: *Root apex cut down; the root-fill-ing and the smooth cut surface can be seen.*

In the process of resecting the apex of the root, instead of the traditional chisel-mallet, we can use the chisel of MM for both the re-moval of the bone mass and cutting the apex of the root.

Results and statements

1. Shaking of the whole skull is moderate compared to traditional mallet-osteotome.

The force of extremely fast, 0.1 second blows shows up in the plastic shaping of the bone. Shaking of the skull by the blows is very little. Naturally, it can be disturbing for patients, very sensitive to that and it may cause a problem, similarly to the noise of the drill. Shaking in sensitive patients can be mitigated by the application of a vacuum or other com-plementary cushion.

2. There are no consequent headaches, dizzi-ness or nausea.

Following surgery, no cases of dizziness, headaches or nausea occurred out of 269 pa-tients, which are mostly caused by the move of the auditory ossicles.

3. In osteotomy, any deviation from the de-sired direction, due to differences of bone density, can be avoided more easily.

A handpiece, operated by MM and holdable quite firmly, „deviates", and goes in a slant di-rection more rarely than a traditional chisel. At the same time, keeping direction and en-suring parallelism requires considerable at-tention and practice.

4. It can be operated by one hand at better visibility.

The small handpiece is easy to hold and it is also comfortable. Shaping the bone with both a traditional drill and piezo or laser, cooling fluid is continuously needed, which can sig-nificantly hinder vision. Using MM, it is not necessary, we can see well at every moment. It is also advantageous in that no spray com-pleted with some saliva and the flora of the oral cavity gets in the face, eyes and respira-tory tract of the operating staff.

5. Faster bone-healing due to living bone sur-faces

Shaping the bone without a cooling fluid there is no need to wash or rinse the bone and, as a result, no whitened and „washed out" bone or lifeless-looking bone surface is created. Fol-lowing the application of MM, the bone is red and shows a far more viable colour.

Based on both histological tests in animal ex-periments and practical experience, we can state that wound-healing and ossification are faster than in the case of rotary instru-ments.

6. At the preparation of implant sockets, the bone is parted and not drilled. The bone is pre-served without shaving and without any loss.

The preparation of an implant socket can be easily performed even in the case of an al-veolar ridge as wide as 5-6 mm, because the bone is pushed apart and no bone is shaved off the bone mass, the amount of which is small, anyway. We open the bone apart and carry out horizontal or vertical expansion.

7. With doubly-curved tips, any part of the oral cavity is accessible for osteotomy.

In the part of the oral cavity located closer to the pharynx, accession to bone surface is easier with the curved tips of MM; it can as well be easily used in the position of the sec-ond molar.

8. It is easy to prepare the implant socket even in case of a thin bone.

Unless the surface of the bone is not cov-ered with an extremely hard cortical, begin-ning with an osteotome of width of 1 mm, the preparation of the implant socket can be started with blows of appropriate force. If the cortical is hard, the application of either a spherical drill or a piezo can be of help for passing through. Then, in the spongiosa we can pass forward with the MM osteotome.

9. The implant, with its self-cutting edge, can be well screwed into the prepared implant socket. Bone-splitting can be carried out eas-ily and precisely.

The self-cutting implant of approximately the same size as the socket prepared with the tip of MM of appropriate thickness, can be screwed in by the help of a ratchet spanner. It is normally reasonable to prepare a socket into the bone of a diameter smaller by 0.5-0.6 mm than the implant to be put in. This is in-fluenced by bone density as well as shaping the surface of the implant.

At bone splitting, we follow a similar proce-dure. The cortical can be transected with an MM blade, a piezo or a drill, depending on hardness.

In the spongiosa, we can pass forward with the MM tips. Reaching the appropriate depth is indicated by the lines on the MM tips, with divisions similar to those on the drills for the implant socket.

10. Removal of roots and teeth can be carried out with special tips preserving the bone.


Figure 16.1

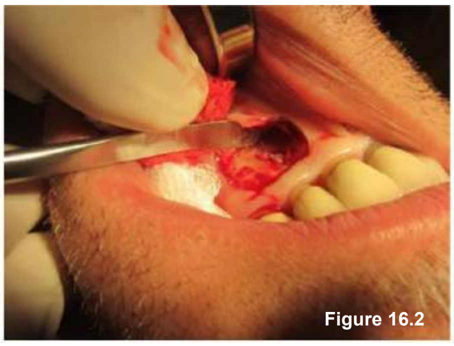


Figure 16.2


Figure 16.3

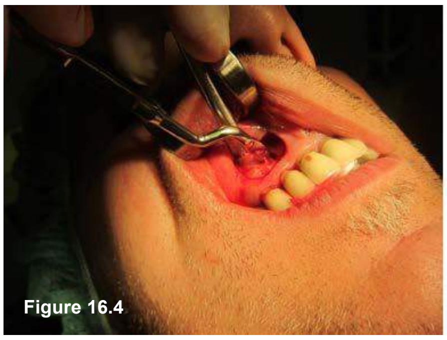


Figure 16.4


Figure 16.5


Figure 16.6

For the removal of teeth and roots thin, smooth, bent and curved tips can be applied. Tips introduced with mechanical power are capable of separating the surface of the tooth from that of the bone.

11. At bone condensation widening and thick-ening take place at the same time.

MM osteotome tips widen, condense and thicken the bone mass at our disposal si-multaneously. Thus we have the chance to preserve and maximally utilise the bone.

12. There is no need to drill, there is no bone loss – „shaving-free bone preparation".

In the case of soft bone (D3 and D4), the bone socket can be formed exclusively by MM, there is no need to apply any rotary instru-ments. In some cases, it can be useful to car-ry out directional drilling with a 2 mm spiral drill, following which, keeping the appropri-ate direction, MM osteotomes of increasing diameters should be applied.

In a considerable part of cases there is no bone loss at all and, in a lesser rate, there is minimal bone loss, which is just a small part of that compared to the bone loss made by traditional drills.

13. There is no warming up experienced on drilling, no cooling fluid is needed. Thus, no physiological substances are washed out of the bone, which promote healing. „Living bone surfaces" are left.

Physiologically important, bioactive sub-stances, indispensible for osseointegration, remain in their place, they do not have to be artificially replaced. At the application of ro-tary instruments, piezo or laser, the cooling fluid washes them out to a significant de-gree and thus, the viability of the bone and its inclination to heal decrease.

14. No debris is created which hinders heal-ing.

Bone debris, lifeless mass can often hinder or slow down bone healing. At the application of MM no debris is produced.

15. It is minimally invasive for the patient, pain can be avoided.

The gentle therapeutic technique, preserva-tion of bone, good visibility and maximal bone preservation significantly contribute to a de-crease in or lack of postoperative complaints. Implantation can often be carried out even without flap formulation.

16. It works with precisely calibrated force, depth and period of time, works with ex-tremely short impulses, so its application is gentle.

Bone-shaping with MM is well predictable. Depth can be controlled continuously by the help of division lines on the tips. The short and gentle impulses effectively shape the bone. In the case of hard bone we can use the piezo technique, then we continue the opera-tion with MM.

Figure 16.1: *On the root apex of tooth 12, granu-lome can be seen in the X-ray image.*

Figure 16.2: *The gra-nulation tissue can be seen following exp-loration by magnetic mallet.*

Figure 16.3: *Bone fenestration with the chisel-shaped tip of magnetic mallet.*

Figure 16.4: *Cutting down the apex of the root with the chisel-shaped tip of magnetic mallet.*

Figure 16.5: *State following cutting down the root apex.*

Figure 16.6: *X-ray image of the state following resection.*

Figure 17.1: *A 42-year-old male patient lost his lower implants inserted 3 years ago. Lateral lower edentia can be seen on either side in the panoramic X-ray image.*

Figure 17.2: *On the left side, we split the 4-5 mm-wide mandibular crest into two parts by piezo.*

Figure 17.1

Figure 17.2

Figure 17.3

Figure 17.4

Figure 17.5

Figure 17.6

Figure 17.3: *We continue splitting by piezo by the blade of MM and deepen it to a depth of 10-12 mm.*

We carefully separate the lingual and buccal plates.

Figure 17.4: *On the planned implantation sites we carry out horizontal expansion by the MM osteotome.*

Figure 17.5: *The 3 inserted SGS 3.75 implants are 10-12 mm long.*

Figure 17.6: *X-ray image of implantation follow-ing horizontal expansion by piezo-assisted MM – 4 pieces on the right side and 3 pieces on the left side.*

17. Bone-splitting and sinus lift can be per-formed easily.

Performing bone-splitting in soft, D3 and D4 bones is considerably simpler. In the case of hard bones it is worth doing bone-shaping in the first cortical level by piezo then, in the spongiosa, we can ad-vance further by MM. In the case of sinus lift there are several technical solutions at our disposal; calibrated force, work with blunt tips can involve a lot of advan-tages.

18. If necessary, it can be combined with other techniques and, in one phase of the interven-tion, we can use MM and in the other phase - a different tool (thread-cutter, piezo, indi-cating bone drill, scalpel, laser and other in-struments).

Conclusions

Magnetic mallet in bone-shaping, implantol-ogy.

- MM is an instrument applied in a wide range of oral surgical and implantological inter-ventions.
- In the case of risk patients and lesser bone mass, it is possible to prepare implant sock-ets by splitting and expanding the bone with minimal bone loss.
- The application of MM, with implants of favourable properties on their surfac-es (e.g. Straumann SLActiv), increases the chance of success, even in high-risk cases.

- It can be well combined with other surgical techniques.


Figure 18.1


Figure 18.2


Figure 18.3


Figure 18.4


Figure 18.5

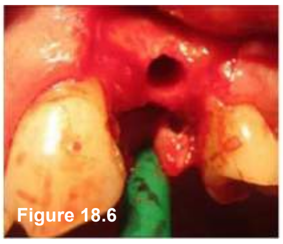


Figure 18.6


Figure 18.7

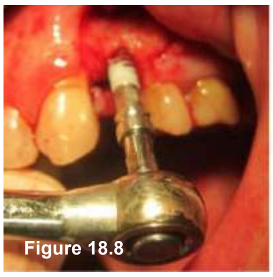


Figure 18.8


Figure 18.9


Figure 18.10

Figure 18.1.: *Fractu-red pin tooth 14 of a 55-year-old male pati-ent. Removal by MM.*

Figure 18.2: *Alteration of extraction hollow into implant socket by MM osteotome.*

Figure 18.3: *Placing an implant with a rachet spanner (SGS 4.2 12) into a socket prepared without a rotary inst-rument.*

Figure 18.4: *X-ray image of tooth 14 befo-re surgery.*

Figure 18.5: *X-ray check-up of implanta-tion.*

Figure 18.6: *Tooth 24 was removed 3 years ago, we inserted an implant in its place by MM. Implant socket prepared with an osteo-tome.*

Figure 18.7: *Further horizontal expansion by MM.*

Figure 18.8: *With the help of a rachet spanner, we insert an implant 4.2 12 SGS.*

Figure 18.9: *Image of an inserted implant.*

Figure 18.10: *X-ray check-up.*

• Its application allows bone preservation even at the removal of teeth and roots.

• Based on our one and a half years' favourable experience, it can be recommended for every-day praxis, especially in implant socket preparation, removal of teeth and roots and bone-splitting. It is indispensible in the case of little bone mass and in high risk patients.

References

Crespi, R.: Magnetic mallet in bone remodeling Manuscript, Meta Ergonomica, Milano 2016.1-124.p.

Crespi,R., Cappare, P., Gherlone, E.: A comparison of manual and electrical mallet in maxillary bone condensing for emmedi-ately loaded implants: A randomiozed study. Clin Implant Dent Relat Res. 2012 Aug 15. doi:10.1111/j. 1708-8208.2012.00485.

Csonka,M. -2014/1. Dr. M. Csonka - Flapless technique with Magnetic Mallet - https://www.youtube.com/watch?v=hyq-G6l5olTU

Csonka,M.-2014/2 Dr. M. Csonka - Root extraction with Magnetic Mallet-https://www.youtube.com/watch?v=I8tyJl1nmLw

Arduini,L.: - 2014 Dental implant with Magnetic Mallet - https://www.youtube.com/watch?v=ZTbI7UopLjA

Gáspár L.: Mágneses kalapács – új eljárás alkalmazása az implantológiában. Implantológia XI. évfolyam, 2014. 2. szám.6-10.o.

Dr. Rajkumar B.
Dr. Bhasin A.
Dr. Shukla P.
Dr. Gupta V.
Dr. Bhatt A.
Dr. Tekriwal S.
Dr. KumarA.

Extraction followed by implant placement using **Magnetic Mallet**: a Case Report

Case Report

Extraction followed by implant placement using Magnetic Mallet: a Case Report

Rajkumar B[1], Bhasin A[2], Shukla P[3], Gupta V[4], Bhatt A[5], Tekriwal S[6], KumarA[7]

[1]Dr. B. Rajkumar, HOD & Professor, [2]Dr. Anika Bhasin, Post Graduate Student, [3]Dr. Preeti Shukla, Post Graduate Student, [4]Dr. Vishesh Gupta, Associate Professor, [5]Dr. Akanksha Bhatt, Assistant Professor, [6]Dr. Shweta Tekriwal, Post Graduate, [7]Dr. Aniket Kumar, Post Graduate. All affiliated with Department of Conservative Dentistry & Endodontics (ADD THIS), Babu Banarasi Das College of Dental Sciences, BBD University, Lucknow, India.

Address for Correspondence: Dr. Akanksha Bhatt, Assistant Professor. Department of Conservative Dentistry & Endodontics, Babu Banarasi Das College of Dental Sciences, BBD University, Lucknow, India, Email: dr.a.bhatt@gmail.com

Abstract

Dental extractions sounds scary to the patients due to complications like dry socket, delayed healing,paresthesia, bleeding from site etc. This case reportintroduces a novel and innovative magneto-dynamical patented device Magnetic Malletused for extraction of the tooth followed by immediate implant placement. This method is least traumatic to patient and produces no post extraction complications with good quality bone healing.

Key Words: Dental Extraction, Dental Implants, Immediate Dental Implant loading.

Introduction

Conventional dental extraction procedures are associated with several postoperative complications like bleeding from site of extraction, dry socket, nerve paresthesia, delayed healing, periodontal pocket, and infection [1]. Magnetic mallet is a magneto dynamic patented medical devicehas application in sinus lift procedures, bone remodeling procedures, dental extractions, and insertion of implants after extraction. Dental extraction performed using this device can be done with minimal or without flap reflection to preserve the blood supply to facial bone plate thus reducing the risk of significant bone loss [2]. This presence of intact buccal bone plate and adequate soft tissues allows the placement of implant immediately.

The ergonomic hand-piece of the Magnetic Mallet can beoperated with only one hand and the impulses are applied with a control foot pedal, leaving the other hand free and allowing greater visibility of the operating field. The standard kit supplied with the Magnetic Mallet comprises a set of 10 tips including blades, bone expanders and drivers for inserting implants. With this kit it is possible to tackle all the various applications for which the instrument has been developed.

Manuscript received 10th May 2016
Reviewed: 24th May 2016
Author Corrected: 8th June 2016
Accepted for Publication 20th June 2016

The impact of Magnetic Mallet ranges from 65 to 260 daN (deca Newton) in 120 microseconds when compared to conventional surgical mallet which ranges from 60 to 80 daN in 300 microseconds, Hence the entire impact of magnetic mallet only affects the bone mass not the craniofacial mass thus giving least psychological trauma to patient [3]. The present case report makes a sincere attempt to introduce a new, innovative, unique and patented tool called as "Magnetic Mallet" manufactured by Meta Ergonomica Di Merlo Mario, Italyto perform tooth root extraction followed by immediate implant placement without trauma.

Case Presentation

A male patient aged 32 years reported to the OPD of department of Conservative Dentistry & Endodontics, Babu Banarasi Das College of Dental Sciences, Lucknow, India with a chief complaint of broken tooth in upper front teeth. He gave history of trauma at his home in which his tooth got fractured and thereafter giving pain since 3 days. The physical build and gait of patient appeared normal. The medical history and extra oral findings were not significant. On Intra-oral Examination, it was observed that 22 toothwas fracturedandtender on vertical percussion. Past dental history statedthat patient had undergone root canal treatment in same tooth 2 years back. After a radiographic examination of that region it was revealed that the affected tooth hasaperiapical radiolucency with grade III mobility. A poor prognosis of 22 tooth clearly opted the tooth for extraction. The dental extraction was planned for same tooth followed by immediate implant placement aided with Magnetic Mallet (Figure1) after five days of antibiotic therapy along with anti-inflammatory drugs.

Figure1: Magnetic mallet Kit

Figure-2: IOPA 22 revealing fractured tooth with incomplete root canal obturation.

Figure- 3: Post extraction IOPA wrt 22 region.

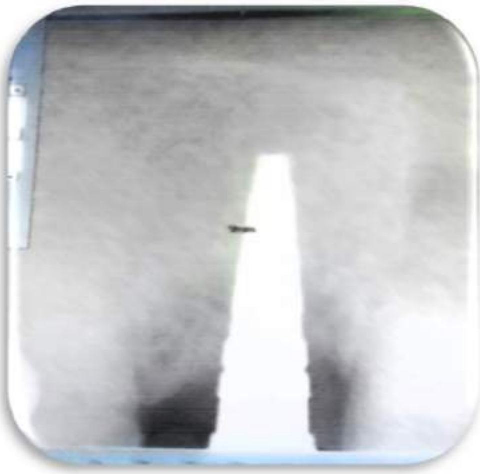


Figure-4: IOPA showing Magnetic Mallet Bone Osteotome just prior to Implant placement.

The local anesthesia 2% (Lignocaine with adrenaline, 1:80,000, ICPA, Mumbai) was administered and tooth was luxated using EXTR 3 which is long spoon shaped instrument in the kit which fits well with the root anatomy of the tooth and was taken out by the same instrument.After the tooth was extracted a radiograph was taken so as to confirm in-toto removal of tooth (Figure 3). Osteotome no. 1 and no. 2 were used in sequence to gain 2mm space beyond socket and a radiograph with osteotome was obtained before the implant placement (Figure 4). The implant of 3.75 diameter and 13 mm length was placed in the extraction socket followed by a radiograph (Figure5). All the extractors and osteotome used were attached to specializedergonomic handpiece which designed to provide a 30% higher force than the standard one, in order to facilitate the surgeon in penetrating maxilla bone having a greater density. It also delivered the clinician a ease of extraction [3].

Discussion

Atraumatic extraction methods are deemed to be important to minimize alveolar bone loss after tooth extraction and to facilitate subsequent implant restoration and optimal esthetic outcomes [4]. With the advent of such techniques, exodontia is no more a dreaded procedure in anxious patients. Newer systems and techniques for extraction of teeth have evolved in the recent few decades [5]. Magnectic Mallet being one of them offers advantages of faster recovery, no bone loss, less trauma during surgery, improving bone quality and prevents the so-called benign paroxysmal vertigo syndrome that is post-operative symptom of vertiginous nature. Moreover, the surgeon can operate with a greater visibility and control, preserving the bone and assuring the greatest possible comfort to the patient, both in complex implant surgeries and even in simple extractions [3]. It works at four different working intensities allowing the surgeon to modulate the force according to the type of operation needed and the receiving bone, proceeding with a greater safety margin and higher precision. With its numerous applications and advantages, MagneticMallet can be boon to the field of dentistry.

Conclusion

The Magnetic Mallet is an asset for dental and implant surgery for operator and patient in cases of maxillary sinus lift, vertical and horizontal bone compaction and expansion and more generally, in all cases where the blow of surgical hammer is normally used. Dental practitioners must make use of this system to provide high quality of treatment for their patients in a short duration of time causing no psychological trauma or fear.

Funding: Nil, **Conflict of interest:** None initiated.
Permission from IRB: Yes

References

1. Motamedi MH. Concepts to consider during surgery to remove impacted third molars. Dent Today. 2007 Oct;26(10):136, 138-41; quiz 141, 129.

2.Kang J, Dym H, Stern A. Use of the power tomeperiotome to preserve alveolar bone during tooth extraction-A preliminary study. Oral Surg Oral Med Oral Pathol Oral RadiolEndod 2009;108:4.

3. Magnectic Mallet [Internet]. [Place: Italy] Sweden & Martina. Available from :http://www.sweden-martina.com/7_magnetic-mallet_642.php.

4. Kumar MPS. Newer methods of Extraction of teeth. Int J Pharm Bio Sci2015; 6(3): 679 – 685.

5. White J, Holtzclaw D, Toscano N. Powertome assisted atraumatic tooth extraction. The Journal of Implant & Advanced Clinical Dentistry 2009;1(6): 35-44.

…………………………...........

How to cite this article?

Rajkumar B, Bhasin A, Shukla P, Gupta V, Bhatt A, Tekriwal S, Kumar A. Extraction followed by implant placement using Magnetic Mallet: a Case Report. *Int J Med Res Rev* 2016;4 (6):1046-1048.doi: 10.17511/ijmrr.2016.i06.31.

………

Dr. Roberto Crespi
Dr. Paolo Capparè
Dr. Enrico Felice Gherlone

Electrical **Mallet** in implants placed fresh extraction sockets with simultaneous osteotome sinus floor elevation.

Electrical Mallet in Implants Placed in Fresh Extraction Sockets with Simultaneous Osteotome Sinus Floor Elevation

Roberto Crespi, MD, MS[1]/Paolo Capparè, MD[2]/Enrico Felice Gherlone, MD, DMD, PhD[3]

Purpose: *To report the application of an electrical mallet (magnetic mallet) in osteotome-assisted surgery for sinus floor elevation with implants placed in fresh sockets and 2-year follow-up.* **Materials and Methods:** *A total of 32 patients (70 implants, 36 in the molar and 34 in the premolar regions) requiring extractions of maxillary premolars and molars were included in this prospective study. In all cases, implants were positioned immediately after tooth extraction. The implant site was prepared with osteotomes pushed by a magnetic mallet. Intraoral digital radiographic measurements were reported at 70 days and 1 and 2 years. Initial alveolar bone height and mean gained alveolar bone height were calculated for each implant over time. All implants were followed for 2 years.* **Results:** *One of 70 implants failed 1 month after surgery. This implant was successfully replaced 6 months later. The cumulative survival rate at 2 years was 98.57%. After surgery, no membrane perforation was reported, and no patient experienced vertigo, distress, nausea, and vomiting. Radiographic results were reported at 70 days and 1 and 2 years from implant placement. The alveolar bone gain following 70 days of healing resulted in a mean value of 2.63 ± 1.01 mm and, at 2 years from implant placement, was stable at 4.08 ± 1.25 mm. Statistically significant differences ($P < .05$) between values at 70 days and 1 year were reported, whereas there were no statistically significant differences ($P > .05$) between 1 and 2 years.* **Conclusions:** *The electrical mallet represents a fast and accurate instrument for placing bone expanders in fresh socket implants and simultaneous sinus floor elevation to avoid patient distress.* Int J Oral Maxillofac Implants 2013;28:869–874. doi: 10.11607/jomi.2679

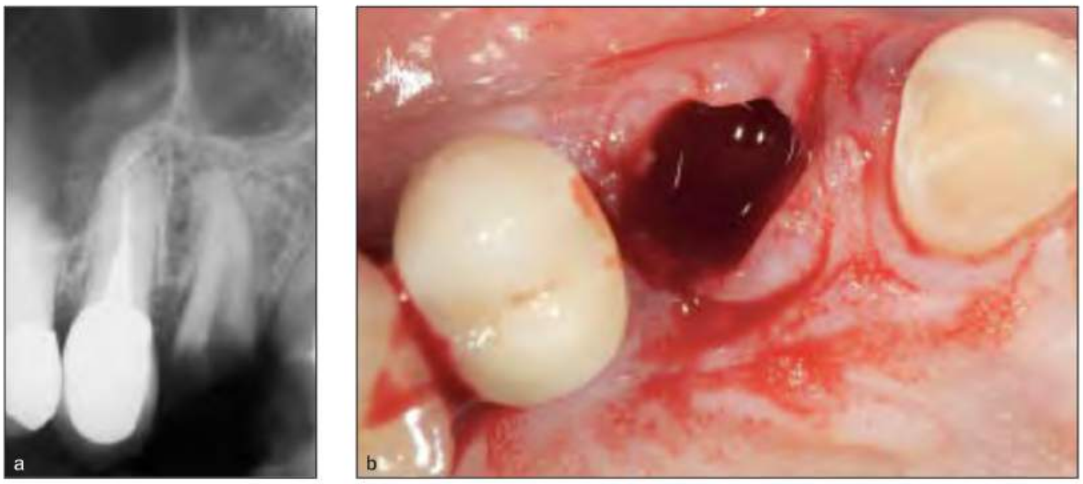
Key words: *dental implant, electric mallet, fresh extraction sockets, osteotome, sinus elevation*

Various authors have obtained good success rates placing dental implants into fresh extraction sockets to prevent the collapse of alveolar bone levels during healing procedures.[1–3] However, in maxillary premolar and molar sites, some anatomical limitations such as reduced bone height or width may prevent implant placement in both the edentulous ridge and fresh sockets. Consequently, to prevent expansion of the sinus floor and preserve the bone volume of fresh sockets after tooth extraction, immediate dental implant placement[4] is recommended. The use of osteotomes for vertical bone augmentation and localized sinus elevation is a suitable procedure to increase the vertical dimension of available bone for implant placement with minimal surgical trauma. The crestal bone is displaced toward the sinus floor, and the apical portion of the implant is placed in the augmented space. In a clinical study[5] at the time of maxillary molar extraction, a modified trephine and osteotome procedure was performed to implode the interradicular bone following maxillary molar extraction. Particulate material and a membrane were then placed to increase regeneration of alveolar bone.

When immediate implant placement is considered for teeth in close proximity to the sinus floor, a two-stage approach is often followed. In many instances, extraction followed by ridge preservation with or without biomaterials is the first step. Placement of an implant is usually attempted after a suitable healing period. Implant placement in fresh extraction sockets and simultaneous maxillary sinus floor elevation using the osteotome technique[6–8] would greatly shorten the total treatment time while providing the operator the benefit of placing longer implants.

[1]Clinical Professor, Department of Dentistry, Vita Salute University, San Raffaele Hospital, Milan, Italy.
[2]Clinician, Department of Dentistry, Vita Salute University, San Raffaele Hospital, Milan, Italy.
[3]Full Professor and Chairmen, Department of Dentistry, Vita Salute University, San Raffaele Hospital, Milan, Italy.

Correspondence to: Dr Roberto Crespi, Department of Dentistry, San Raffaele Scientific Institute, Via Olgettina 58, 20132 Milano, Italy. Email: robcresp@libero.it



Figs 1a and 1b *(a)* Preoperative radiograph of premolars. *(b)* Clinical view of fresh extraction sockets.

Additionally, the use of tapered wide-diameter implants in fresh molar sockets may reduce the anatomical discrepancy between alveolus and implant diameter, although graft material filling the gap between the implant and pocket surface may increase the stability and improve the prognosis.[9]

All studies reported in the literature were carried out by a hand mallet method that may provoke benign paroxysmal positional vertigo (BPPV)[10] as a consequence of working on the implant bed with osteotomes. During the placement of maxillary dental implants with the osteotome technique, the trauma induced by percussion along with hyperextension of the neck during the operation can displace otoliths and induce BPPV.[11] In this clinical study, a new electrical mallet (magnetic mallet) was used for osteotome tapping.

This study reports the effects of the electrical mallet on osteotome-assisted surgery with implant placement in fresh sockets and simultaneous sinus floor elevation over a 2-year period.

MATERIALS AND METHODS

Patients requiring maxillary premolar and molar extractions for root fractures, caries, endodontic lesions, or periodontal disease between January 2008 and October 2009 were included in this prospective study. In all cases, dental implants were positioned immediately after tooth extraction.

The following inclusion criteria were adopted for each patient: in good health, no chronic systemic disease, presence of bony walls of the alveolus, and alveolar ridge at least 10 mm deep. Exclusion criteria were: coagulation disorders, heavy smoking (more than 10 cigarettes per day), alcohol or drug abuse, and bruxism.

The local ethical committee approved the study, and all patients signed a written informed consent form. The patients included were treated by one oral surgeon and one prosthetic specialist in the Department of Dentistry, San Raffaele Hospital, Milan, Italy.

Surgical Protocol

One hour prior to surgery, patients received 1 g amoxicillin and 1 g twice a day for 1 week after surgical procedure. Surgery was performed under local anesthesia (Optocain, Molteni Dental) 20 mg/mL with epinephrine 1:80,000).

All multirooted molars were hemisected, the roots were removed carefully to preserve interradicular bone, and the sockets were debrided. A flapless approach was followed for preservation of the periosteum and keratinized mucosa with an atraumatic and adequate exposure of alveolar anatomy (Figs 1a and 1b).

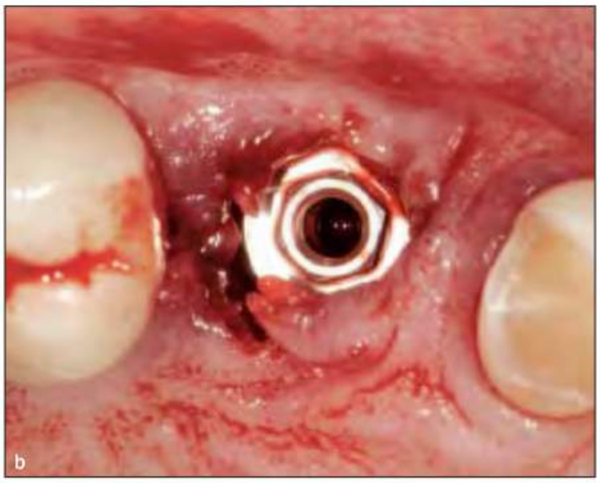
Titanium plasma-sprayed implants (Outlink, Sweden Martina) with a machined 0.8-mm neck, a rough surface, a body with a progressive thread design, and an external hexagon as the implant–abutment junction were positioned.

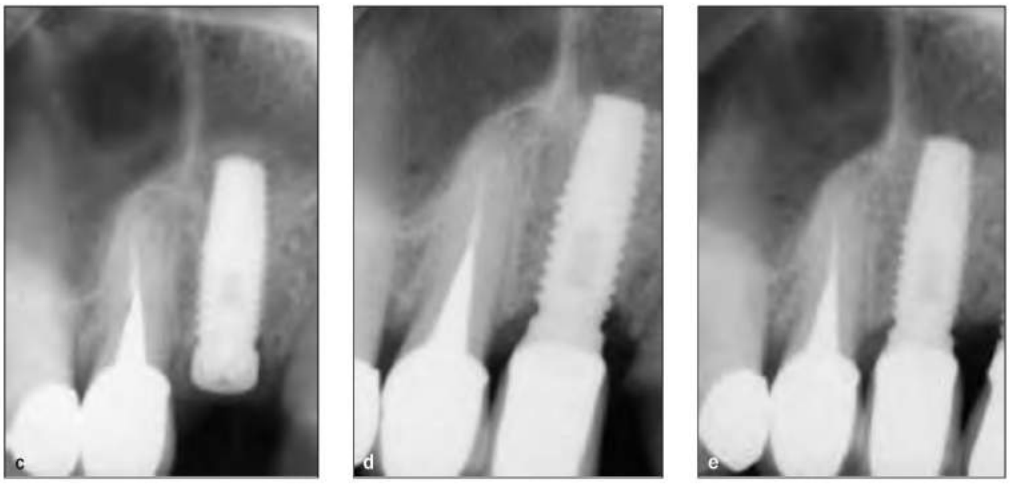
A 2-mm surgical bur (Komet Italia) was used to prepare a stable point in which progressive bone expanders were inserted to create the implant placement site. A postextraction radiograph taken using the parallel technique was used to evaluate the residual bone existing under the sinus floor.

Progressive-diameter bone expanders were inserted in the previous osteotomy site maintaining a palatal direction. The bone expanders were directly attached and pushed by the electrical mallet (Figs 2a to 2c).

The electrical mallet (Meta-Ergonomica, Turbigo) is a magneto-dynamical instrument assembled into a hand piece with a power control device, delivering

Figs 2a to 2e *(a)* Magnetic mallet and osteotome. *(b)* Clinical view of implant placed into the fresh extraction socket. *(c)* Periapical radiograph of the implant placed into the fresh extraction socket. *(d)* Periapical radiograph of the implant 1 year later. The new cortical line that defines the sinus floor can be observed. *(e)* Periapical radiograph of the implant 2 years after placement.





forces with timed application (Fig 2a). The bone expanders attached to the handpiece conduct a shockwave through their tips. The magnetic wave and the subsequent shockwave are calibrated to the timing of force application and induce axial and radial movements on the tips of the bone expander, with a fast force of 90 daN/8 µs.

The magnetic mallet imparted a longitudinal movement to the osteotomes along the central axis, moving up and down toward the pilot bone osteotomy site, providing a driving mechanism of longitudinal movements. Such mechanical sequences progressively condensed the internal bone wall of the initial osteotomy site radially outward with respect to the central axis, creating high-density bone tissue along a substantial portion of the length of the prepared implant site.

The initial preparation was performed with the smallest instruments (B2, apical diameter, 1.5 mm; B3, apical diameter, 1.9 mm). The further bone expander was 4.5 × 15 mm in length, with an apical diameter of 2.3 mm. This bone expander performed the initial sinus floor displacement, maintaining 2 to 3 mm before its final position. Subsequently, a 4.5 × 13-mm-long instrument was used with a progressively larger tip; it was pouched with the same occlusal movements of the previous one. Very delicate, careful tapping was now sufficient to displace the complex of the sinus membrane as well as cortical and pericortical osseous tissue into the the sinus cavity. These structures are considered to be potential sources of osteogenetic cells and their integrity must be preserved while they are displaced.[12] The implant was then tapped in position. A small piece of collagen inserted below the borders of the soft keratinized mucosa lining the extraction socket was used to cover the surgical field. The collagen (Gingistat, Acteon) stops the bleeding and ensures the stability of the blood clot. The collagen is held in position by inserting the suture needle at the center of the alveolus and suturing the collagen and tissue together with a crossed suture, which was not tightened. The horizontal extensions of the buccal vertical releasing incisions were extended as necessary, in conjunction

Table 1 Implant Dimensions and Positions (n = 70)			
Implant (diameter x length)	5 x 10 mm	5 x 13 mm	Total
Tooth no.*			
14	0	0	0
15	7	6	13
16	9	6	15
17	1	0	1
24	1	4	5
25	2	14	16
26	5	12	17
27	0	3	3
total	25	45	70

*FDI tooth numbering system.

Table 2 Mean Alveolar Bone Height Gained	
Time from implant placement	Bone height gained (mm)
70 days (placement of provisional prosthesis)	2.63 ± 1.01
1 y	4.03 ± 1.18
2 y	4.08 ± 1.25

with the partial-thickness flaps, to provide greater flap mobility. Sutures were placed to obtain primary wound closure and were removed after 1 week.

Seventy days after implant insertion, provisional prostheses were fitted and worn for 2 to 3 months before the definitive reconstruction was delivered. In addition, implants were considered successful only after 5 months of use with the definitive reconstruction and occlusal loading. Success criteria for implant survival included: implant stability, absence of radiolucent zone around the implants, no mucosal suppuration, and no pain. Moreover, patient experiences immediately after surgery were evaluated for pain, swelling, nasal or oral bleeding, vertigo, nausea and vomiting, and suppuration.

Radiographic Assessments

Periapical digital radiographic examinations (Schick CDR, Sirona) were performed perpendicular to the long axis of the implant with a long-cone parallel technique using an occlusal template at baseline (presurgery), implant placement, 70 days (placement of provisional prosthesis), and 1- and 2-year follow-ups. A blinded radiologist measured bone height over time by marking the reference points and measured lines on the screen interactively. The implant height (a known dimension) was used for calibration. The difference of bone level was measured using included software (Sirona). The following parameters were assessed from the periapical radiograph:

- Presurgical distance from the alveolar crest to the floor of the maxillary sinus
- Amount of new radiopacity between the sinus floor and alveolar crest, measured from the mesial and distal surfaces of each dental implant surface.

Mean for initial and gained alveolar bone height was obtained from the radiographic evaluation and was recorded at baseline (presurgery), implant placement, provisional prosthesis placement, and 1 and 2-year follow-ups from implant placement. The intraexaminer error was calculated by comparing the first and second measurements with a paired *t* test at a significant level of 5%. No statistically significant difference was calculated between values ($P > .05$).

Statistical Analysis

Dedicated software was used for statistical analysis (SPSS 11.5.0, IBM). All values are presented as mean s ± standard deviations. To compare the difference between radiographic data at every time point, a Student two-tailed *t* test was adopted ($P < .05$ was considered the threshold for statistical significance).

RESULTS

Thirty-two patients (20 women and 12 men) with a mean age of 54.5 years (range, 29 to 68 years) were selected for the study. Seventy implants (36 in molar and 34 in premolar regions) were positioned immediately after tooth extraction. Twenty-five implants had a diameter of 5 mm with a length of 10 mm and 45 implants had a diameter of 5 mm with a length of 13 mm (Table 1).

Surgical and Prosthetic Procedure

One of 70 implants failed 1 month after surgery. This implant was successfully replaced 6 months later. After 1 year, all implants were stable, and no signs of inflammatory reaction at the peri-implant soft tissue level were observed. Apart from expected pain and swelling, there were no other complications. After this surgical procedure, two patients experienced minor nasal bleeding, which disappeared within the first 24 to 48 hours. Suitable wound healing around provisional abutments was presented, with a fine adaptation to the provisional crown. Minor swelling of the gingival mucosa was present in the first days after surgery, and no mucositis or flap dehiscence with suppuration were found. The definitive porcelain-fused-to-metal restorations were attached 4 months after implant placement. The cumulative survival rate at 2 years was 98.57%.

No patient experienced vertigo, dizziness and disorientation, nausea, or vomiting on sitting up after surgery, as has been known to be induced by surgical hammer percussion using the osteotome technique.[10,11] The surgical procedure was fast, and the implant bed preparation was precise with the magnetic mallet.

Radiographic Evaluation

Radiographic results were reported at 70 days (provisional prosthesis placement), and 1 and 2 years from implant placement (Table 2).

Baseline bone levels (initial alveolar bone height) were 6.55 ± 1.34 mm. The alveolar bone gain following 70 days of healing, evaluated as the presence of radiopacity around exposed mesial and distal implant surfaces within the created space at the floor of the maxillary sinus, resulted in a mean value of 2.63 ± 1.01 mm.

After 1 year, the radiopacity around exposed mesial and distal implant surfaces incrementally increased (Table 2; Fig 2d). At 2 years from implant placement, the mean bone height measurements were stable at 4.08 ± 1.25 mm (Table 2; Fig 2e). However, a statistically significant difference ($P < .05$) between 70 days and 12 months was reported, whereas no statistically significant differences ($P > .05$) were found between 1 and 2 years were found.

These results demonstrated a significant increase in bone height between 70 days and 1 year, with stable bone levels over a 2-year follow-up.

DISCUSSION

The clinical and radiographic results reported a survival rate of 98.57% for all implants after a 2-year follow-up period. These results may be explained by the ability of residual alveolar bone for its ability to stabilize an implant of large dimensions in the desired prosthetic position,[13,14] with regard to force distribution and patient plaque control.

This surgical procedure obtained osseointegration of implants whose lengths largely exceeded the preoperative bone dimensions and diameter considered adequate to restore maxillary molars and premolar. Radiographic analysis of the successful implants shows that an increase of 4 mm of available bone is possible with this procedure.

Primary stability was achieved when implants were tapped into place because the maxillary cortical and cancellous bone, covered by the preserved periosteum connective tissues, are viscoelastic. This postextractive surgical procedure allows for implant placement into fresh maxillary premolar and molar extraction sockets obtaining primary stability in intraseptum bone spongiosa.

The use of 5-mm-diameter implants made it possible to increase stability and reduce postextraction defects, improving occlusal load-bearing in molar areas and allowing higher mechanical stability.

Furthermore, several studies have explained the capacity to obtain bone without grafting material when the sinus membrane has been elevated beyond the anatomical limits of the sinus floor, either crestally[15] or laterally.[16–18]

Nedir et al[19] confirmed that the osteotome sinus floor elevation procedure without grafting material was sufficient to create bone beyond the natural limit of the sinus since implants gained endosinus bone despite the lack of grafting material and without shrinkage of the augmented area.

The ability to place implants in ideal anatomical positions at the time of mandibular molar extraction, with or without concomitant regenerative therapy, would represent a key development in the treatment procedure.[20] Cafiero et al[21] immediately placed 82 tapered implants with an endosseous diameter of 4.8 mm and a shoulder diameter of 6.5 mm into fresh molar sockets. All implants healed uneventfully yielding a survival rate of 100% and healthy soft tissue conditions after 12 months. However, tapping of the expansion osteotomes with the hand mallet represents the greatest inconvenience of this technique, since it may induce BPPV in patients who have experienced no previous episodes of this form of vertigo.[22,23] In the present study, no patients claimed distress or vertigo when trying to sit up immediately after surgery. However, incidence of this complication may have been higher. Since implant treatment is increasingly being carried out with older patients, and because of the widespread use of the bone expansion technique with osteotomes, incidence of BPPV can be expected to increase.

The low force of bending waves produced by the hand hammer (40 daN/2 ms) was found to depend on the density, area moment of inertia, and density-dependent elastic constants of bone.[23] It is important to account for the changes of these parameters along the bone, as well as hyperextension of the neck during the operation since these practices can displace otoliths.

The probable explanation for the lack of patient discomfort may be explained by the magnetic wave and the subsequent shockwave of the electric mallet, since they are calibrated by the timing of force application, inducing axial and radial movements applied at the tip of the osteotome with a fast force of 90 daN/8 µs. With this procedure, the trauma to the craniofacial bones is minimized as much as possible, reducing the forces only to the target area.

The fast force of the magnetic mallet supplied precise control of the entry direction of the osteotome tip into the bone. This is an important concept since bone is generally formed of parts with different densities, and the expander tends to be deflected when it moves from bone with a specific density to another with a lower density. Furthermore, the handling of the device is very simple since the mechanical oscillations transmitted to the osteotome are transmitted without difficulties to the bone.

Implants immediately placed in premolar and molar extraction sockets with bone expanders pushed by a magnetic mallet represent a predicable surgical procedure and do not lead to bone injury. This surgical technique is rendered safe and comfortable, without risk of vertigo[10] for patients. With a survival rate of 98.57% after 2 years of loading, this technique compares well to classic implant placement procedures. The magnetic mallet device had a good bone condensing efficiency, especially in softer bone, because of the magnetic wave and the subsequent shockwave, which induce axial and radial movements with a fast force on the osteotome tip and resulted in no patient distress.[23]

CONCLUSIONS

The magnetic mallet is fast, precise, and efficient in bone condensing and can be seen as a suitable instrument for preparing a superior fresh socket for implant placement with a simultaneous sinus elevation procedure. Patient distress commonly induced by use of a hand mallet is also avoided.

Further clinical studies are required to improve the parameters of surgical procedure and soft tissue management and to develop more suitable macro- and microtextured dental implants.

ACKNOWLEDGMENT

The authors reported no conflicts of interest related to this study.

REFERENCES

1. Tolman D, Keller E. Endosseous implant placement immediately following dental extraction and alveoloplasty: Preliminary report with 6-year follow-up. Int J Oral Maxillofac Implants 1991;6:24–28.
2. Wilson TG, Schenk R, Buser D, Cochran D. Implants placed in immediate extraction sites: A report of histologic and histometric analyses of human biopsies. Int J Oral Maxillofac Implants 1998;13:333–341.
3. Covani U, Cornelini R, Barone A. Bucco-lingual bone remodeling around implants placed into immediate extraction sockets: A case series. J Periodontol 2003;74:268–273.
4. Schwartz-Arad D, Grossman Y, Chaushu G. The clinical effectiveness of implants placed immediately into fresh extraction sites of molar teeth. J Periodontol 2000;71:839–844.
5. Fugazzotto PA, De Paoli S. Sinus floor augmentation at the time of maxillary molar extraction: Success and failure rates of 137 implants in function for up to 3 years. J Periodontol 2002;73:39–44.
6. Barone A, Cornelini R, Ciaglia R, Covani U. Implant placement in fresh extraction sockets and simultaneous osteotome sinus floor elevation: A case series. Int J Periodontics Restorative Dent 2008;28: 283–289.
7. Summers RB. The osteotome technique: Less invasive methods of elevating the sinus floor. Compend Contin Educ Dent 1994;15: 698–708.
8. Rosen PS, Summers R, Mellado JR, Salkin LM, Shanaman RH, Marks MH. The bone-added osteotome sinus floor elevation tecnique: Multicenter retrospective report of consecutively treated patients. Int J Oral Maxillofac Implants 1999;14:853–858.
9. Block MS, Kent JN. Placement of endosseous implants into tooth extraction sites. J Oral Maxillofac Surg 1991;49:1269–1276.
10. Peñarrocha-Diago M, Rambla-Ferrer J, Perez V, Pérez-Garrigues H. Benign paroxysmal vertigo secondary to placement of maxillary implants using the alveolar expansion technique with osteotomes: A study of 4 cases. Int J Oral Maxillofac Implants 2008;23:129–132.
11. Saker M, Ogle O. Benign paroxysmal positional vertigo subsequent to sinus lift via closed technique. J Oral Maxillofac Surg 2005;63: 1385–1387.
12.. Kim S-W, Lee K, Yun K-I, Kim C-H, Park J-U. Adult stem cells derived from human maxillary sinus membrane and their osteogenic differentiation. Int J Oral Maxillofac Implants 2009;24:991–998.
13. Schropp L, Wenzel A, Kostopoulos L, Karring T. Bone healing and soft tissue contour changes following single-tooth extraction: A Clinical and radiographic 12-month prospective study. Int J Periodontics Restorative Dent 2003;23:313–323.
14. Polizzi G, Rangert B, Lekholm U, Gualini F, Lindström H. Brånemark system wide platform implants for single molar replacement: clinical evaluation of prospective and retrospective materials. Clin Implant Dent Relat Res 2000;2:61–69.
15. Leblebicioglu B, Ersanli S, Karabuda C, Tosun T, Gokdeniz H. Radiographic evaluation of dental implants placed using an osteotome technique. J Periodontol 2005;76:385–390.
16. Palma VC, Magro-Filho O, de Oliveria JA, Lundgren S, Salata LA, Sennerby L. Bone reformation and implant integration following maxillary sinus membrane elevation: An experimental study in primates. Clin Implant Dent Relat Res 2006;8:11–24.
17. Chen TW, Chang HS, Leung KW, Lai YL, Kao SY. Implant placement immediately after the lateral approach of the trap door window procedure to create a maxillary sinus lift without bone grafting: A 2-year retrospective evaluation of 47 implants in 33 patients. Int J Oral Maxillofac Surg 2007;65:2324–2328.
18. Hatano N, Sennerby L, Lundgren S. Maxillary sinus augmentation using sinus membrane elevation and peripheral venous blood for implant-supported rehabilitation of the atrophic posterior maxilla: Case series. Clin Implant Dent Relat Res 2007; 9:150–155.
19. Nedir R, Bischof M, Vazquez L, Nurdin N, Szmukler- Moncler S, Bernard JP. Osteotome sinus floor elevation technique without grafting material: 3-year results of a prospective pilot study. Clin Oral Implants Res 2009;20:701–707.
20. Fugazzotto PA. Implant placement at the time of mandibular molar extraction: Description of technique and preliminary results of 341 cases. J Periodontol 2008;79:737–747.
21. Cafiero C, Annibali S, Gherlone E, et al. Immediate transmucosal implant placement in molar extraction sites: A 12-month prospective multicenter cohort study. Clin Oral Implants Res 2008;19:476–482.
22. Cheng S, Timonen J, Suominen H. Elastic wave propagation in bone in vivo: Methodology. J Biomech 1995;4:471–478.
23. Crespi R, Capparè P, Gherlone E. Electrical mallet provides essential advantage in maxillary bone condensing. A prospective clinical study. Clin Implant Dent Relat Res 2012 Jan 11 [epub ahead of print].

Prof. Werner Zechner

Clinical Evaluation of the **Magnetic Mallet Device**

Univ.Prof.DDr. Werner Zechner, Private Practice & Dental University Clinic Vienna

Sensengasse 2a, A 1090 Vienna, Austria

Clinical Evaluation of the Magnetic Mallet™ Device

In this report, the clinical experiences on the pre-clinical and clinical use of the magnetic mallet for osteotomies and tooth extractions is described after having introduced this clinical procedures in 2016.

The application of various oral-surgical, and pre- and simultaneous implantologic bone augmentation techniques such as vertical osteotomies, lateral spreading and condensing of the alveolar crest as well as tooth extraction techniques have been described in literature in many peer-reviewed publications. Horizontal and vertical clinical procedures (Summer´s osteotomy, bone spreading etc) have been described with the use of manual mallets, and resulted in predictable results regarding the technique itself as well as its implant survival and success rates on various observation times.

The introduction of the magnetic mallet device promised a shorter and more efficient time of energy transfer on the implant bed to be augmented when compared to manual instruments according to an investigations of the Centro Nazionale di Ricerca (University of Milan, data provided by Meta Ergonomica):

- No pre-clinical complications of adverse observations have been made in the initial phase of use as well as during several training courses the use of the magnetic mallet (approximately 50 applications)

- No clinical intra-operative complications (alveolar bone or instrument fractures, dislocations, injuries of anatomical structures) have been observed during the observation period (> 100 applications in both centers)

- No adverse post-operative side effects such as headache, paroxysmal vertigo or other discomfort has been detected in the observation time. Comments of patients feedback ranged from enthusiastic feedback after successfully avoiding more invasive grafting procedures (such as lateral sinus floor elevation, lateal onlay grafts, …) up to moderate acoustic discomfort limited to the Summer´s procedure with no post-operative complaints. The amount of patients with intraoperative acoustic discomfort, mostly with dense bone qualities of Typ I and Typ II+ according to Lekholm & Zarb (1985) was less than 10% and much less than for manual mallet used for summer´s osteotomies with >30%.

- So far, less only 3 patients have been treated with the magnetic mallet chisels for a minimal-invasive extraction of teeth: The roots were successfully removed, no adverse effects have been observed, the number of treatments for this indication , however, is very low in our centers for the time being.

In conclusion, the introduction of the magnetic mallet device in our training and clinical setting has broadened the field of minimal invasive indications, increased the safety of the described techniques, reduced the patient´s discomfort so far without any substantial adverse effects.

Univ.Prof.DDr. Werner Zechner, Private Practice & Dental University Clinic Vienna

Sensengasse 2a, A 1090 Vienna, Austria

Univ.Prof.DDr. Werner Zechner

Lekholm & Zarb 1985 Patient selection and preparation. In tissue-integrated prosthesis: Osseointegration in clinical dentistry. Chicago: Quintessence Publ Co. 1985; 199-209.

Dr. B Rajkumar
Dr. Devang Kankane
Dr. Garima Popli
Dr. Vishesh Gupta
Dr. Akanksha Bhatt

Changing the era of implant dentistry using a wonder tool: Electrical **Magnetic Mallet**

CHANGING THE ERA OF IMPLANT DENTISTRY USING A WONDER TOOL: ELECTRICAL MAGNETIC MALLET

Dr. B Rajkumar [1] | Dr. Devang Kankane [2] | Dr. Garima Popli [2] | Dr. Vishesh Gupta [3] | * Dr. Akanksha Bhatt [4]

[1] Professor & Head of Department, Department of Conservative Dentistry & Endodontics, Babu Banarasi Das College of Dental Sciences, BBD University, Lucknow, INDIA.

[2] Post Graduate Student,Department of Conservative Dentistry & Endodontics, Babu Banarasi Das College of Dental Sciences, BBD University, Lucknow, INDIA.

[3] Associate Professor, Department of Conservative Dentistry & Endodontics, Babu Banarasi Das College of Dental Sciences, BBD University, Lucknow, INDIA.

[4] Assistant Professor, Department of Conservative Dentistry & Endodontics, Babu Banarasi Das College of Dental Sciences, BBD University, Lucknow, INDIA. (*Corresponding Author)

ABSTRACT

Implant dentistry has become a revolutionary branch nowadays. The use of magnetic mallet has provided us with some clinical advantages during the surgical procedure over the traditional method of osteotomy using hand mallet and chisel. The present clinical report stated the procedure of surgical placement of an implant in the mandible using an innovative device known as Electrical Magnetic Mallet with great precision.

INTRODUCTION

The alveolar ridges reduce in horizontal dimension after the tooth is lost.1 Conventional method of restoring the missing tooth with an implant is drilling technique or making use of hand mallet and chisel in osteotomy procedures. Existing literature reports the incidence of Benign paroxysmal positional vertigo (BPPV) with the use of hand mallet while placing dental implants in the maxilla.2Osteonecrosis has also been reported at the implant sites which were placed using drills. Limitations to these procedures led to the introduction of a novel approach which makes use of piezoelectric frequency. The Electrical Magnetic Mallet (Meta-Ergonomica, Turbigo, Milan, Italy), is a dynamic device consisting of a hand piece and a power unit that defines the force to be applied and the timing of application. Power unit implies magnetic wave to the osteotome connected with the hand-piece which results in the longitudinal movements along the central axis of the osteotome.3The present case report demonstrates restoration of the partially edentulous ridge with dental implants using Electrical Magnetic Mallet.

CASE REPORT:

A 57 year old female was referred to the Department of Conservative Dentistry and Endodontics, Babu Banarasi Das College of Dental Sciences, Lucknow, with the chief complaint of long span partially edentulous area. As the patient was not willing for a removable prosthesis and since the long span did not favour either conventional or adhesive bridgework, dental implant with prosthesis was advised. Past medical and dental history was recorded which reveals good general health, non-smoker and absence of any chronic systemic diseases.

Pre-operative examination was done which revealed presence of D3 bone in left mandibular posterior region i.r.t 36 and size of implant was decided accordingly (Fig.1). Bone height and width were measured as 12mm × 5mm in the molar region. Implant was planned to place in the lower left posterior region (extraction done 7 years back).

Fig 1: Pre-operative OPG

Patient was given 1 g of amoxicillin orally one hour prior to surgery. Patient was asked to rinse her mouth twice with Peridex (Chlorhexidine Gluconate 0.12% Oral Rinse). Local anaesthesia administered Xylocaine (20 mg/mL with adrenaline 1:80,000). Two Nerve blocks were given: inferior alveolar nerve block and long buccal nerve block. Incision was given at the implant site using SM64 blade (Swann Mortan) held by blade holder of magnetic mallet [fig.2 (b)]. The implant site was prepared with osteotomes at frequency 30KHz, sizes 1 and 2, pressed by electrical mallet (Magnetic Mallet, Meta-Ergonomica, Turbigo, Milan, Italy) [fig.2(a)]. One implant was placed successfully. Periapical radiographs were obtained for evaluation before and after implant placement [fig.2(c,d)].

Fig 2: (a) Magnetic Mallet with instruments; (b)Using Electrical osteotome ;(c)Peri-apical radiograph showing placement of osteotome; (d) Peri-apical radiograph showing Implant.

DISCUSSION:

Success of implant placement is highly dependent on the density of bone. Literature reviewed implants in dense bone gave better results and far good prognosis than the soft bone.[4] According to Misch[5], there are four types of bone in term of its densities.

Volume and quality of the surrounding bone are two major parameters for the success of dental implants to a great extent. Bone density depends (minimal to severe, A- E) on residual jaw shape and different rates of bone resorption following tooth extraction (Ribeiro-Rotta et al., 2010). The atrophy of the alveolar ridge at different rates results in characteristic jaw shapes and density, due to which obtaining anchorage for dental implants becomes a difficult task. Sufficient bone density and volume are therefore crucial factors for ensuring implant success (Lekholm & Zarb, 1985). The trabeculae in D3 are approximately 50% weaker than those in D2 bone. D3 bone is most often found in the anterior maxilla and posterior regions of either arch. The D3 anterior maxilla is usually of less width than its mandibular D3 counterpart. The D3 bone is not only 50% weaker than D2 bone, the bone-implant contact is also less favourable in D3 bone.[4]

In case of soft bone or resorbed ridges, it is mandatory to preserve the existing bone. Osteotomes used for implant placement has a beneficiary act in compressing & manipulating the bone. Also, osteotome technique do not generate heat, which is a major determinant for osteo-integration. Advantageous use of magnetic mallet on the trabecular bone with the series of gradual increasing tapered instruments is the lateral compression of bone. Consequently there were improvements in the quality and density of bone by condensing D3 bone to D2 and D4 bone to D3. Good success rate are observed when the implants placed with this procedure especially when there is deficit of bone width & height.

REFERENCES

1. Chiapasco M, Abati S, Romeo E, Vogel G. Clinical outcome of autogenous bone blocks or guided bone regeneration with e- PTFE membranes for the reconstruction of narrow edentulous ridges. Clin Oral Implants Res 1999; 10: 278–288.
2. Penarrocha-Diago M, Rambla-Ferrer J, Perez V, Perez- Garrigues H. Benign paroxysmal vertigo secondary to placement of maxillary implants using the alveolar expansion technique with osteotomes: a study of 4 cases. Int J Oral Maxillofac Implants 2008; 23:129–132. (A)Electrical Mallet Provides Essential Advantages in Maxillary Bone Condensing. A Prospective Clinical Study. Clinical Implant Dentistry and Related Research 2013; 15(6)874-882.
3. Roberto Crespi, Paolo Cappare, Enrico Felice Gherlone. Electrical mallet provides essential advantages in split-crest and immediate implant placement. Oral Maxillofac Surg (2014) 18:59–64.
4. Ayse Gulsahi. Bone Quality Assessment for Dental Implants, Implant Dentistry - The Most Promising Discipline of Dentistry, Prof. Ilser Turkyilmaz (Ed.) (2011), ISBN: 978-953-307-481-8,
5. Carl E. Misch, ContemporaryImplantDentistry 3rd Edition.

Dr. Lajos Gáspár

Experiences in the application of bonealbumin humangraft

Dr. Lajos Gáspár

Experiences in the application of BONEALBUMIN HUMAN ALLOGRAFT

The Author hereby expresses his special thanks to *Dr. Csák Csaba, Dr. Glasz Tibor, Dr. Horváthy Dénes, Dr. Lacza Zsombor, Dr. Simonffy László, Dr. Trimmel Bálint, Kónya János, Dr. Kivovics Márton, Prof Dr. Szabó György, Dr. Csönge Lajos, Dr. Török Roland, Dr. Tóka József, Dr. Benedek Gábor, és Dr. Szabó Zoltán*, whose works and performances contributed to the expansion of our knowledge in the experiences in the examination and application of BoneAlbumin.

In significant part of bone shaping processes, interventions of implantology and oral surgery are supplemented by the substitution of the amount of bone necessary for the ideal or minimal amount. For the substitution of bone losses, there are several different materials of human or animal origin, as well as synthetic materials. Initially, based on the wide range of literature in this topic, we can determine that none of the today applied methods, materials or procedures are perfect.

States of bone losses

Following the loss of teeth and resorption of the bone, bone supply may be so poor, as:

- Implant cannot be possible to put in a traditional way—according to Misch—when the horizontal width of the alveolar crest is smaller than 5 mm, or vertical height is smaller than 8 mm.
- Even if implant can be put, there is such a thin bone layer around the implant, that the success of ossification is not sure.
- Primer stability cannot be accessed.
- A certain part of the side surface of the implant is not covered by bone.
- A certain part of the implant in not under bone level.

In states of bone losses, before putting implants, possibilities for treatments can be divided into 4 groups:

1. Bone—rendered suitable by bone shaping

Plastic transformation of the available alveolar crest in order to make it able to admit the implant

- Horizontal expansion–widening
- Vertical expansion–raising
- Condensation–to access the appropriate bone density

2. Into bone rendered suitable by bone grafting:

- Autograft - The graft originates from the same person.
- Allograft - The donor and the recipient entities belong to the same species, but genetically they are not identical.
- Xenograft - The graft originates from different species than it will be put in.
- Synthetic materials - Hydroxiapatite, bio ceramics, beta tricalcium phosphate, calcium sulphate.

3. Into bone rendered suitable by bone shaping and bone grafting:

- Surgical technique of bone grafting Lateral augmentation, sinus lifting, bone splitting.
- Bone grafting materials, according to their origin: autograft, allograft, xenograft, synthetic materials
- Bone grafting devices.
- Manual-, rotational-, piezo-, laser devices, magnetic hammer.

4. Into bone rendered suitable by guided bone regeneration (GBR) technique:

- Nonabsorbable diaphragms -Teflon Gore tex, Titan reinforcement PTFE (poli-tetra- fluoro-ethylene)
- Absorbable diaphragms - collagene, /BioGuide (4-6 months), polylactic acid (PLA), poliglycolic acid (PGA), EpiGuide (6-12 months), liophilised dura mater, Lyodura, Lyoplant.

Because of the fear from bovine spongiform encephalopathy (BSE), nowadays, the use of the otherwise popular bovine has significantly decreased, while in the recent years, the interest in synthetic or allograft materials has showed a significant increase.

Synthetic bone grafts

One of the popular synthetic materials is the pure phase ß tricalcium phosphate (ß-TCP). Based on both animal experiments and clinical results, its advantage is that neither of the material itself, nor its degradation product is toxic, it cannot contain viruses, prion or any other protein. It is tissue friendly, its remodelling does not result in inflammatory symptoms. The clean ß tricalcium phosphate (β-TCP), as a Cerasorb, is also a widely used osseoconductive material. Due to its chemical features, while the osteogenesis its resorption is quick and complete.

While its introduction, platelet rich plasma, (PRP) raised high hopes, which, due to its factors, improves ossification. But until now, we haven't found such literature, where data would prove the significantly beneficial combined effect of PRP and synthetic bone grafts—rather, on the contrary, in fact.

Bone grafts of xenograft are mainly of bio materials of bovin origin, which consists of calcified matrix. One of them, called Bio-Oss is an efficient xenograft which can be used safe—it is a bone derivative of deproteinized and sterilized bovin with 75-80% porosity. It has outstanding osseoconductive features.

Calcium phosphate cement (CPC, e.g. VitalOs) solidifies very quickly, crosslinking around the formation of the new bone.

The most important features of bone grafts

The use of today's new bone grafts allows that contrary to spontaneous recovery, the regeneration shouldn't be scarring or connective tissue remodelling, which contain the formation of—from the aspect of implantology—valueless tissues. The material which is to be put in should meet several requirements. It shouldn't damage the implant receiver organism, it shouldn't contain any infectious agent, thus it shouldn't transmit any infections. If it is possible, bone resorption should be continuous and synchronized with osteogenesis, giving way to the forming new bone tissue gradually. The principle of remodelling should be prevailed: the new bone should be similar to the original one, moreover, it shouldn't delay but has a positive, osseoinductive influence on the ossification process, and it shouldn't improve formation of bone at places where originally—e.g. outside of periosteum—there wasn't any.
Application of own bone is known in several bone grafting methods, and for more than 50 years it is applied with success; however, there is a growing demand on other type of bone grafting materials, as well. Beef bone, which had been prevalent and successfully applied for decades, seems to be excluded from the practice, while professional attention turned towards other materials and new solutions.

Bone grafting materials

For bone grafting—as we know it very well—there can be several materials applied. Here we can't afford to review the complete list of them, but we can highlight the most typical ones introducing their features, as well.
While the choosing, process the advantages and disadvantages of the available materials shall be considered.
All over the world, autologous bone grafts are still the gold standard. From the aspect of biocompatibility, it is optimal. Although, its disadvantage is that it has limited availability, while in all cases it needs a second surgical intervention. In oral surgery and implantology it is particularly critical, as bone grafting is necessary in those cases and patients where there is not enough bone available. Thus, bone taking which is necessary for bone transplant is limited.

While smaller augmentations where own bones are used, the available amount of autologous bone can be obtained from intraoral surgical intervention as well, but for frequently applied sinus elevatio or bone demand of greater volume, autologous bone can be obtained from the iliac crest, by bone transplant. However, this operation is quite a serious one. The question arises, whether the second surgical intervention is proportionate to the target of the original operation, therefore, the augmentation. It must be considered that the second surgical intervention increases the risk of the operation, and in most cases, in the donor region there is a stronger, longer lasting pain, moreover, there are more complications happened than while the first intervention.

Knowing these, several professionals pointed out the necessity of autologous bone grafting in the 1980s. There were countries, where the application of allogeneic bone transplant was a widely-spread method, while in others—due to legislative obstacles—it remained limited. The great advantage of this method is that there is no need for a second surgical intervention. However, there is the danger that due to its not diagnosed disease, the donor may transmit infections. Furthermore, rejection reaction may also be possible—as in all cases of transplanted tissues. It is true for the materials of the otherwise popular bovin origin, as well.
The above risks may be prevented by the application of synthetic materials, which become more and more perfect and popular, while they are available without limits and second surgical intervention. Disadvantage of them is not to have any osseoinductive features. Regarding their chemical and physical features, the different known synthetic materials differ from eachother.

For the classification of alloplastic materials, resorption tendency, phase-purity, solidity and porosity are important criteria.

Resorption tendency is one of the basic requirements for real regeneration, therefore, the ideal outcome of the treatment. Formation of new bone simultaneously with the complete resorption of the bone graft can lead to the reparation of the original conditions, exclusively. Phase-purity guarantees homogeneity and same absorbency, which provides continuously solid augmentation under the resorption, as well. We know that foreign phases are absorbed in a slower manner, or they do are not absorbed at all—remaining in the new bone tissue forming small islands there. While the remodelling process, these remaining islands obstruct the formation of bone trabeculae appropriate to the direction of loading.
So as to avoid the early resorption of the augmentation put in, thus the unsuccessful process, initial solidity is necessary, which ensures constant volume under the

regeneration period. Porosity—the appropriate pore size of the bone graft—enables veins grow into the augmentation area, as well as the immigration of the cells there.

For nonabsorbable materials, such as hydroxyapatite (HA) or even for bone grafts of bovin origin, we know that there is only bone integration taking place there, as they do not improve the natural remodelling process of the bone appropriate to the direction of loading. Therefore, these are only reparations; so, the result of the treatment cannot be called regeneration.

In practice, tricalcium-phosphate (TCP) is quite a popular and widely spread, absorbable material of ceramic nature, with two types of solidity available. The thermodynamic type of it is less stable, which—under physiological circumstances—partly transforms to hydroxyapatite (HA), while in situ establishes a foreign phase, which may have an unfavorable effect on regeneration.

Based on the experiences, the more stable type of TCP does not transform into any other material, and it resorbs in physicochemical way. In the last years, for augmentation purposes, synthetic, pure phase ß tricalcium phosphate (ß-TCP) Cerasorb® seemed to be proved. Based on the experiences this material completely resorbs under a certain period of time, simultaneously with the formation of new bone, thus it can be considered a real bone regenerative material.

In order to optimize the conditions of bone regeneration, it is a widely-spread method to add platelet rich plasma (PRP) into the augmentation of the bone graft, which can be generated under the treatment in the operating theatre, from the own blood of the patient. Its growth factor content has a positive influence on osteogenesis, wound-healing and the regeneration of soft tissues.

It is known that the most important and contained at the highest concentration growth factors are the platelet derived growth factor (PDGF) and the transforming growth factor (TGF- ß1+2). Their high concentration in bone stock is proven. According to the literature, platelets and bone stock contain hundred times higher concentration of TGF-ß than generally other tissues. We also know that on the surface of osteoblasts we can find TGF- ß receptor of the highest concentration. It indicates its important role in bone regeneration. Based on clinical and animal experiments, due to the influence of PDGF and TGF- ß, cells involved in the regeneration process migrate to the place of defect, where they will become active. For example, macrophages, fibroblasts and monocytes release several other growth factors, in order to improve the regeneration process as well as angiogenesis. Besides the general stimulation of regeneration PDGF and TGF- ß have a direct effect on osteoblasts, as well. From the results, we can see that PDGF improves the chomotaxis of osteoblast precursor cells, while TGF- ß improves the differentiation and proliferation of osteoblasts. It has also been proved, that TGF- ß obstructs the activity of osteoclast cells which are responsible for the breakdown of bone tissue.

It is an important issue that the rate of proliferation of stem cells is improved by both growth factors. However, as we can see, they do not result either in the faster resorption of the augmentation, or in the delay of the formation of new bone. It has been proven that the positive effect of PRP results in the faster transformation of the new bone into a lamellar bone, which provides the appropriate bone density and quality sooner—which is essential from the aspect of the stability of the implant.

In the last years, the application of natural and synthetic calcium phosphate ceramics appeared in bone grafting as a significant alternative solution. Regarding their mineral composition, features and micro architecture, these materials are quite similar to human trabecular bone, while they show high affinity for proteins.

According to their chemical composition, calcium phosphate materials—applied in practice—can be hydroxyapatites (HA), beta tricalcium phosphates (ß-TCP), the combination of biphasic calcium phosphates and beta tricalcium phosphates (combination of HA and ß-TCP), and carbonate-free apatite. At the same time, literature contains such modification processes, according to which a change in the content of the materials results in a significant change of the biological features of the whole material. One of these successful modification processes is the substitution of phosphate with silicate ion (Si-CaP), which resulted in a material with new features, which proved to be useful in the process of bone formation.

Today, with the rapid development of dental implantology it has been clear that the most important requirement against bone grafting is the permanent result which lasts for years and the remodelling of the bone grafting material. Thus, it is a clear basic requirement against bone grafting materials, that the human body should not give immune response for them, and its application should cause as small operational load on the patient as possible. It is also very important that the application of them should remain within the limits of costs.

BoneAlbumin

Regarding their features, all the traditional allografts, xenografts and synthetic materials are less valuable than own bone, this is why both tendencies (own and not own bone) have advantages and disadvantages.

The advantages of these tendencies mentioned, are combined in a new method, where from a bone taken out of alive and otherwise examined human by an orthopedic operation experts create an alloplastic material, which—following appropriate processes—they treat with albumin. The created material, called BoneAlbumin, has become a part of the toolbox of dental implantology with features significantly different from previous materials (Skaliczki G et al. – 2013, Klára T et al. – 2014, Horváthy D et al. – 2016, Schandl K et al. – 2016).

Figure 1: *BoneAlbumin granules in sterile pack, ready for operational application.*

Animal experiments

Since 2006, under the leadership of dr. Lacza Zsombor, the Hungarian working teams have been working on this new method within the framework of BoneAlbumin researches. The examination of the material had been started by animal experiments, then, after receiving the necessary authorizations, experts made the first human implants. Based on the positive laboratory, clinical and histological results they made further developments. The dental, oral surgery and clinical examinations regarding its human application started in 2015.
When implanting hip prosthesis, while the operation the femur head as a living bone will be released and from this bone ball with the diameter of 5cm it will be possible to produce—with the method worked out by the mentioned working team—a kind of granules, a bone block. For its use in oral surgery, dentistry and implantology, the necessary authorizations are available, the clinical examination programs have been started, and the first results have already been received.

As a result of animal experiments, it has been proven, that BoneAlbumin:

1. is an active substance;
2. accelerates ossification;
3. provides a surface suitable for the adhesion of progenitor cells
4. decreases the colonization of bacteria

Tissue bank

The experts of the West Hungarian Regional Tissue Bank of the County Hospital in Győr, under the leadership of dr. Csönge Lajos, by bone physiological and bone histological examinations and methods, have studied the features and behavior of human allograft treated with albumin as well as the most important steps of the formation of types of bone allograft materials. According to their opinion, ideal bone donor is not older than 40 years, and for the formation spongiosa or corticospongiosa parts are necessary. The grain size in the bone granules may vary, it may be smaller than 0.5mm or around 2mm or even bigger than that. And bone blocks can be formed in a pre-set size. According to the Urist protocol, while the formation of bone graft, bones of human preparation should be first, desantigenised, then partly decalcinated, and finally, lead through self-digestion (autolysis) and chemical sterilisation. Next, there is albumin added to the preparation. The osseoconductive, osseoinductive and osteogenesis-inductive effects of BoneAlbumin improve the build-in process of bone graft.

Clinical application

While the 3D-planning and the work out of the first steps and methods of the individual bone block in the dental laboratory (dr. Csák Csaba, Kónya János, dr. Tóka József), first, based on the CT-image of the patient, the planning starts with the determination of dimensions. Then, with the help of a computer-controlled program, according to the individual bone loss of the patient, the bone block will be formed. The steps of the virtual planning are followed by CAD-CAM bone shaping, when from the bone block, the individual, precise 3-dimension block will be shaped.

While the implant of 3D-planned, and -formed bone blocks, on the ready block is not required to do any corrections, because it can be put in almost immediately. The intercourse through a wide surface accelerates and makes the vascularization and building-in of the block even safer. Grafting is not necessary to be supplemented by granules, and the operation is safer and faster, than in the cases when the bone block is from the patient's own bone. Although, wound closure by a tension free lobe has a major importance. The operation should happen under antibiotic protection and it is important not to make BoneAlbumin wet, it can be put on the surface immediately and directly, without any pre-treatment. So as to avoid the loading of the block above the implanted bone it is not advised to use any prosthesis, and the patient should avoid smoking for at least 3 weeks.
Experts have compared the behavior of bovin Bio-Oss to human BoneAlbumin, at socket preservation following the extraction of lower wisdom-teeth. The examined demarcation, postoperative pain and oedema, as well as the success of the healing process of the bone. For BoneAlbumin, experts had positive experiences.
There have been clinical working teams to examine the effects of BoneAlbumin, in the area of socket preservation following extraction of wisdom-teeth (dr. Simonffy László, dr. Gyulai Gaál Szabolcs, dr. Trimmel Bálint), in the cases of sinus lifts (prof. dr. Szabó György, dr. Kivovics Márton), and, in the clinical implant practice (dr. Benedek Gábor, dr. Tálos Mariann), which results have been published in several professional forums.

BoneAlbumin application in the Gáspár Medical Center

In the Gáspár Medical Center, experts examined primarily the combined application of BoneAlbumin and magnetic hammer. In the framework of that, there were socket preservation, bone splitting, lateral and vertical bone augmentation, rehabilitation of chin defects following cystectomy, as well as sinus-lifts got into the test groups.
Between 1 October, 2014 and 1 April 2017, we applied magnetic hammer for 419 patients.

Type of intervention	Male (pers.)	Female (pers)	Total (pers)
Tooth extraction and/or immediate implantation	37	55	92
Bone compression	39	73	112
Horizontal bone expansion	59	65	124
Vertical bone expansion	18	22	40
Sinus lifting	14	16	30
Cyst bone graft	8	13	21
Összesen	**176**	**244**	**419**

Between 1 March, 2015 and 1 April 2017, we applied the combination of magnetic hammer and BoneAlbumin for 102 patients.

Type of intervention	Male (pers.)	Female (pers.)	Total (pers.)
Tooth extraction and/or immediate implantation	13	18	31
Bone compression	11	12	23
Horizontal bone expansion	7	9	16
Vertical bone expansion	3	3	6
Sinus lifting	10	11	21
Cyst bone graft	2	3	5
Total	**46**	**56**	**102**

For cases of implantation assisted by magnetic hammer, there were 835 implants put in.

	Number of patients (pers.)	Number of implants (pcs)
Male	155	311
Female	247	524
Total	**402**	**835**

Among implants put in, there were 81 pieces of MIS, 103 pieces of Straumann, 565 pieces of SGS, 72 pieces of Paltop, 11 pieces of Bego Semados and 3 pieces of Denti got into the program.

Case studies

Case 1 (abb 2)

For P.I. 58-year-old female patient in subtotal upper jaw tooth loss, we made sinus lift on the right side, we applied BoneAlbumin (granules) as a bone grafting material. The splitting of the quite thin alveolar process was made

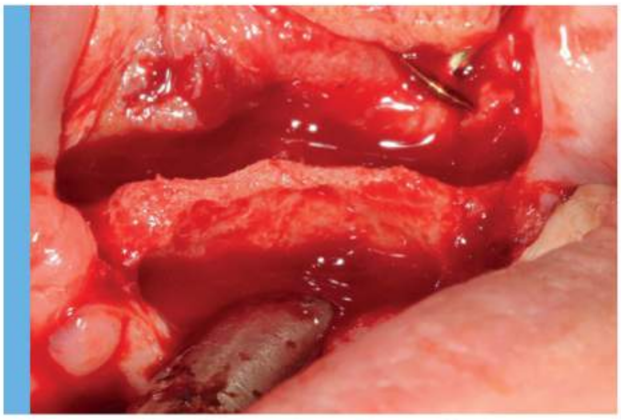


Figure 2.1: *P.I. with left side knife edged ridge of 2–3mm width.*

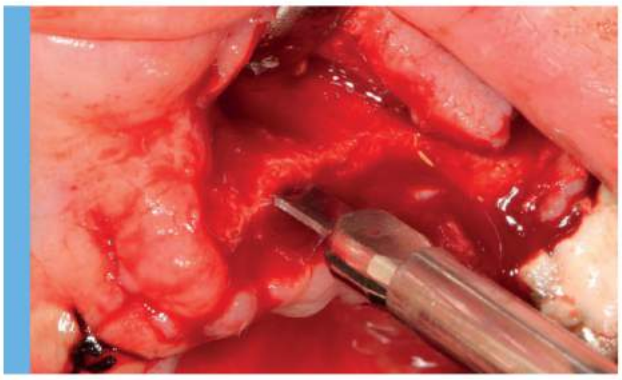


Figure 2.2: *Bone splitting of the ridge with the help of the blade of the magnetic hammer.*

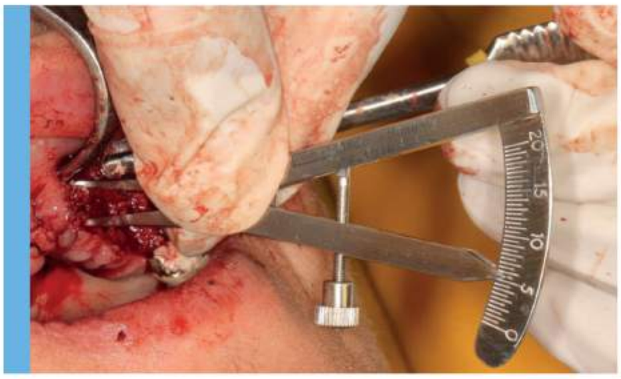


Figure 2.3: *Augmented width of ridge is of 5.5 mm.*

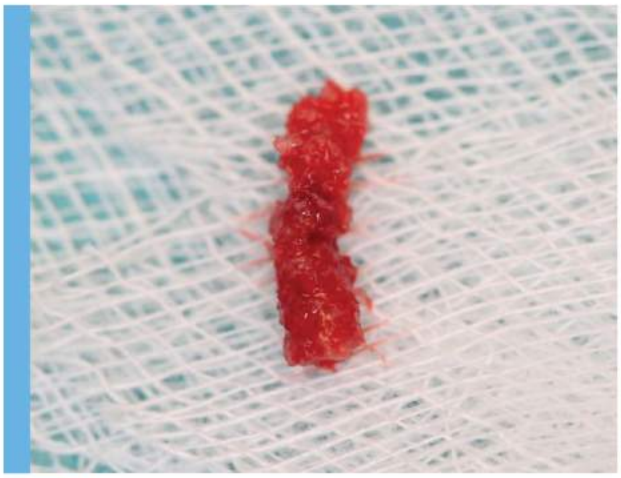


Figure 2.4: *Bone sample from the split ridge grafted with BoneAlbumin, 6 months after the augmentation. From the place of tooth number 1.6.*

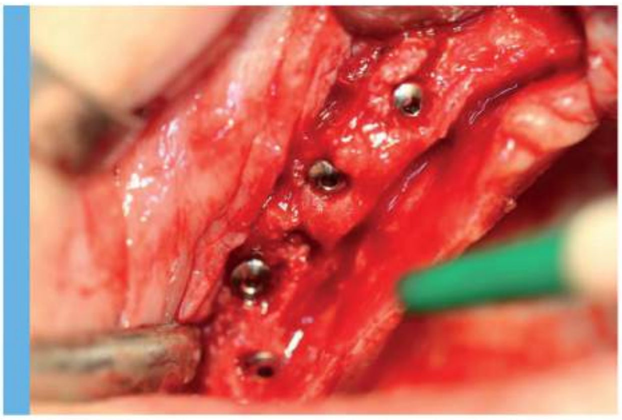


Figure 2.5: *The 4 pieces of implants implanted in the right side, and the wide, bony ridge.*

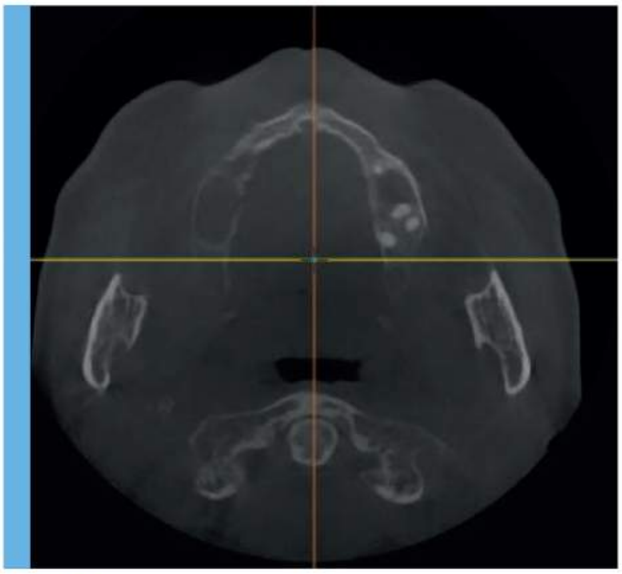


Figure 2.6: *CT cross-section before the bone grafting.*

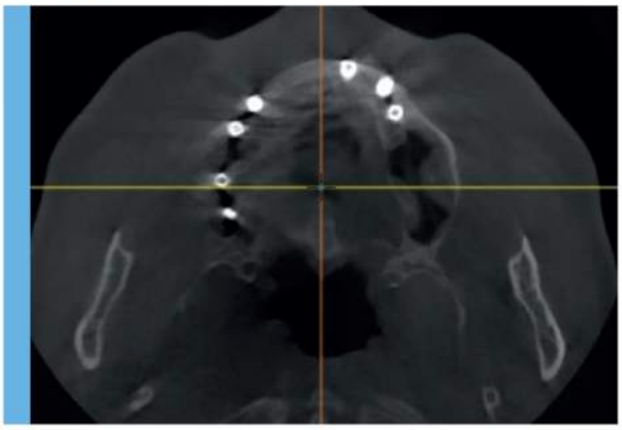


Figure 2.7: *CT image following the bone grafting, then implantation.*

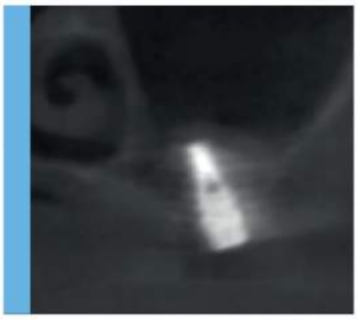


Figure 2.8: *Implant at the place of tooth number 1.6, and the cross-section of the bone.*

by bone cutting blade of magnetic hammer. At the end of the ridge, we split the knife-edged ridges of 2—4 mm vertically, grafted it with BoneAlbumin chips, widened it and covered with a diaphragm. At the end of the ridge, we augmented the extremely thin ridge of 2—3 mm to the width of at least 5.5 mm. Panoramic radiography and CT images show the significant amount of bone grafting. Following the bone grafting process, the wound healing was untroubled.

While the second operation, 6 months after the bone grafting process, with the help of a magnetic hammer, without drilling we put in 7 implants to the upper jaw.

While the operation with the help of a bone trepan—as the first step of the formation of the implant bed—we made bone biopsy from the upper alveolar crest, used to be split and grafted with BoneAlbumin and had been healing for 6 months. The newly formed bone had been histologically processed (dr. Glasz Tibor, 2nd Department of Pathology, Semmelweis University).

Case 2 (abb 3)

For B.G. 65-year old male patient applied for prosthesis implantation with total tooth loss in lower jaw, and, in upper jaw with 4 frontal teeth residual roots.

While the operation we removed the roots of the teeth, we made sinus lift both sides of the quite thin upper jaw with 1—2mm width, and we grafted alveoles with BoneAlbumin. Panoramic radiography and CT images show the significant amount of bone grafting. On the CT-image, at most parts, bone height is around 12 mm.

Figure 3.1: *B.G. Panoramic radiography image before the operations.*

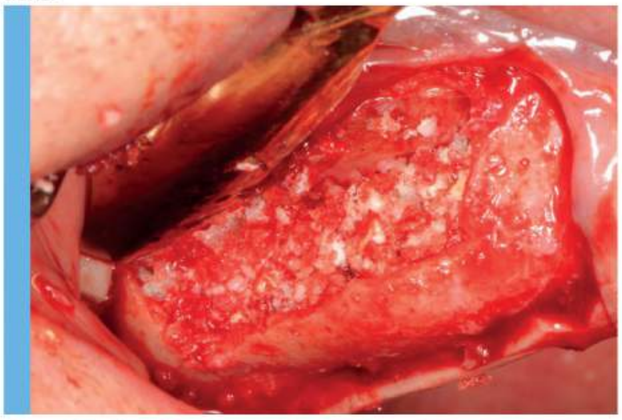


Figure 3.2: *Alveole grafted with BoneAlbumin.*

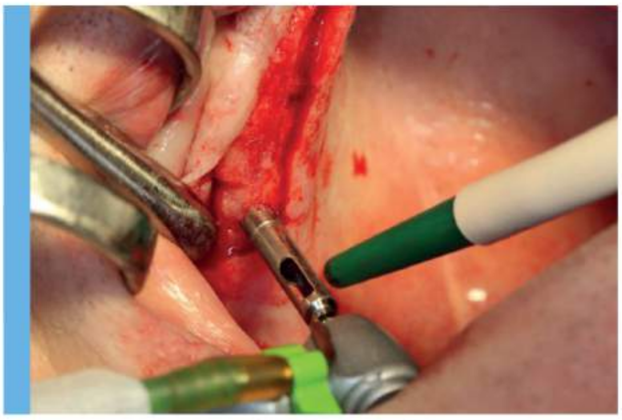


Figure 3.3: *Bone sampling from the place of tooth number 1.6., 6 months later.*

Figure 3.4: *Bone sample in the trepan, shows a living, bleeding bone, macroscopically.*

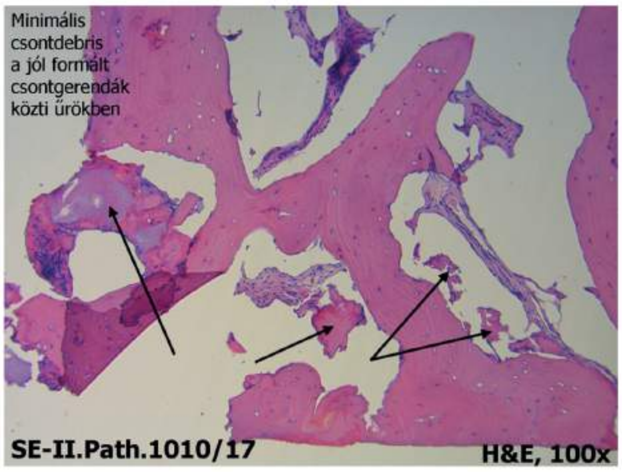


Figure 3.5: *Haematoxylin—eosin staining, 100x zooming. In tissue image, trabeculas are well-formed.*

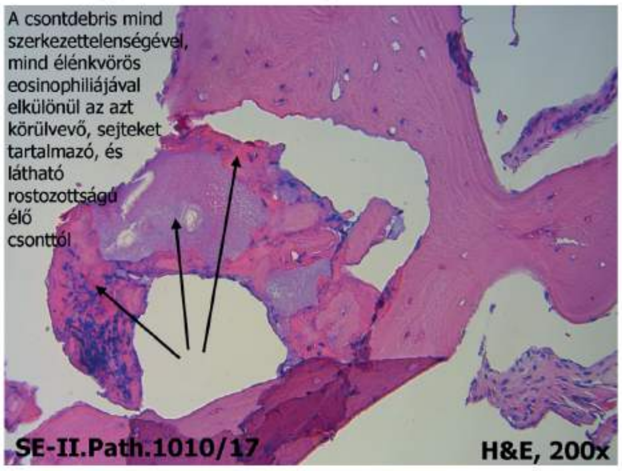


Figure 3.6: *Haematoxylin—eosin staining, 200x zooming. Living bone tissue containing cells.*

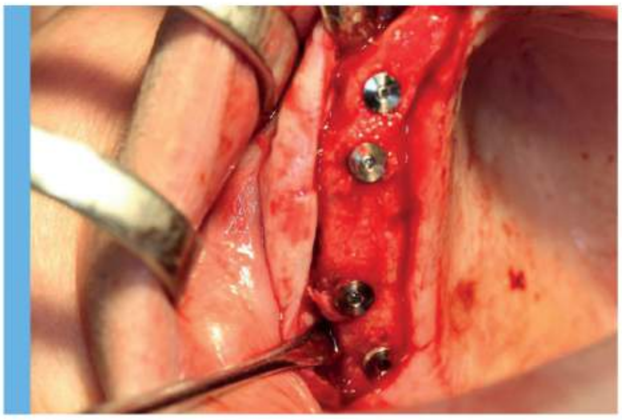


Figure 3.7: *The 4 pieces of implants put into the upper right quadrant.*

Figure 3.8: *Panoramic radiography image following the implantation.*

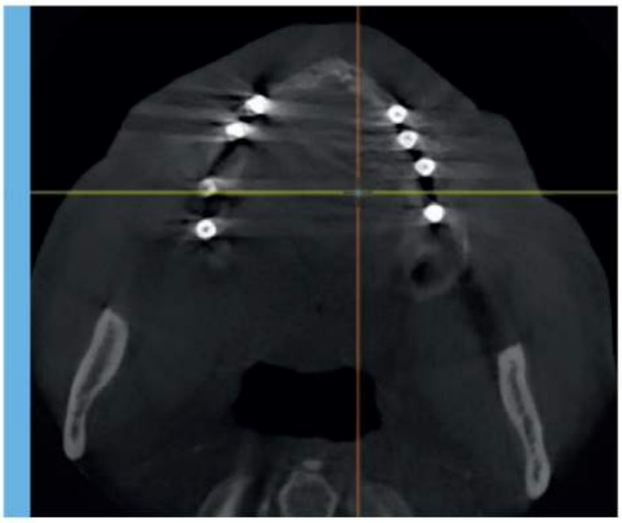


Figure 3.9: *CT image on the alveolar crest in the period following the implantation.*

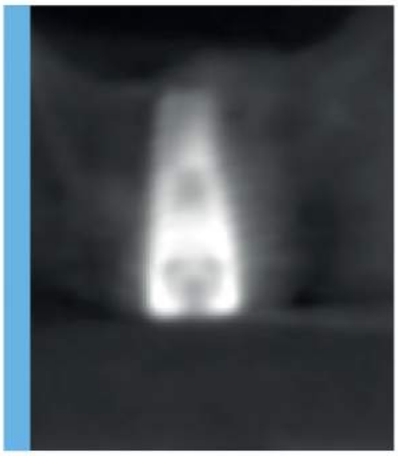


Figure 3.10: *Implant put in the place of tooth number 1.6., and the CT cross-section of the bone*

Following a 6-month healing and ossification period, at the place of the BoneAlbumin grafting, from the newly formed bone we made bone biopsy by bone trepan—as the first step of the preparation of implant bed. We sent the material to histological examination (dr. Glasz Tibor 2nd Department of Pathology, Semmelweis University).

While the implantation process—following the formation of implant bed by a magnetic hammer—there were 8 pieces of SGS implants put in.

Case 3 (abb 4)

B.J. 62-year old female patient had had fractured teeth for 4 years with 2 pieces of zirconia implants in the upper left molar region. We planned another zirconia implants instead of the broken ones, following the removal of the broken implants, bone grafting and another implantation process.

While the first operation we applied soft tissue expander, then with the help of bone trepan we removed the 2 pieces of broken implants. We split the knife edge ridge with the help of the engraver of the magnetic hammer, we made bone grafting, then we applied titanium mesh. While the second operation following the ossification process, to the augmented area we implanted 3 pieces of zirconia implants of Denti-type. On the implants, we put zirconia bridge.

Figure 4.1: *B.J. panoramic radiography image of broken implants at the places of teeth number 2.6—2.7.*

Figure 4.2: *The image of the upper left molar region with the broken implants and minimal width of ridge.*

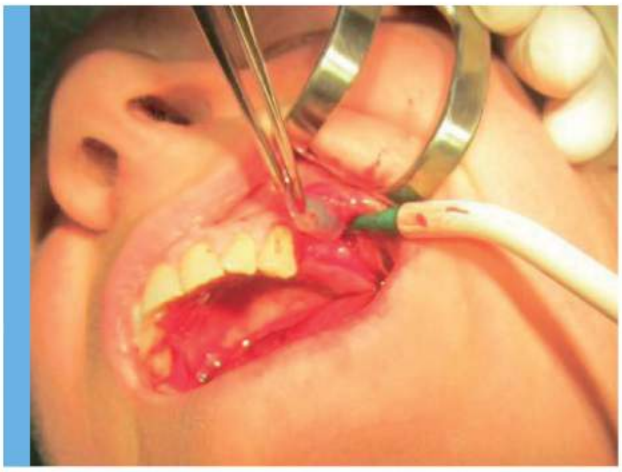


Figure 4.3: *Removal of the soft tissue expander.*

Figure 4.4: *Augmentation with BoneAlbumin, then application of titanium mesh, following the splitting of knife edged ridge.*

Figure 4.5: *Bone grafting, closed with titanium mesh.*

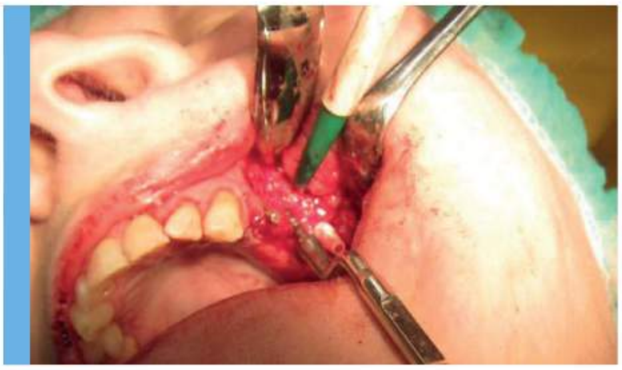


Figure 4.6: *Following a 9-month period of ossification, putting in zirconium implants, with implant bed formed with the help of magnetic hammer.*

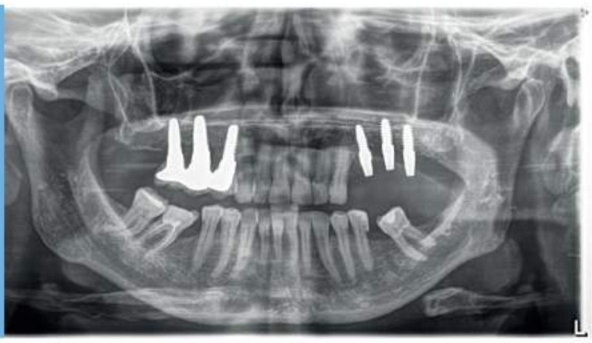


Figure 4.7: *Panoramic radiography image on the new Denti-type zirconium implants.*

Figure 4.8: *The 3 pieces of zirconium implants put in, and the width of ridge.*

Figure 4.9: *Zirconium fixed partial denture (FPD) on implants, in mouth.*

Case 4 (abb 5)

D.A. a 39-year old female patient with cysts on teeth number 3.6—3.7 in the lower left molar region came to us for treatment.

The cyst made the jaw so thin as the extraction of the teeth created the risk of break through the mandibular bone. While the first operation, we removed the dental crowns of teeth number 3.6—3.7 by air-turbine, then in the axis of dental neck plane, by burnishing teeth like seashells, we made longitudinal ducts with the help of fissure diamond bur. Into the ducts we placed cyst constricting equipment. 9 months after the cyst constricting process, with the help of the engraver of the magnetic hammer, we removed the seashell-like remnants from the alveolus, in teeth number 3.6-3.7, then we made cystectomy. We grafted bone cavities with BoneAlbumin chips. 6 months after bone grafting, to the places of teeth number 3.6—3.7, where previously there were cysts, 2 pieces of SGS implants had been put in. We started the formation of the implant bed by bone trepan, thus we made histological

Figure 5.1: *D.A. panoramic radiography image before the operations. Cysts on teeth number 3.6—3.7.*

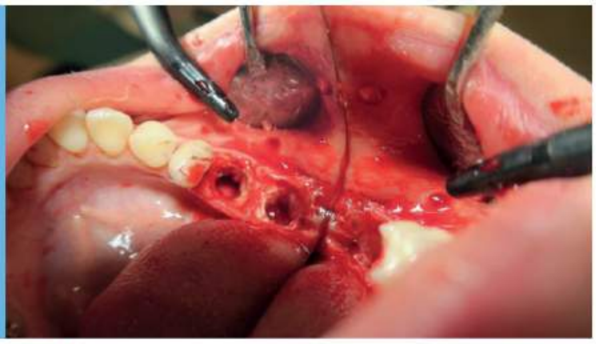


Figure 5.2: *Teeth burnished to seashell-like figure, prepared for cyst constricting.*

Figure 5.3: *Panoramic radiography image before cyst constricting. In the middle of the teeth number 3.6—3.7 there are ducts prepared for the cyst constricting equipment.*

bone-sampling according to the localization of the former cyst chamber. (dr. Glasz Tibor 2nd Department of Pathology, Semmelweis University). The samples of biopsy had been sent to histological examination.

Summarizing

Following the application of BoneAlbumin in oral surgery, dentistry and implantology, we can determine the following experiences:

- The advantages experienced in a 10-year application in orthopedic surgery are true for jaws as well, its application is advantageous, while it combines the several positive features of bone grafts.

Figure 5.4: *Cyst constricting equipment and the seashell-like pieces of teeth remnants after their removal*

Figure 5.5: *Cysts grafted with BoneAlbumin, following cystectomy.*

Figure 5.6: *Panoramic radiography image following cystectomy and BoneAlbumin grafting.*

Figure 5.7: *6 months after the augmentation, bone sampling from the original place of the cyst, from BoneAlbumin.*

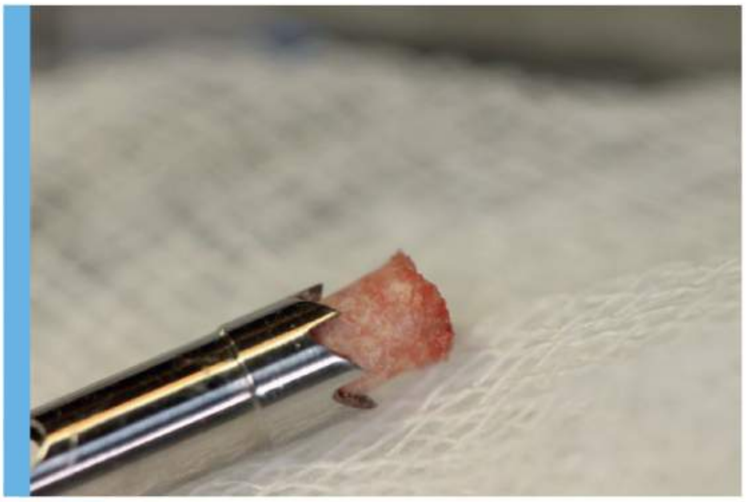


Figure 5.8: *Bone sample in the trepan shows a living, bleeding bone macroscopically.*

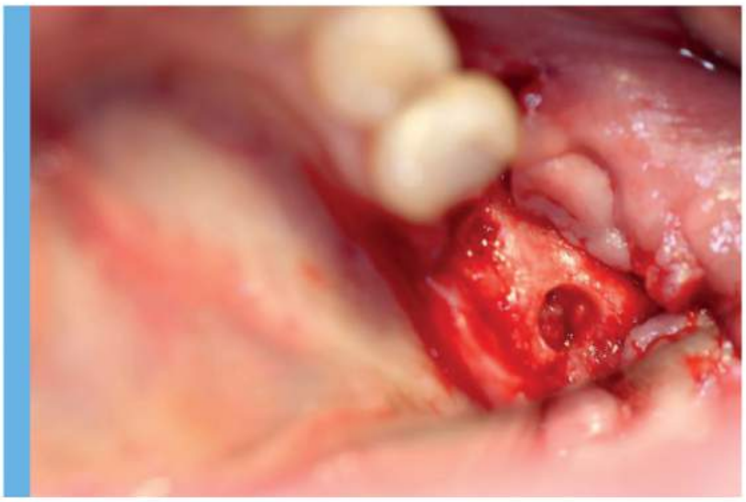


Figure 5.9: *At the place of the tissue sampling with trepan, there is living, hard, bleeding bone tissue.*

- In jaws, tissue integration is particularly good, according to clinical and histological finds, there is a living bone forming.
- Compared to other bone grafts, at the bone-graft border the demarcation is smaller.
- The new bone structure is very similar to the original own bone structure.
- The degree of resorption—in the present monitoring period—is significantly smaller the for the implanted own bone.
- There aren't any granules and lifeless grains, such as there were in synthetic or xenograft bone graft materials.

In clinical practice, based on our experiences, positive features have continuously been proven, so BoneAlbumin may represent a significant breakthrough in bone grafting processes of oral surgery, dentistry and implantology.

In bone grafting in the fields of implantology and oral surgery, the application of BoneAlbumin opened up new avenues. Based on our experiences (in sinus-lifting, augmentation following bone-splitting, grafting process following extraction, augmentation, grafting bone losses, bone blocks, etc.), as for its behavior shows a transition between own implanted bone (autograft) and the bone of human origin (allograft). As a result of adding Albumin to it, in clinical practice, this material behaves as it was autograft, but with the application of it bone taking process—therefore, the second operation may be avoided. After mixing it with own blood or bone scrape, it results a bone even more similar to the living one than other bones of animal origin or synthetic ones, as well. Granules, blocks, spongiosa, corticalis human bones may be applied.

We consider the things said particularly important, knowing that with the continuous expansion of the average age the number of old people is growing, who lost their teeth but still live an active life. They have lost not only their teeth, but the significant amount of their bone stock, as well. In these cases, experts can reach success only with choosing the most humane bone shaping methods, tools and bone grafting materials.

Figure 5.10: *Panoramic radiography image after the implantation made 6 months after the bone grafting.*

Dr. Roberto Crespi
Dr. Paolo Capparè
Dr. Enrico Felice Gherlone

Electrical **Mallet** provides advantages in split crest and immediate implant placement

Oral Maxillofac Surg
DOI 10.1007/s10006-013-0389-2

ORIGINAL ARTICLE

Electrical mallet provides essential advantages in split-crest and immediate implant placement

Roberto Crespi · Paolo Capparè · Enrico Felice Gherlone

Received: 22 August 2012 / Accepted: 1 January 2013

Abstract

Purpose The aim of this prospective study was to compare the use of a hand mallet versus an electrical mallet in osteotome-assisted surgery for split-crest procedures.

Methods Partially edentulous patients, with an alveolar ridge width inferior to the optimally desirable implant diameter, were selected for this study. Forty-six split-crest procedures were performed in 46 patients. They were randomly divided in two groups: in the control group, 23 patients, the split crest was performed with osteotomes using a handheld mallet, while in the test group, 23 patients, the split crest was prepared with osteotomes using an electrical mallet. Alveolar ridge width and incision dimensions were measured with a periodontal probe, before and after the split-crest procedure. One hundred eighty-one implants were immediately placed. Follow-up examinations were performed at baseline and 6, 12, and 24 months.

Results The survival rate, at 2-year follow-up, was 98.31 %. Indeed, two implants placed in the maxilla failed to integrate at second-stage surgery. The initial width of the alveolar ridge varied from 2 to 3.5 mm; the average was 2.8±0.7 mm. The final ridge width varied from 5 to 8 mm; the average was 7.2±1.7 mm. The split length varied from 7 to 28 mm; the average was 17.5±7.7 mm. No statistically significant differences ($P>0.05$) were found between test and control group in split length and alveolar width values before and after the split-crest procedure.

Conclusions The use of a magnetic mallet provided some essential clinical advantages during crest splitting and immediate implant placement in comparison with a hand mallet.

Keywords Bone condensing · Split crest · Electrical mallet · Surgery mallet

R. Crespi · P. Capparè · E. F. Gherlone
Department of Dentistry, Vita Salute University,
San Raffaele Hospital,
Milan, Italy

R. Crespi (✉)
Department of Dentistry, San Raffaele Scientific Institute,
Via Olgettina 58,
20132 Milan, Italy
e-mail: robcresp@libero.it

Published online: 18 January 2013

Introduction

In implant dentistry, a minimal amount of surrounding bone is necessary at implant placement, since in the horizontal dimension, the optimal thickness of the vestibular and buccal surrounding bone lamellae should be 1 mm [1]. When a tooth is lost, the alveolar ridge is reduced in the horizontal dimension, and frequently, immediate implant placement with routine techniques is not possible because of the discrepancy between the thickness of the ridge and the diameter of the implant. Although numerous procedures have been advocated to augment the alveolar crest with autogenous bone grafting [2, 3] or guided bone regeneration [4], a risk of dehiscence and infections may jeopardize the graft [2, 5, 6]. To treat narrow alveolar ridges, a split-crest bone manipulation technique [7, 8] was introduced as alternative approach to bone grafting and GBR procedures. It consists in splitting the atrophic crests into two parts with a longitudinal greenstick fracture and opening the space with Summers osteotomes [9], allowing space for implant placement with sufficient surrounding bone. The space created between the two cortical plates fills with new bone, thus enlarging the width of the alveolar ridge. The chisel method lacks precision and it is difficult to control. Thus, the split-crest technique has undergone considerable improvement with different devices for bone cutting. Rotating [10] or oscillating [11] disks are less stressful for the patient but present significant limitations because of accessibility, with the possibility of injuries to the lips, tongue, and surrounding soft tissues. The piezoelectric device represents a novel alternative technique of atraumatic bone surgery [12–14]. The piezoelectric ridge expansion technique performs mesial and distal cuts and a longitudinal crest incision, but successive spreading of the vestibular table is still made by the osteotome. During the placement of maxillary dental implants using the osteotome technique, the trauma induced by percussion with the hand mallet, along with hyperextension of the neck during the operation, can displace bone fragments and induce benign paroxysmal positional vertigo (BPPV) [15]. In this clinical study, a new electrical mallet was used for cutting the bone crest and creating expansion. The purpose of this prospective study was to compare the use of a hand mallet versus electrical mallet in osteotome-assisted surgery for a split-crest procedure.

Materials and methods

Between September 2007 and December 2009, 46 patients, 33 women and 13 men with a mean age of 53.8 years (range, 31 to 73 years), were included in this prospective clinical study. The patients were treated by one oral surgeon and one prosthodontist at the Department of Dentistry, San Raffaele Hospital, Milan, Italy, for evaluation and management of partial edentulism. The following inclusion criteria were adopted: partial edentulism in maxillary or mandibular bones, alveolar ridge with no vertical bone reduction, and crestal width not lower than 2.5–3 mm having not enough width to accommodate the planned implant diameter (Ø, 3.75–5 mm) with at least 1 mm of surrounding bone. Aesthetic and prosthetic evaluations required an increase of the vestibulo–palatal dimensions, and the patients had to be nonsmokers and in good general health. Exclusion criteria were: chronic systemic diseases, alcohol or drug abuse, and a history of vertigo. The local ethical committee approved the study, and all patients signed an informed consent form. The diagnosis was made clinically and radiographically.

Surgical protocol

The patients received 1 g amoxicillin (Zimox, Pfizer Italia, Latina, Italy) 1 h prior to surgery and 1 g twice a day for a week after the surgical procedure. Surgery was performed under local anesthesia (Optocaine (Molteni Dental, Scandicci (FI), Italy), 20 mg/ml with adrenaline, 1:80,000). Forty-six split-crest procedures were performed in 46 patients to receive 118 implants. Patients were randomly divided in two groups chosen from sealed envelopes. In the control group (CG), 23 patients, the split crest was performed with osteotomes using a hand mallet, while in the test group (TG), 23 patients, the split crest was prepared with osteotomes using an electrical mallet. Both in CG and TG, 118 titanium plasma spray implants (Outlink, Sweden Martina, Due Carrare, Padova, Italy) with a machined neck of 0.8 mm, a rough surface, and a body with a progressive thread design with an external hexagon as implant–abutment junction were positioned.

In the maxilla, 82 implants (69.49 %) were planned for placement; in the mandible, there were 36 (30.51 %). The majority of the sites (61.02 %) were in the posterior region. Indications were distributed into five segments, 33 anterior or posterior partial bridges and 13 single crowns.

Twenty-five implants had a diameter of 3.75 mm and a length of 13 mm, 18 with a length of 10 mm, and 50 implants had a diameter of 4.2 mm and a length of 13 mm, 25 with a length of 10 mm (Table 1).

Alveolar ridge width and incision dimensions were measured with a periodontal probe (Hu-Friedy PGF-GFS, Hu-Friedy, Chicago, IL, USA) at the nearest 0.5 mm. The alveolar ridge width was measured before and after the split-crest procedure.

In the control group using the edentulous ridge expansion technique, a palatal incision in crestal direction was performed, and partial-thickness buccal and lingual flaps were raised, followed when necessary by two vertical incisions defining the surgical area [8]. After the flaps were reflected, two transperiosteal incisions were made into the bone parallel to the incisions; two vertical grooves were formed by the penetration of the vestibular cortical plate of the bone at 1 mm away from the teeth. In the absence of teeth, the discharges were performed 3–5 mm away from the closest implant planned site. The crestal incision was continued into the bone to perform an intraosseous groove with an n.64 Beaver blade (Becton Dickinson Acute Care, Franklin Lakes, NJ). This groove was continued apically by impacting the Beaver with the hand mallet and was prepared and deepened down to 7–11 mm. The implant site was created by expanding the bone tissue both laterally against the preexisting lateral walls and apically, moving up and compressing with the hand mallet a progressive series of bone expanders (Sweden Martina, Due Carrare, Padova, Italy). In this way, the buccal plate was slowly dislocated in a facial direction. Care must be taken

Table 1 Implant dimensions and position for both control and test groups ($n=118$ implants)

Implant position	Implant size (mm)				Total
	3.75× 10	3.75× 13	4.2× 10	4.2× 13	
Maxilla	3	19	13	47	82
Mandible	15	6	12	3	36
Total	18	25	25	50	118

to maintain a zone of spongiosa beneath the cortical plate with a minimum thickness of 1.5 mm [16] (Fig. 1). The osteotomy was gradually expanded in 0.5-mm increments using osteotomes inserted to the working depth. The final diameter of the osteotomy was 1.2 mm less than the implant diameter, depending on local bone density. Implants were then placed within the confines of the newly created space. In the test group, the crestal incision into the bone was performed with an n.64 Beaver blade, and expansion of the osteotomy was carried out following the same procedure reported in the control group with a similar osteotome, but they were directly attached and pushed by the electrical mallet. The electrical mallet (Magnetic Mallet, Meta-Ergonomica, Turbigo, Milano, Italy) is a magneto-dynamical instrument assembled into a hand piece energized by a power control device, delivering forces by timing of application (Fig. 1h). The bone expanders were attached to the hand piece that pushes a shock wave on their tip. The magnetic wave and the subsequent shock wave were calibrated regarding the timing of application of the force, and induced axial and radial movements applied on the tip of the bone expander, with a fast force of 90 daN/8 μs. The magnetic mallet imparted to osteotomes a longitudinal movement along the central axis, moving up and down toward the pilot bone hole, providing a driving mechanism of longitudinal movements. Such mechanical sequence of osteotomes progressively condensed the internal bone wall of the initial hole radially outward with respect to the central axis to create high-density bone tissue along a substantial portion of the length of implant site preparation. The magnetic mallet device had a better bone condensing efficiency, especially in softer bone because of the magnetic wave and the subsequent shock wave; induced axial and radial movements applied on the tip of the osteotome with a fast energy prevent patient distress. The buccal flap [8] was apically repositioned

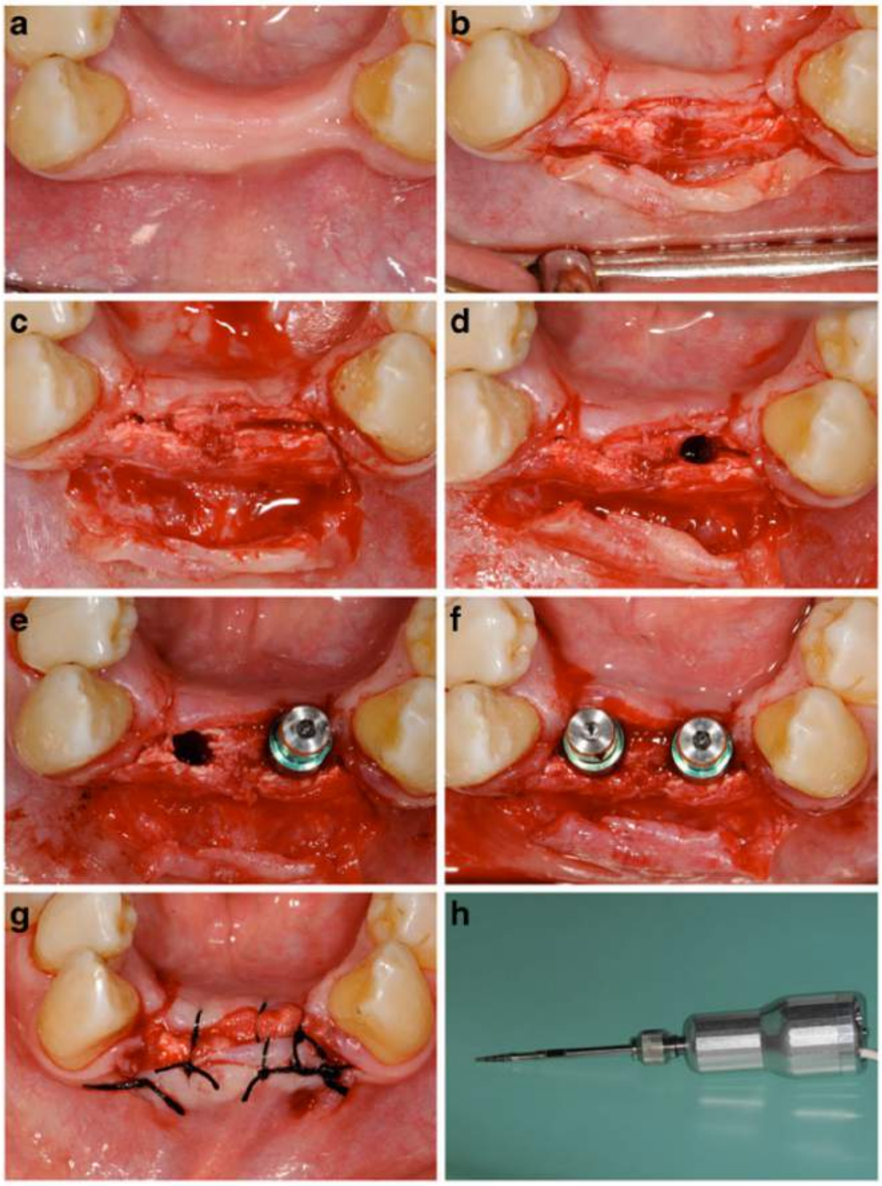


Fig. 1 Clinical aspect of the edentulous ridge before treatment (**a**); partial-thickness buccal and lingual flaps are raised, followed by two vertical incisions (**b**); horizontal and vertical transperiosteal incisions are made in the bone (**c**); the buccal plate is dislocated in the vestibular direction (**d**); implants are placed within the newly created bone space (**e**, **f**); sutures in position (**g**); the electrical mallet (**h**)

and stabilized with sutures tied to the margin of the palatal flap and anchored buccally with a loose loop to the periosteum at the level of the alveolar mucosa. A small piece of collagen, which is inserted below the borders of the soft keratinized mucosa that lines the extraction socket, was used to cover the surgical field. The collagen (Gingistat, Acteon Pharma, Bordeaux, France) stops the bleeding and ensures the stability of the blood clot (Fig. 1).

After 3 months of implant insertion, temporary prostheses were then fitted and worn for 2–3 months before the final reconstruction (Fig. 2).

Follow-up evaluation and success criteria

The following clinical parameters were checked: pain, occlusion, and prosthetic mobility. The success criteria of the split-crest procedure with magnetic mallet included presence of implant stability, absence of radiolucent zone around the implants, no mucosal suppuration, and no pain. Follow-up examinations were performed at baseline and 6, 12, and 24 months.

Statistics

Dedicated software was used for all statistical analyses (SPSS 11.5.0, SPSS Inc., Chicago, IL, USA). All data were reported as mean ± standard deviation. Student's t test was used to compare alveolar width values before and after split crest, and split length between the two groups ($P<0.05$ was considered the threshold for statistical significance).

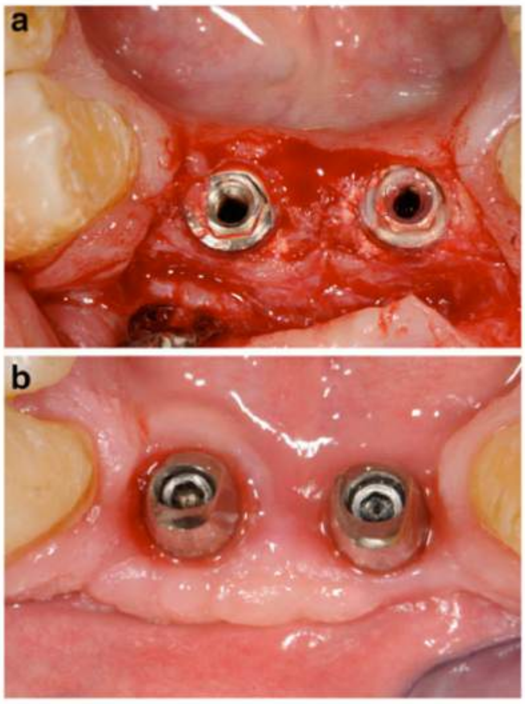


Fig. 2 Implants at the second-stage procedure; note total bone fill and expansion of the ridge profile (**a**); abutment placement and aspect of the alveolar crest with the physiologic curvature (**b**)

Results

In all patients, minor swelling of gingival mucosa was present in the first days after surgical procedures, and no mucositis or flap dehiscence with suppuration was found. Temporary crowns were positioned 3 months later, and final prosthetic restorations were cemented 6 months after implant placement.

Of the 118 placed implants, two implants placed in the maxilla (dimensions, 4.2×10 and 3.5×10 mm, respectively) in the control group failed to integrate at second-stage surgery. The initial ridge width of the failed implants was 2.5 and 3 mm, respectively, and split length was 7 and 8 mm, respectively. So, the survival rate at 2-year follow-up was 98.31 %. In particular, the test group reported a survival rate of 100 %, while the control group reported a survival rate of 96.61 %.

Initial width of the alveolar ridge varied from 2 to 3.5 mm; the average was 2.8±0.7 mm. Final ridge width varied from 5 to 8 mm; average was 7.2±1.7 mm. Split length varied from 7 to 28 mm; average was 17.5±7.7 mm.

Test and control group values of alveolar width and split length are reported in Table 2. No statistically significant differences ($P>0.05$) were found between test and control group in split length, alveolar width values before and after split-crest procedure.

In the control group after surgery, one patient experienced intense vertigo, with dizziness accompanied by distress, nausea and vomiting, and the sensation of objects moving around her. The vertigo remitted spontaneously after 1 day.

The patients in the test group presented no symptoms of BPPV. The surgical procedure was faster in the test group, and the implant bed preparation was more precise with the magnetic mallet.

Discussion

The split-crest procedure in combination with immediate implant placement has been introduced by Simion et al. [7] and

Table 2 Values of alveolar width and split length for both control and test groups (n=46 patients)

Values (mm)	Control group	Test group	P value
Initial alveolar width	2.9±1.0	2.5±0.5	0.5306
Final alveolar width	7.3±1.4	7.1±1.4	0.6889
Split length	15.8±6.8	18.1±7.9	0.2956

Scipioni et al. [8]. This surgical procedure involved splitting the alveolar ridge longitudinally in two parts, provoking a longitudinal greenstick fracture at the top of the bone to create a space-making defect. This procedure prevents the need for onlay grafts taken from the hip, the maxillary tuberosity, symphysis of the chin, or the external oblique ridge, presenting postoperative morbidity associated with bone harvesting. In the ridge-splitting procedure, the corticotomies can be performed using a Beaver blade, fissure bur, diamond disk, reciprocal saw, or piezoelectric device. Apart from jarring the patient with painful blows, the chisel pushed by the hand mallet lacks precision and is difficult to control, especially in severely resorbed ridges with high bone density. Rotating or oscillating disks are less stressful for the patient but present significant limitations as regards accessibility, with the possibility of injuries to the lips, tongue, and surrounding soft tissues [17]. The electronic scalpel uses an ultrasound frequency that makes for great precision and safety when performing osteotomy due to the fact that the vibration range in which it works makes it capable of cutting hard tissues like bone without damaging other soft tissues like the gums, blood vessels, nerves, or sinus membranes [14]. However, as described by Blus et al. [18], bone cutting with an ultrasonic device by continuous gentle upward–downward or forward–backward movements of the vibrating tip, but successively, osteotomes pushed by hand mallet were used for implant site preparation. Bone chisels are impacted into bone by a mallet with precise and gentle blows; the approach is time consuming, and it requires technical skills and a steep learning curve. Furthermore, tapping of the expansion osteotomies with a hand mallet represents the greatest inconvenience of the technique, and in some cases, it may induce BPPV in patients who have experienced no previous episodes of this form of vertigo [15, 19]. Because implant treatment is increasingly being carried out with older patients and because of the widespread use of the bone expansion technique with bone expander, incidence of BPPV can be expected to increase. As reported in this study, the use of a magnetic mallet provided some essential advantages during clinical application in comparison with the use of a manual tool. The low force produced by the hand hammer (40 daN/2 ms) was found to depend on the density, area moment of inertia, and density-dependent elastic constants of bone [20]. It is important to account for the changes of these parameters along the bone, and along with hyperextension of the neck during the operation, since these practices can displace bone fragments. In the patients of the test group, neither symptoms nor distress was noted. The probable explanation for the lack of patient discomfort may be explained by the magnetic wave and the subsequent shock wave, since they are calibrated by the timing of application of the force, inducing axial and radial movements applied on the tip of osteotome with a fast energy of 90 daN/8 μs. With this procedure, the trauma to the craniofacial bones is minimized as much as possible, reducing the forces only to the target area. This is an important concept since bone is generally formed of parts with different density, and that the expander tends to be deflected when it moves from a bone part with a specific density to another bone part with a different density. Segmental ridge split with a magnetic mallet represents a predictable surgical procedure, does not lead to bone injury, and does not lead to bone overheating. This surgical technique is rendered safe, less technique sensitive, and comfortable, without risk of any form of vertigo. With a survival rate of 98.31 % of the placed implants after 2 years of loading, this technique compares well to classical implant placement procedures. The magnetic mallet device had a better bone condensing efficiency, especially in softer bone because of the magnetic wave and the subsequent shock wave; induced axial and radial movements applied on the tip of osteotome with a fast energy prevents patient distress. However, further clinical trials are mandatory to evaluate the efficiency of this new device for osteotome procedure, but these results encourage the development and continuation of this technique.

Conflict of interest We certify that we have no affiliation with, or financial involvement in, any organization or entity with direct financial interest in the subject matter or materials discussed in the manuscript and that the material is original and has not been published elsewhere.

References

1. Nedir R, Bischof M, Briaux JM, Beyer S, Szmukler-Moncler S et al (2004) A 7-year life table analysis from a prospective study on ITI implants with special emphasis on the use of short implants. Results from a private practice. Clin Oral Implants Res 15:150–157
2. Chiapasco M, Abati S, Romeo E, Vogel G (1999) Clinical outcome of autogenous bone blocks or guided bone regeneration with e-PTFE membranes for the reconstruction of narrow edentulous ridges. Clin Oral Implants Res 10:278–288
3. Fiorellini JP, Nevins ML (2003) Localized ridge augmentation/preservation. A systematic review. Ann Periodontol 8:321–327
4. Hammerle CH, Jung RE, Feloutzis A (2002) A systematic review of the survival of implants in bone sites augmented with barrier membranes (guided bone regeneration) in partially edentulous patients. J Clin Periodontol 29(Suppl):226–231
5. Nevins M, Mellonig JT (1992) Enhancement of the damaged edentulous ridge to receive dental implants. A combination of allograft and the Gore-Tex membrane. Int J Periodontics Restorative Dent 12:97–111
6. Rominger JW, Triplett RG (1994) The use of guided tissue regeneration to improve implant osseointegration. Int J Oral Maxillofac Surg 52:106–112
7. Simion M, Baldoni M, Zaffe D (1992) Jawbone enlargement using immediate implant placement associated with a splitcrest technique and guided tissue regeneration. Int J Periodontics Restorative Dent 12:462–473

8. Scipioni A, Bruschi GB, Calesini G (1994) The edentulous ridge expansion technique: a five year study. Int J Periodontics Restorative Dent 14:451–459
9. Summers RB (1994) The osteotome technique: part 2-the ridge expansion osteotomy (REO) procedure. Compendium 15:422–426
10. Coatoam GW, Mariotti A (2003) The segmental ridge-split procedure. J Periodontol 74:757–770
11. Khoury F, Happe A (2000) Soft tissue management in oral implantology: a review of surgical techniques for shaping an esthetic and functional peri-implant soft tissue structure. Quintessence Int 31:483–499
12. Torella F, Pitarch J, Cabanes G, Anitua E (1998) Ultrasonic ostectomy for the surgical approach of the maxillary sinus: a technical note. Int J Oral Maxillofac Implants 13:697–700
13. Vercellotti T (2000) Piezoelectric surgery in implantology: a case report of a new piezoelectric ridge expansion technique. Int J Periodontics Restorative Dent 20:359–365
14. Vercellotti T, De Paoli S, Nevins M (2001) The piezoelectric bony osteotomy and sinus membrane elevation: introduction of a new technique for simplification of the sinus augmentation procedure. Int J Periodontics Restorative Dent 21:561–567
15. Peñarrocha-Diago M, Rambla-Ferrer J, Perez V, Pérez-Garrigues H (2008) Benign paroxysmal vertigo secondary to placement of maxillary implants using the alveolar expansion technique with osteotomes: a study of 4 cases. Int J Oral Maxillofac Implants 23:129–132
16. Albrektsson T, Zarb G, Worthington P, Eriksson AR (1986) The long-term efficacy of currently used dental implant: a review and proposed criteria of success. Int Oral Maxillofac Implants 1:11–27
17. Schwartz-Arad D, Chaushu G (1997) The ways and wherefores of immediate placement of implants into fresh extraction sites: a literature review. J Periodontol 68:915–923
18. Blus C, Szmukler-Moncler S (2006) Split-crest and immediate implant placement with ultra-sonic bone surgery: a 3-year life-table analysis with 230 treated sites. Clin Oral Impl Res 17 (6):700–707
19. Saker M, Ogle O (2005) Benign paroxysmal positional vertigo subsequent to sinus lift via closed technique. J Oral Maxillofac Surg 63:1385
20. Cheng S, Timonen J, Suominen H (1995) Elastic wave propagation in bone in vivo. Methodol J Biomech 28(4):471–478

Nayansi Jha
Eun Ha Choi
Nagendra Kumar Kaushik
Jae Jun Ryu

Types of devices used in ridge split procedure for alveolar bone expansion: A systematic review

PLOS ONE

RESEARCH ARTICLE

Types of devices used in ridge split procedure for alveolar bone expansion: A systematic review

Nayansi Jha[1], Eun Ha Choi[2], Nagendra Kumar Kaushik[2]*, Jae Jun Ryu[1]*

1 Department of Prosthodontics, Graduate School of Clinical Dentistry, Korea University Anam Hospital, Seoul, Republic of Korea, 2 Plasma Bioscience Research Centre and Department of Electrical & Biological Physics, Kwangwoon University, Seoul, Republic of Korea

* kaushik.nagendra@kw.ac.kr (NKK); koprosth@unitel.co.kr(JJR)

Citation: Jha N, Choi EH, Kaushik NK, Ryu JJ (2017) Types of devices used in ridge split procedure for alveolar bone expansion: A systematic review. PLoS ONE 12(7): e0180342. https://doi.org/10.1371/journal.pone.0180342

Editor: Yogendra Kumar Mishra, Institute of Materials Science, GERMANY

Received: April 26, 2017

Accepted: June 14, 2017

Published: July 21, 2017

Data Availability Statement: All relevant data are within the paper.

Funding: This work is supported by Korea University and Kwangwoon University in 2017. Authors also obtained support from a grant from the National Research Foundation of Korea (NRF), which is funded by the Korean Government, Ministry of Science, ICT and Future Planning (MSIP) (NRF-2010-0027963) (NRF-2016K1A4A3914113).

Competing interests: The authors have declared that no competing interests exist.

Abstract

The aim of this systematic review was to evaluate instrumentation procedures of the alveolar ridge expansion technique (ARST) with or without Guided Bone Regeneration (GBR) and to identify the most used instruments for successful outcome. An electronic as well as manual literature search was conducted in several databases including Medline, Embase, and Cochrane Central Register of Controlled Trials, for articles written in English up to September 2016. The question in focus was to identify the type of device for ridge expansion that is most frequently used and provides adequate bone expansion and implant success rate. To meet the inclusion criteria, the studies were analysed for the following parameters: prospective or retrospective studies, cohort or case studies/series, cases with 5 or more human subjects, type of device used for surgery, location of defect, and minimum follow up period. The frequency of osteotome usage in this study was approximately 65%, and on average, the implant success was 97%. The motorized expanders and ultrasonic surgery system are easier to use and cause less trauma to the bone compared to the traditional/conventional instruments like mallets and osteotomes. However, their cost is a limiting factor; hence, osteotomes remain a popular mode of instrumentation.

Introduction

Earlier, ridge-widening techniques were used as a form of pre-prosthetic ridge plasty for providing support to partial/full dentures. With the introduction of root form implants and the concept of osseo-integration, the ridge plasty technique has once again become popular [1]. The concept for this novel technique was introduced by Tatum in 1986. Simion et al. [2] and Sciopini et al. [3] introduced the bone splitting technique using chisels for ridge expansion [4, 5]. A few literature reports depict different modifications of the ridge-split procedure (RSP) with or without inter-positional bone grafting in the edentulous maxilla and mandible [1].

If the alveolar bone width is 3mm or greater but less than 6mm, the alveolar ridge augmentation using a ridge splitting and bone expansion technique may be performed, for successful implant placement. At least 1mm of trabecular bone should be present between the cortical plates, when considering the minimum alveolar bone width for surgical purposes. This will allow the bone to spread adequately on either side of the ridge and maintain adequate blood supply. Several ridge split techniques have been developed in the past few decades, including split crest osteotomy, ridge expansion osteotomy, and various other modifications [4].

Ridge splitting is a technique-sensitive procedure that may be performed with many different instruments, ranging from chisel and mallet to scalpel blades, spatula, osteotomes, piezoelectric surgical systems, lasers, and ultra-fine fissure burs. The alveolar ridge expansion creates a self-space making defect [5] in the atrophied alveolar crests [2, 6]. When any instrument is used on the alveolar ridge (for ridge expansion), the mechanism involves inducing a greenstick fracture with lateral positioning of the buccal cortical plate. A longitudinal osteotomy takes places with the formation of a new implant bed [5]. Amongst the various instruments used for ridge expansion, osteotomes are the most popular ones. Gonzalez et al. [7] in their study, strongly advocated using the osteotomes to avoid unwanted fracture lines in the buccal or lingual cortical plates. Padmanabham et al. [8] showed that lesser resonance frequency was generated with an osteotome than with conventional techniques. There was more primary stability and lesser bone loss with gradual bone expansion, and heat generated due to instrumentation was minimal [9] with osteotomes.

One of the traditionally used devices is the chisel and (hand) mallet. Nowadays, electrical or magnetic mallet has been introduced, which is used in combination with the osteotomes. The osteotome is attached to the hand-piece (mallet), which transmits shock waves to the tip of the instrument, thereby creating longitudinal movements on the bone surface [10]. Crespi et al. [10] advocated the use of magnetic mallet instead of hand mallet as it provided more comfort and stability to the operator.

The modern devices used for ridge expansion include motorized ridge expanders, expansion crest device, and piezoelectric device used for ultrasonic bone surgery. They are non-cutting drills that can facilitate width expansion of atrophic ridges without using a surgical mallet; they can also be used as condensers of trabecular bone [11].

Usage of expansion crest device for ridge expansion can also be considered one of the alternatives to conventional techniques. The main advantage of using this device is that it allows distribution of expansion forces, which helps in preventing bone removal from the buccal cortex, and adequate site preparation can be achieved. The device has been used most successfully in areas that have cancellous bone in the edentulous ridge [12].

The piezoelectric surgery systems are the newest crest expansion devices in dentistry. They work on the principle of piezoelectric effect, which was discovered in the 1880s [13]. In comparison to other alternatives for bone cutting procedures, the ultrasonic or the piezoelectric device has been found to be the most effective. With this device, selective cutting of the bone without affecting the soft tissue (nerves and blood vessels) may be carried out [14]; further, an oscillating tip with an irrigating fluid provides a cleaner working area and greater visibility (cavitation effect) at the surgical site [15] without causing bone heating (compared to conventional devices).

According to our knowledge, until now no systematic review has focused on evaluating the instrumentation techniques for ridge expansion. Therefore, this systematic review aimed to evaluate instrumentation procedures of alveolar ridge expansion techniques with or without GBR as well as their effect on survival rates of dental implants.

Materials and methods

For the following review, we used Cochrane Collaboration [16] and Preferred Reporting Items of Systematic Reviews and Meta-analysis [17] to prevent any risk of bias.

Question in focus

According to the PICO (problem, intervention, comparison, and outcome) model, we decided to address the following question; 'What type of device for ridge expansion is most frequently used and provides adequate bone expansion and implant success rate?'

Information source and search strategy

A scoping review was performed according to PRISMA statement [17] for systematic reviews (see S2 Appendix) for which an electronic and a manual literature search were conducted using several databases including Medline, Embase, and Cochrane Central Register of Controlled Trials, for articles written in English from inception up to September 2016. In the electronic search, the search string comprised a combination of key words (i.e., medical subject headings, MeSH) and free text terms. The linkage was conducted using Boolean operators (OR, AND). The following search strategy was applied: (Alveolar Bone spreading) OR (Split ridge expansion) OR (Split crest) (Ridge split) OR (Ridge expansion) OR (Corticotomy) OR (Crestal osteotomy), and other such terms were searched. In addition, manual search for the potential articles was also performed.

Eligibility criteria and screening process

Articles were included in this systematic review if they met the following inclusion criteria:

1. prospective or retrospective, cohort or case studies/series
2. Cases with 5 or more human subjects.
3. Type of device used for surgery
4. Location of defect
5. Minimum follow up period

References obtained from the search strategy were screened, and duplicates were removed manually, after assessment of title and abstract. This was cross-checked by N.J and G.U.J. A study was included when it met one or more (inclusion) criteria. Only articles written in English were considered for the study.

Number of subjects involved, flap design, implant success rate and gap filling using GBR were analysed on the basis of defect location in maxilla, mandible or both (Tables 1, 2 and 3) [7–43]. Additionally, the various instruments used for ridge expansion were analyzed to focus on the specific type/technique of device used and to identify the most commonly used approach/method. Various characteristics like study type, device specifications, patient discomfort during surgery, ridge width, and complications associated with instrument use were evaluated (Tables 4, 5 and 6) [7–43]. Case series or case reports and clinical studies with missing information were excluded. Articles that mentioned less than 5 subjects and cadaveric/in vitro studies were also excluded.

Quality assessment of included studies

Risk of bias in included studies. For the RCTs, the quality of trials was determined using the Cochrane Collaboration's tool [16] for assessing risk of bias. The randomization and allocation methods were designated as adequate, inadequate or not applicable, selective reporting and incomplete/complete outcome data and other bias were designated as yes or no.

Table 1. Characteristics of included studies (Maxilla).

PUBLICATION	TYPE OF STUDY	NO.OF PATIENTS	FOLLOW UP RATE	FLAP DESIGN FOR SURGERY	TIME OF PROSTHESIS LOADING	SUCCESS RATE OF IMPLANTS	GAP FILLING/ ADDITIONAL GBR ON OUTER BUCCAL REGION
Shaik et al[28]] (2016)	PCS	10	3 mon	-	Prosthesis after 3 mon	-	No
Teng et al[32] (2014)	CR	31	6 mon	full	Implants after 6 mon	-	Gap filling (all cases)
Mounir et al[20] (2014)	RCT	22	1 yr	Full/split	Implants at 6 mon	-	Gap filling (all cases)
Anitua et al[23] (2012)	CS	6	Mean follow up 19 mon	Full	Final Prosthesis loading 1yr after OI.	100%	Gap filling (all cases)
Gonzalez et al [7] (2011)	RCCS	8	24 mon	full	Immediate implant, prosthesis after 4 mon	-	Gap filling (all cases)
Demarosi et al [9] (2009)	PCoS	23	Follow up 3,6,12 mon P.O	full	Immediate implant	97%	No
Ferrigno et al[2] (2005)	PCT	40	6 to 24 mon	partial	Immediate implant insertion	100%	Gap filling (all cases)
Sethi et al[42] (2000)	PCT	150	1,3,6,12 mon after resto	partial	Cemented resto about 8–9 mon after surgery	-	No
Yilmaz et al[43] (1998)	PCoS	16	3 mon	Full/partial	Prosthesis at 6 mon	-	Gap filling (7 cases)

mon = months, OI = osseo-integration, yr = year, resto = restoration, P.O = Postoperatively, RCCS = retrospective case control study, PCT = prospective controlled study, PCoS = prospective cohort study, RCT = randomised control trial, CR = clinical report, PCS = prospective clinical study, CS = case series

https://doi.org/10.1371/journal.pone.0180342.t001

Table 2. Characteristics of included studies (Mandible).

PUBLICATION	TYPE OF STUDY	NO.OF PATIENTS	FOLLOW UP RATE	FLAP DESIGN FOR SURGERY	TIME OF PROSTHESIS LOADING	SUCCESS RATE OF IMPLANTS	GAP FILLING/ ADDITIONAL GBR ON OUTER BUCCAL REGION
Ella et al[26] (2014)	PCS	32	1 yr	full	Implants after 6 mon	-	Gap filling-53% cases
Rodriguez et Al [33] (2013)	PCoS	143	6 mon after surgery to up to 13 yrs	full	Definite restorations,3–6 mon P.O	-	No
Kawakami et Al [21] (2013)	RCT	12	-	Full	Removable Prosthesis after 6mon	-	Gap filling (all cases)
Scarano et al[34] (2011)	PCoS	22	1 to 6 mon after 1st surgery and sub.	Full	-		Gap filling (all cases)
Sohn et al[15] (2010)	CS	32	-	full	14–17 mon	-	Gap filling (all cases)
Holtzclaw et Al [14] (2010)	CS	13	6–12 mon	full	Implants at 5 mon, resto 4mon after implants	-	Gap filling (all cases)
Enislidis et Al[39] (2006)	PCT	5	1,3,6 mon	partial	Implants after 6 mon	97%	Gap filling (all cases)
Basa et Al[4] (2004)	PCT	21	3–4 mon	Split flap	Immediate implant	-	Gap filling (all cases)
Mazzocco et al [11] (2011)	RCT	8	14,30,90 days	full	Implant at 6 mon	-	No

mon = months, yr = year, P.O = postoperative, resto = restoration, RCCS = retrospective case control study, PCT = prospective controlled study, PCoS = prospective cohort study, RCT = randomised control trial, PCS = prospective clinical study, CS = case series

https://doi.org/10.1371/journal.pone.0180342.t002

Table 3. Characteristics of included studies (Maxilla & Mandible).

PUBLICATION	TYPE OF STUDY	NO.OF PATIENTS	FOLLOW UP RATE	FLAP DESIGN FOR SURGERY	TIME OF PROSTHESIS LOADING	SUCCESS RATE OF IMPLANTS	GAP FILLING/ ADDITIONAL GBR ON OUTER BUCCAL REGION
Crespi et al[10] (2014)	RCT	46	6, 12, 24 mon	Partial	Temporary prosthesis after 3mon	-	No
Demetriades et Al [31] (2011)	CS	15	6 mon	split	Prosthesis after 5mon	97%	Gap filling (all cases)
Anitua et al[22] (2011)	RCoS	15	1, 3, 6, 12 mon, mean follow up 11–28 mon	Full	Abutments placed 3 mon after implant installation	100%	Gap filling (all but 1)
Cortes et al[36] (2010)	CS	21	Min follow up 6 weeks after surgery	-	Prosthesis within 6mon	-	Gap filling (33% cases)
Blus et al[37] (2010)	PCoS	43	3,6,12 mon After loading and then annually	Partial	Prosthesis after 5–6 mon of implant healing	95%-maxilla 100%- mandible	Outer buccal filling (all cases)
Danza et al[18] (2009)	RCS	86	3–35 mon	Full/partial	Final resto within 8 weeks	-	No
Jensen et al[38] (2009)	RCS	40	Followup- 6 mon to 1 yr	Full/partial	Immediate implant insertion	93%	Gap filling (6 cases)
Chiapasco et al [12] (2006)	PCT	45	Mean follow up 20.4 mon	partial	Abutment placed 3–4 mom after surgery	97.3%	No
Laster et al[30] (2005)	CR	9	1 yr	-	Prosthesis after 4 mon	97%	No
Suh et al[40] (2005)	CS	10	2 yrs	Full/partial	Abutments placed at 5–6 mon	100%	No

mon = months, yr = year, resto = restoration, RCoS = retrospective cohort study, PCT = prospective controlled study, PCoS = prospective cohort study, RCT = randomised control trial, CR = clinical report, PCS = prospective clinical study, CS = case series, RCS = retrospective clinical study, Er: YAG = erbium: yttrium- aluminium garnet

https://doi.org/10.1371/journal.pone.0180342.t003

1. **Low Risk of Bias**-when all criteria were met (adequate method allocation and positive (yes) response to bias criteria)
2. **Unclear Risk of Bias**-criteria were partly met
3. **High Risk of Bias**-when one or more criteria were not met

For the observational studies, the adapted version of Newcastle-Ottawa [18] (modified) was used. The following topics were evaluated for quality assessment.

1. **Selection** of study groups (sample size calculation, representation of cases included and excluded for ridge expansion, selection of controls [ridge expansion not performed], instrument used [traditional or modern devices for ridge split].
2. **Comparability** of cases and control based on study design, instrumentation used.
3. **Outcome**–follow-up long enough for outcome, success rate of implant, and assessment of results based on whether the bone gap was filled or not. The study was analyzed on the basis of stars given to each parameter. A total of 12 stars were given, out of which studies with 8–12 stars (more than 80% domain fulfilled) were high quality studies, 5–8 were medium quality, and less than 5 were considered low quality studies.

Table 4. Outcomes based on devices used for surgery (Traditional devices).

PUBLICATION	DEVICE USED FOR BONE EXPANSION	DEVICE SPECIFICATION	COMPANY (BRAND)	WIDTH OF BONE(before and after surgery)	PATIENT DISCOMFORT DURING SURGERY	COMPLICATION (BUCCAL/LINGUAL BONE FRACTURE)
Shaik et al[28] (2016)	Osteotome kit, mallet	-	Sirag surgical Enterprises, Chennai, India	B- 3.94 mm [M] A-7.39 mm[M]	-	2 (buccal)
Crespi et al[10] (2014)	Osteotome, Electrical and hand mallet	-	Sweden Martina, Due Carrare, Padova, Italy) (Magnetic Mallet, Meta-Ergonomica, Turbigo, Milano, Italy	B-2.5 mm[M] A-7.26 mm[M]	1pt-BPPV	-
Teng et al[32] (2014)	Chisel, Mallet, Manual reamers	Reamer size-2, 2.5, 3 mm	Bicon®, Boston, USA	[MI]-2.8 mm tolerable pain and swelling		-
Mounir et al[20] (2014)	Osteotomes	-	-	-	-	-
Kawakami et Al [21] (2013)	Surgical burs, saw, chisel	-	-	B-4 mm	-	-
Gonzalez et al[7] (2011)	Diamond disc/ reciprocat ing saw, osteotomes	-	-	B-3.42 mm	-	-
Demetriades et Al[31] (2011)	Osteotomes	-	-	B-3-5 mm	-	1(buccal)
Scarano et al[34] (2011)	Scalpel, chisel, osteotome	-	Bone system, Milano, Italy	B-1,3,5 mm [MI]-3 mm	-	-
Holtzclaw et al [14] (2010)	Chisel	-	-	B-3.72 mm [M] A-7.09mm [M]	-	-
Blus et al[37] (2010)	Osteotomes Conical screws	-	Bone Management System, Meisinger	B-3.3±0.3mm [MI] A- 6 ±0.4mm [MI]	-	-
Jensen et al[38] (2009)	osteotomes	-	-	B-3-4 mm,	-	1-buccal fracture, 1-lingual fracture
Demarosi et al[9] (2009)	osteotomes	Cylindro-conical expansion osteotomes	Straumann®, Germany	B-2.5–4.5 mm A-6-7.5 mm	-	-
Enislidis et al[39] (2006)	Osteotome, Mini blade(chisel)	Ref no 376900	Becton, Dikins on Surgical System, NJ	-	-	-
Ferrigno et al[25] (2005)	Osteotome	Flat with linear tip	GEAS® Impla ntology and Oral Surgery, Udine, Italy	B-3to 5 mm	-	1(Buccal)
Suh et al[40] (2005)	Microsaw Blades scalpel mallet	#15 blade	Friadent, Dentsply	-	-	-
Basa et al[41] (2004)	osteotome	-	-	B-3-4 mm	-	-
Sethi et al[42] (2000)	osteotome	Paraboloid tips	Harley Dental Technical Centre, London, United Kingdom	-	-	-
Yilmaz et al[43] (1998)	Chisel and mallet	-	-	[MI]-2.8 mm	-	-

Pt = patient, BPPV = benign paroxysmal positional vertigo, B = before, A = after, [M] = mean, [MI] = mean increase

https://doi.org/10.1371/journal.pone.0180342.t004

Table 5. Outcomes based on devices used for surgery (Modern devices).

PUBLICATION	DEVICE USED FOR BONE EXPANSION	DEVICE SPECIFICATION	COMPANY (BRAND)	WIDTH OF BONE(before and after surgery)	PATIENT DISCOMFORT DURING SURGERY	COMPLICATION (BUCCAL /LINGUAL BONE FRACTURE)
Ella et al[26] (2014)	Bone expansion device	2 steel arms with transverse screw	Meisinger	B-3 mm	-	43% cases (buccal)
Rodriguez et Al [33] (2013)	Threaded bone expanders	-	Microdent System, Barcelona, Spain	-	-	1(buccal)
Anitua et al[23] (2012)	Motorized expanders	-	BTI-Ultrasonic, BTI Biotechnolo gy Institute S.L., Vitoria, Spain	B-2.97 mm [M] A-10.3 mm [M]	-	-
Mazzocco et al [11] (2011)	Motorized ridge expander	-	MRE; Biotechnolo gy Institute	B-2-3 mm A-7 mm	-	-
Anitua et al[22] (2011)	Motorized expanders	-	BTI- Ultrasonic®, BTI Biotechnolo gy Institute S.L., Vitoria, Spain	B- 4.29 mm [MI] A-7.63 mm[MI]	-	-
Cortes et al[36] (2010)	Motorized bone expanders	Screw assisted bone expanders, ratchet, carrier	Microdent, Barcelona, Spain	B-3-4 mm A-5-6 mm	-	-
Danza et al[18] (2009)	Piezo surgery device	-	Surgibone; Silfradent, Forli, Italy	-	-	-
Chiapasco et al [12] (2006)	Extension crest device	2 surgical steel arms and transverse screw	Extension Crest®, Bio srl, Milan, Italy	B- 3–4 mm A-7-8 mm	-	1(Buccal)

B = before, A = after, [MI] = mean increase

https://doi.org/10.1371/journal.pone.0180342.t005

Data analysis. The data were collected as tables and pooled according to the characteristics selected. The main criteria decided for the studies were based on the type of devices/instruments used.

Results and discussion

Study selection

The search strategy yielded 2,076 articles. Out of these, 2,048 were excluded after review of title or abstract or if they were duplicate articles. After thorough examination of the remaining

Table 6. Outcomes based on devices used for surgery (Traditional and modern devices).

PUBLICATION	DEVICE USED FOR BONE EXPANSION	DEVICE SPECIFICATION	COMPANY (BRAND)	WIDTH OF BONE (before and after S urgery)	PATIENT DISCOMFORT DURING SURGERY	COMPLICATION (BUCCAL/LINGUAL BONE FRACTURE)
Sohn et al[15] (2010)	Piezoelectric saw,		SurgyBone, Silfradent, Sofia, Italy Dual Laser;	B-2-4 mm A-not reported	-	5(Buccal)
	Er:YAG laser,	6w,20Hz	Lambda Scientifica, Altavilla Vicentina, Italy			
	Chisel and mallet, osteotome		D. Flanagan, Willimantic, Conn			
Laster et al[30] (2005)	Osteotome, Crest widener	Activation screws	Laster crest widener	[MI]-4-6 mm	-	-

Er: YAG = erbium: yttrium- aluminium–garnet, before, A = after, [MI] = mean increase

https://doi.org/10.1371/journal.pone.0180342.t006

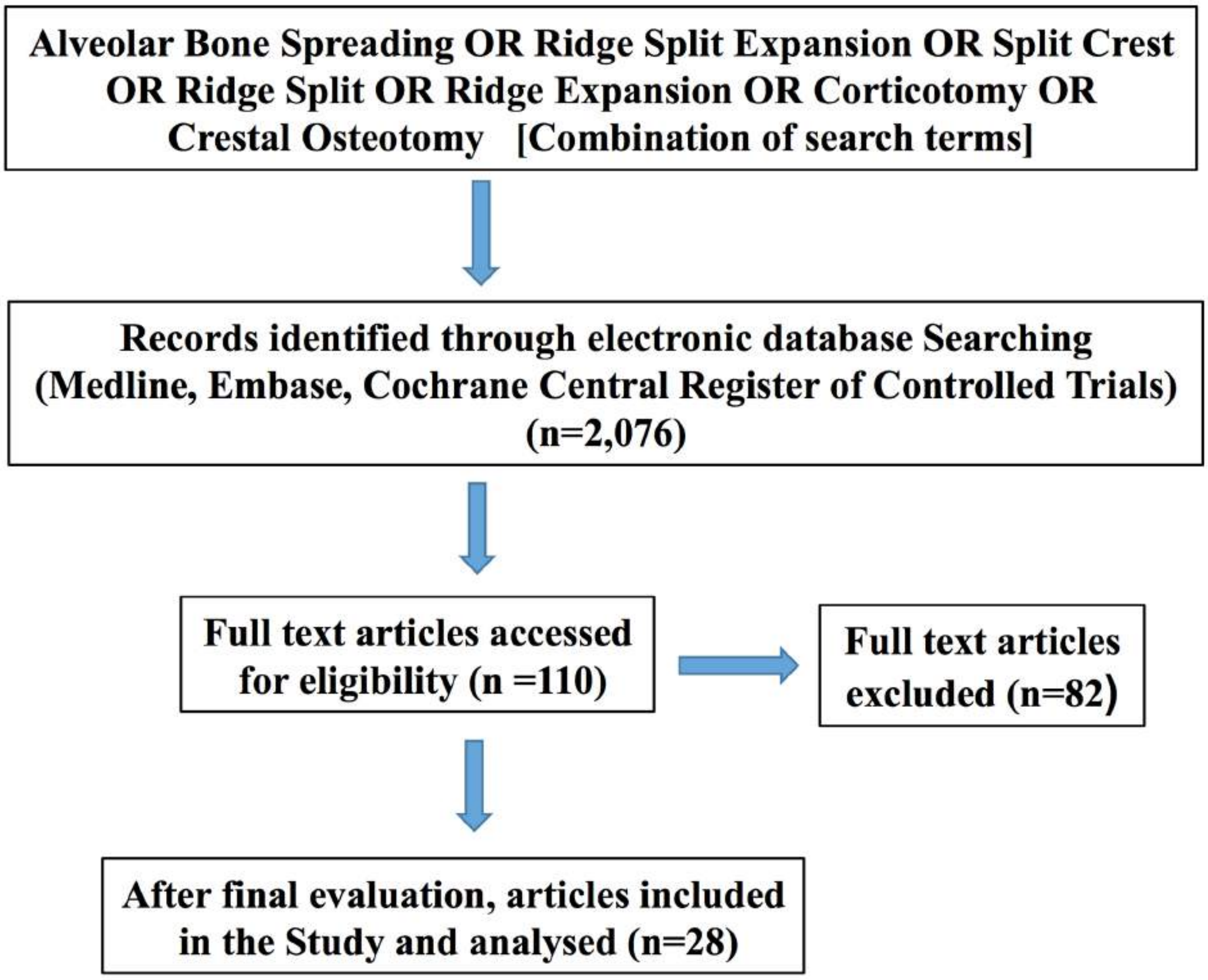


Fig 1. Flow chart of the screening process using different databases.

https://doi.org/10.1371/journal.pone.0180342.g001

articles, 28 were found to be potentially fulfilling the inclusion criteria and were subsequently analyzed (Fig 1).

Quality of included studies. There were 4 RCTs and the others were observational studies. The quality assessment of the observational studies using modified Newcastle-Ottawa Scale (NOS) is presented in S1 Appendix. According to the NOS, among the studies analyzed, one was of medium quality [19], while all others were of low quality. According to the Cochrane Handbook for Systematic Reviews of Interventions, one RCT [10] was at high risk of bias due to unclear method of allocation and no information on performance, detection, and reporting bias. Other 3 RCTs [11, 20, 21] were at low risk of bias due to 2 having random sequence generation and one study appearing to be free of other sources of bias; these studies reported the expected outcome domains.

Main result analysis and discussion

After tooth extraction, there are dimensional changes in the alveolar bone, resulting in bone remodelling and reduction in different directions. The bone formation is due to deposition of osteoblasts on the alveolar bone, while osteoclastic activity results in removal/destruction of bone. Most of the alveolar bone lost, is composed of bundle bone. Re fabrication of this portion of alveolar bone is a difficult task but can be accomplished by ridge preservation procedures [12].

The process of ridge split is a vertical osteotomy i.e. cutting of bone downright in the vertical direction to provide space within bone for incorporation of graft material or implants. The alveolar bone is known to be viscoelastic in nature. For very thin alveolar ridges (< 3mm), ridge expansion procedures are very beneficial, as bone in such cases are very soft, have lower elastic modulus, which reinforces their viscoelastic nature and can result in better bone expansion [22].

In this study, we reviewed 4 RCTs and 24 observational studies. The aim of our review was to analyze the various instruments used for the ridge-split procedures and identify the ones used with maximum frequency and high implant success rate. Some of the studies (case series) included in our review did not have control groups, and there was significant heterogeneity of the studies; hence, meta-analysis could not be carried out for our studies.

Among the RCTs, 2 studies demonstrated comparison of the devices used for alveolar ridge expansion. In the first study, by Crespi et al.[10] comparison between electrical and hand mallet was conducted for bone expansion; although no significant differences in results, between the two devices were observed, the electrical mallet was found to be clinically more beneficial than the hand mallet. Bone has different density in different areas and the amount of force applied to the bone (using various instruments) determines the predictability and success of surgical procedure. Use of electrical mallet resulted in low force on the bone with no patient discomfort. The authors [10] reported that the forces were subjected to only to the target areas with minimum trauma to the cranial bones. This may be attributed to the timing of force applied and the movements at the osteotome tips at an energy of 90daN/8μ [10]. In the second study, Mazzocco et al. [11] compared motorized ridge expanders and lateral ridge augmentation for alveolar bone expansion. The differences between the two techniques were statistically insignificant; both were equally effective for successful bone augmentation.

Type of instrument used and patient discomfort reported. Ridge expansion can be performed using various kinds of devices (Fig 2). The traditional devices include chisel and mallet; surgical burs; microsaw blades; osteotomes etc. While the modern devices include the motorized bone expanders; expansion crest devices; ultrasonic/piezoelectric devices and bone expanders. With new technologies availability and advancement in the diagnostic field, a shift from the traditional to the modern devices has been seen. The modern devices have an edge over the traditional ones as they act within a short interval of time, cause minimum trauma and prevent bone heating. These factors in turn result in faster bone healing. All this helps to save the clinician's time and alleviates fear from the patient's mind as well.

The earliest instruments used for alveolar ridge expansion were chisels and blades. However, using these instruments was difficult as there was no control and precision. This lead to the advent of newer devices for the bone cutting.

We analyzed the type of device used in each study. Some procedures involved use of traditional instrumentation techniques (chisel, blades, osteotomes, mallets, burs and drills), and in some cases, modern devices were used (piezo surgery device, expansion crest device and motorized expander).

Of the studies included, 13 reported the use of the traditional device, osteotomes with a frequency of 65%, and amongst the modern expansion devices, there was frequent use of motorized expanders (Fig 3). No significant patient discomfort was observed for any of the included studies, except in one case [10] with vertigo. For all cases, where motorized bone expanders were used, 100% success rate was noted.

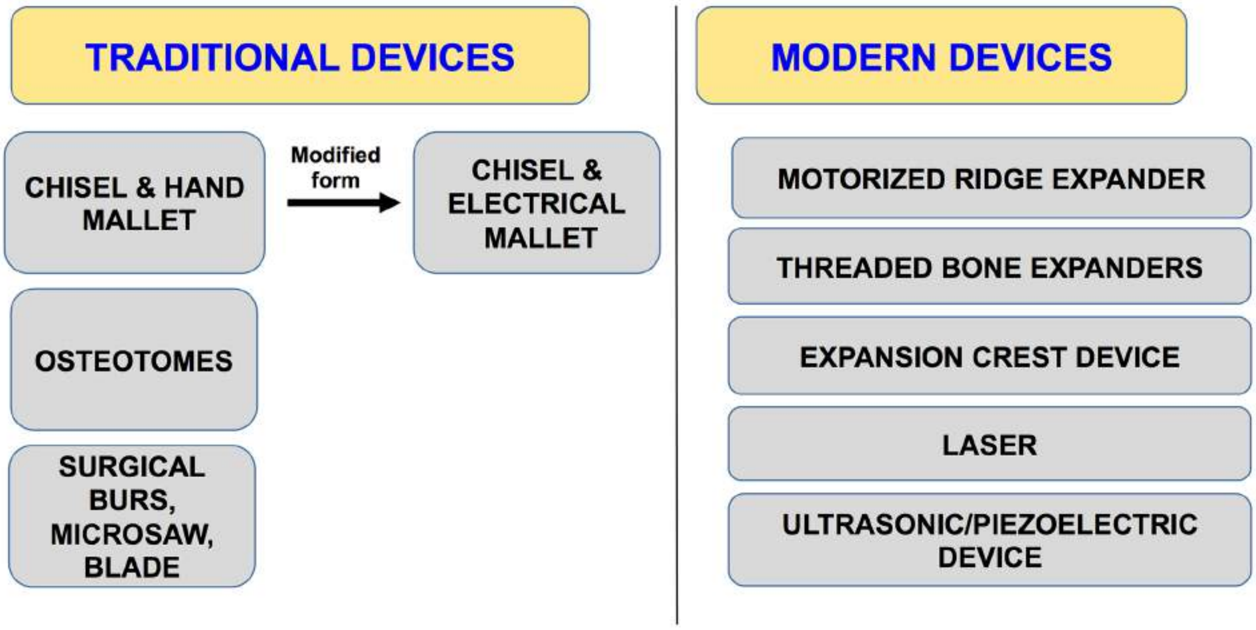


Fig 2. Devices used for ridge expansion.

https://doi.org/10.1371/journal.pone.0180342.g002

Bone width. An analysis of the bucco-lingual bone width, before ridge expansion (for the placement of implants) is very important. When the bucco-lingual width is about 3mm, but less than 6mm [4], ridge splitting/ augmentation is recommended. Various instruments are used for the ridge splitting process. In this review, we analysed the initial and final bone width, used for the surgical procedures.

In most of the cases, use of traditional device- the osteotomes was seen very frequently. They showed very good results with an average increase in bone width of about ± 3mm. In the

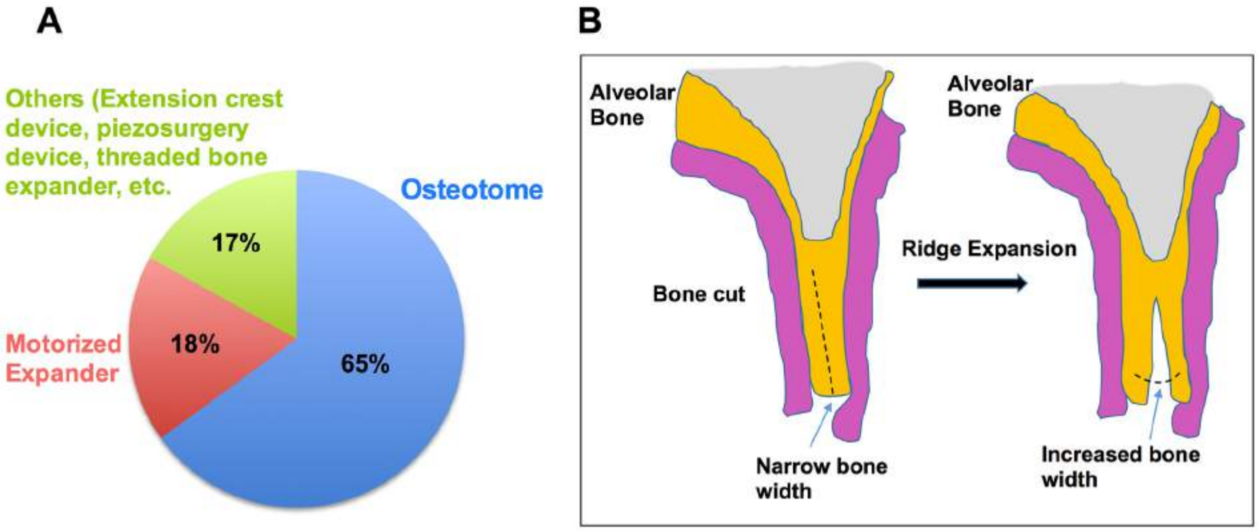


Fig 3. Frequency of the various devices used (A) and schematic representation of ridge split procedure (B).

https://doi.org/10.1371/journal.pone.0180342.g003 category of the modern devices, piezo surgery devices and motorized expanders were used with an average bone width increase of ± 3.44mm.

Of all the included studies, 8 included data for the alveolar crest initial width (mean = 3.5 mm), while 13 mentioned the final width (mean = 6.65mm); 6 studies mentioned only the difference in alveolar width after expansion (mean = 3.22mm). In cases where motorized bone expanders were used, the mean bone width gain for ridges ≥4 mm was 2.93 mm, while the expansion obtained for ridges <4 mm was 3.95 mm; this indicates that motorized bone expanders provide the best results.

The use of motorized bone expanders has thereby been indicated for extremely resorbed ridges, as they cause minimum tissue damage, facilitate quick and precise movements for the clinician, and can also be placed in apical and occlusal alveolar ridge areas [23] where conventional technique applications are limited.

Implant success rate and gap filling. The success rate was variable for all the studies included, with an average of 97%, irrespective of whether gap filling with a barrier membrane was done or not. For all the studies, which reported the success rate of implants, osteotomes were used. Anitua et al. [22, 23] also reported 100% success rates using motorized expanders and piezoelectric device; however, these devices are still not used commonly.

The gap filling for ridge expansion procedures may be done using collagen or mineral graft material. The inter-positional gap filling and the outer buccal region filling (after GBR) frequency was analyzed, in this study. In fourteen studies, gap filling for all subjects was done, while in 4 cases selective gap filling was done. Gap filling may or may not influence the final outcome of implant success [24, 25] however, since the graft material takes part in the bone remodelling process, it expedites the healing process. Ella et al. [26] advocated the use of bone filling substitutes, especially in the horizontally expanded sites as it resulted in reduced resorption around the implant bony walls. The direct contact between the bone walls and implant is reduced with bone substitutes acting as a cushion against ischaemic resorption with some gain in bone volume. Jensen et al. [27] have reported that generally gap filling of less than 3mm do not require any graft material except collagen sponge. However, the amount of gap width which necessarily requires any grafting is difficult to determine and whether grafting facilitates or impedes osseo integration remains uncertain.

Complications due to devices used. The most common complications observed during, or on completion of the ridge expansion procedure, was bone fracture. The mandibular bone has thicker cortical plate and is less flexible than the maxilla, hence the rate of bone fracture during ridge expansion (especially in the buccal region) is more for mandibular region. Studies have shown that ridge expansion with osteotomes or implant insertion [25] may lead to fracture of the cortical plate (mostly labial). Of all the studies included, 7 reported bone fracture, with buccal fracture being more common. In a study by Ella et al. [26] buccal bone fracture occurred because expansion was done in a narrow ridge (width, 3mm). Shaik et al. [28] reported fracture of the buccal plate due to pulling of the osteotome (after tapping), more in the buccal direction. To prevent bone fracture, Hotzclaw et al. [14] used a modified technique whereby apical hinge cuts were used, which were not fully in the buccal plate so that some mobilization of the buccal plate could be achieved. It was observed that buccal bone fracture was frequent with osteotome usage, and use of motorized expanders was associated with no reported bone fracture or any other complications.

Comparison with other studies / reviews

Till now three main systematic reviews [5, 24, 29] have been carried out, which study the survival rate of titanium implants after ridge expansion procedure, assessment of predictability, dimensional change, and other factors associated with ridge expansion and evaluation of clinical and radiological analysis of ridge splitting with or without GBR. In comparison to prior systematic studies, this analysis did not include any animal studies. We aimed to analyze the type of instruments used for the ridge expansion procedure and found that osteotomes were the most frequently used for such procedures.

This review shows that osteotomes remain the most popular device, especially in the maxillary bone [9] due to the lower possibility of heat generation and the increased initial stability because of lateral condensation of bone [7]. The osteotomes do not surgically remove the bone during preparation, rather they exert pressure in the form of lateral compression facilitating increased bone density and successful primary retention of dental implants. Further, there is less risk of crestal bone loss around the implant, and hence, less fear and anxiety related to implant failure [30]. However, there are several disadvantages to this technique. It cannot achieve vertical bone height, and only width gain is possible. Ridge split surgeries using osteotomes may be difficult to perform and require a lot of skill; there is considerable operator dependency involved as well [6, 31]. Amongst the modern expansion devices, the motorized bone expanders and piezoelectric surgery devices have shown promising results. The conventional osteotomy techniques [44] cannot always prevent trauma to the nerves and blood vessels.

Piezosurgery is a type of ultrasonic instrumentation. Piezoelectric bone surgery or piezosurgery or ultrasonic osteotomy is a procedure in which bone cutting is done using low frequency ultrasonic vibrations. The concept of ultrasonic osteotomy/piezo-surgery was introduced which is based on the reciprocal piezo effect [45]. A polarized piezo-ceramic receives a certain amount of voltage which causes deformation of piezoelectric crystals; creating alternate expansion and contraction of the material. This helps in selective cutting of bone without any damage to the soft tissue and other surrounding structures. It appears that the expander works not only for its intended purpose, but also as a condenser of the trabecular bone [11]. Piezo-surgery has also been shown to be feasible in inferior alveolar nerve surgery as it favors smaller osteotomies and preserves the neurovascular bundle without any nerve injury. Additionally, it is known to reduce dental fear and patient (psychological) stress and has very less noise generation [15]. The motorized expanders and ultrasonic surgery system are easier to use, provide more alveolar bone width gain in comparison to the traditional devices, and cause less trauma to the bone compared to the traditional/conventional instruments such as mallets and osteotomes. However, their cost is a limiting factor, and therefore, osteotomes remain a popular mode of instrumentation for ridge expansion procedures.

Limitations

In this review, most of the current included studies, were of low quality and had limited scientific evidence. Also, most studies included were case series with methodologies representing low levels of evidence. The literature study was confined to English publications, which may have introduced a selection bias. Additional studies that provide a successful comparison of the devices used for ridge width expansion, need to be performed. For a better determination of the most favorable ridge expansion technique [5], well designed studies according to CONSORT guidelines [46] may be needed.

Conclusion

Based on the results from the available studies, it was found that the successful use of alveolar ridge expansion device is dependent on several factors. Patient discomfort during surgery, the gap filling with GBR, before or after surgery and complications seen during or after surgery are possible factors that affect the success outcome of the ridge expansion devices.

The osteotomes are the most widely used conservative devices for ridge expansion due to their ease of usage and availability. Using an osteotome allows excellent (manual) control with adequate determination of the implant axis. The device is simple to use and very cost effective, hence can be used on a large scale. However, piezoelectric device and other modern devices are being increasingly used as new devices for crest ridge expansion. They are more suitable to prevent any trauma to the vulnerable structures like mucosa, nerves and blood vessels. Since there is less trauma to the bone, it results in faster healing. These devices should be used more in the future.

Supporting information

S1 Appendix. Quality assessment of the observational studies (NOS).
(DOCX)

S2 Appendix. PRISMA checklist.
(DOCX)

Author Contributions

Conceptualization: Nayansi Jha.

Data curation: Nayansi Jha.

Formal analysis: Nayansi Jha.

Funding acquisition: Eun Ha Choi, Nagendra Kumar Kaushik, Jae Jun Ryu.

Project administration: Nagendra Kumar Kaushik.

Resources: Eun Ha Choi, Nagendra Kumar Kaushik.

Supervision: Nagendra Kumar Kaushik.

Validation: Nagendra Kumar Kaushik.

Visualization: Eun Ha Choi, Jae Jun Ryu.

Writing – original draft: Nayansi Jha.

References

1. Tolstunov L, Hicke B. Horizontal augmentation through the ridge-split procedure: a predictable surgical modality in implant reconstruction. J Oral Implantol 2013; 39: 59–68. https://doi.org/10.1563/AAID-JOI-D-12-00112 PMID: 23402358
2. Simion M, Baldoni M, Zaffe D. Jawbone enlargement using immediate implant placement associate with a split crest technique and guide tissue regeneration. Int J Periodontics Restorative Dent 1992; 12(6):462–473.
3. Scipioni A, Bruschi GB, Calesini G. The edentulous ridge expansion technique: a five-year study. Int J Periodontics Restorative Dent 1994; 14 (5):451–459. PMID: 7751111
4. Khairnar MS, Khairnar D, Bakshi K. Modified ridge splitting and bone expansion osteotomy for placement of dental implant in esthetic zone. Contemp Clin Dent 2014; 5(1):110–114. https://doi.org/10.4103/0976-237X.128684 PMID: 24808709
5. Mestas G, Alarcón M, Chambrone L. Long-Term Survival Rates of Titanium Implants Placed in Expanded Alveolar Ridges Using Split Crest Procedures: A Systematic Review. Int J Oral Maxillofac Implants 2016; 31(3):591–599. https://doi.org/10.11607/jomi.4453 PMID: 27183068
6. Duncan JM, Westwood RM. Ridge widening for thin maxilla: A clinical report. Int J Oral Maxillofac Implants 1997; 12(2):224–227. PMID: 9109273

7. Gonza´lez-Garcı´a R, Monje F, Moreno C. Alveolar split osteotomy for the treatment of the severe narrow ridge maxillary atrophy: a modified technique. Int. J. Oral Maxillofac. Surg 2011; 40: 57–64. https://doi.org/10.1016/j.ijom.2010.03.030 PMID: 20729037

8. Padmanabhan T, Gupta RK. Comparison of Crestal Bone Loss and Implant Stability Among the Implants Placed with Conventional Procedure and Using Osteotome Technique: A Clinical Study. J of Oral Implantology 2010; 36(6):475–483. https://doi.org/10.1563/AAID-JOI-D-09-00049 PMID: 21142790

9. Demarosi F, Leghissa GC, Sardella A, Lodi G, Carrassi A. Localised maxillary ridge expansion with simultaneous implant placement: A case series. Br J Oral Maxillofac Surg 2009; 47(7): 535–540. https://doi.org/10.1016/j.bjoms.2008.11.012 PMID: 19150155

10. Crespi R, Capparè P, Gherlone EF. Electrical mallet provides essential advantages in split-crest and immediate implant placement. Oral and maxillofac Surg 2014; 18(1):59–64.

11. Mazzocco F, Nart J, Cheung WS, Griffin TJ. Prospective evaluation of the use of motorized ridge expanders in guided bone regeneration for future implant sites. Int J Periodontics Restorative Dent 2011; 31(5): 547–554. PMID: 21845249

12. Chiapasco M, Ferrini F, Casentini P, Accardi S, Zaniboni M. Dental implants placed in expanded narrow edentulous ridges with the Extension Crest device. Clin Oral Implants Res 2006; 17(3): 265–272. https://doi.org/10.1111/j.1600-0501.2005.01196.x PMID: 16672021

13. Curie J, Curie P. Contractions et dilatations produites par des tensions dans les cristaux hémièdres à faces inclinées. C R Acad Sci Gen 1880; 93:1137–1140.

14. Holtzclaw DJ, Toscano NJ, Rosen PS. Reconstruction of posterior mandibular alveolar ridge deficiencies with the piezoelectric hinge-assisted ridge split technique: a retrospective observational report. J Periodontal 2010; 81(11):1580–1586.

15. Sohn DS, Lee HJ, Heo JU, Moon JW, Park IS, Romanos GE. Immediate and Delayed Lateral Ridge Expansion Technique in the Atrophic Posterior Mandibular Ridge. J Oral Maxillofac Surg 2010; 68(9): 2283–2290. https://doi.org/10.1016/j.joms.2010.04.009 PMID: 20580146

16. Higgins JP, Green S, eds. Cochrane Handbook for Systematic Reviews of Interventions. Version 5.0.1. Cochrane Collaboration. http://handbook.cochrane.org/. Updated March 2011.

17. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the PRISMA Statement. Int J. Surg 2010; 8:336–341. https://doi.org/10.1016/j.ijsu.2010.02.007 PMID: 20171303

18. Wells GA, Shea B, O'Connell D et al. The New Castle-Ottawa Scale (NOS) for assessing the quality of non-randomised studies in meta-analysis. The Ottawa Hospital Research Institute. http://www.ohri.ca/programs/clinical_epidemiology/oxford.htm. Accessed March 2016.

19. Danza M, Guidi R, Carinci F. Comparison between Implants Inserted into Piezo Split and Unsplit Alveolar Crests. J Oral Maxillofac Surg 2009; 67(11):2460–2465. https://doi.org/10.1016/j.joms.2009.04.041 PMID: 19837318

20. Mounir M, Beheiri G, El-Beialy W. Assessment of marginal bone loss using full thickness versus partial thickness flaps for alveolar ridge splitting and immediate implant placement in the anterior maxilla. Int J Oral Maxillofac Surg 2014; 43(11):1373–1380. https://doi.org/10.1016/j.ijom.2014.05.021 PMID: 24973295

21. Kawakami PY, Dottore AM, Bechara K, Feres M, Shibli JA. Alveolar osteotomy associated with resorbable non-ceramic hydroxylapatite or intra-oral autogenous bone for height augmentation in posterior mandibular sites: a split-mouth prospective study. Clin. Oral Impl. Res 2013; 24(9): 1060–1064.

22. Anitua E, Begoña L, Orive G. Clinical Evaluation of Split-Crest Technique with Ultrasonic Bone Surgery for Narrow Ridge Expansion: Status of Soft and Hard Tissues and Implant Success. *Clin* Implant Dent Relat Res 2013; 15(2):176–187. https://doi.org/10.1111/j.1708-8208.2011.00340.x PMID: 21453394

23. Anitua E, Begoña L, Orive G. Controlled Ridge Expansion Using a Two-Stage Split-Crest Technique with Ultrasonic Bone Surgery. Implant Dent 2012; 21(3):163–170. https://doi.org/10.1097/ID.0b013e318249f50b PMID: 22534365

24. Bassetti MA, Bassetti RG, Bosshardt DD. The alveolar ridge splitting/expansion technique: a systematic review. Clin Oral Implants Res 2016; 27(3):310–324. https://doi.org/10.1111/clr.12537 PMID: 25586966

25. Ferrigno N, Laureti M. Surgical advantages with ITI TER implants placement in conjunction with split crest technique. 18-month results of an ongoing prospective study. Clin Oral Implants Res 2005; 16(2):147–155. https://doi.org/10.1111/j.1600-0501.2005.01125.x PMID: 15777323

26. Ella B, Laurentjoye M, Sedarat C, Coutant JC, Masson E, Rouas A. Mandibular Ridge Expansion Using a Horizontal Bone-Splitting Technique and Synthetic Bone Substitute: An Alternative to Bone Block

Grafting? Int J Oral Maxillofac Implants 2014; 29(1):135–140. https://doi.org/10.11607/jomi.2201 PMID: 24451864

27. Jensen OT, Ellis E III, Glick P. The book flap, in Jensen OT (ed): The Osteoperiosteal Flap. Chicago, Quintessence Publishing, 2009.

28. Shaik LS, Meka S, Kattimani VS, Chakravarthi SP, Kolli NN, Lingamaneni KP, et al. The Effect of Ridge Expansion on Implant Stability in Narrow Partially Edentulous Ridges—A Preliminary Clinical Study. J Clin Diagn Res 2016; 10(9): ZC28–ZC33. https://doi.org/10.7860/JCDR/2016/21286.8452 PMID: 27790575

29. Elnayef B, Monje A, Lin GH, Gargallo-Albiol J, Chan HL, Wang HL, et al. Alveolar ridge split on horizontal bone augmentation: a systematic review. Int J Oral Maxillofac Implants 2015; 30(3):596–606. https://doi.org/10.11607/jomi.4051 PMID: 26009911

30. Laster Z, Rachmiel A, Jenson OT. Alveolar Width Distraction Osteogenesis for Early Implant Placement. J Oral Maxillofac Surg 2005; 63(12):1724–1730. https://doi.org/10.1016/j.joms.2005.09.001 PMID: 16297692

31. Demetriades N, Park JI, Laskarides C. Alternative Bone Expansion Technique for Implant Placement in Atrophic Edentulous Maxilla and Mandible. J Oral Implantol 2011; 37(4):463–471. https://doi.org/10.1563/AAID-JOI-D-10-00028 PMID: 20662673

32. Teng F, Zhang Q, Wu M, Rachana S, Ou G. Clinical use of ridge-splitting combined with ridge expansion osteotomy, sandwich bone augmentation, and simultaneous implantation. Br J Oral Maxillofac Surg 2014; 52(8):703–708. https://doi.org/10.1016/j.bjoms.2014.03.028 PMID: 25081953

33. Rodriguez JG, Eldibany RM. Vertical splitting of the mandibular body as an alternative to inferior alveolar nerve lateralization. Int J Oral Maxillofac Surg 2013; 42(9):1060–1066. https://doi.org/10.1016/j.ijom.2013.04.014 PMID: 23769148

34. Scarano A, Murmura G, Sinjiari B, Assenza B, Sollazzo V, Spinelli G, et al. Expansion of the alveolar bone crest with ultrasonic surgery device: Clinical study in mandible. Int J Immunopathol Pharmacol 2011; 24(2 Suppl):71–75. https://doi.org/10.1177/03946320110240S213 PMID: 21781449

35. Sohn DS, Ahn MR, Lee WH, Yeo DS, Lim SY. Piezoelectric osteotomy for intraoral harvesting of bone blocks. Int J Periodontics Restorative Dent 2007; 27(2): 127–131. PMID: 17514884

36. Cortes AR, Cortes DN. Non-traumatic Bone Expansion for Immediate Dental Implant Placement: An Analysis of 21 Cases. Implant Dent 2010; 19(2):92–97. https://doi.org/10.1097/ID.0b013e3181d46f46 PMID: 20386211

37. Blus C, Szmukler-Moncler S, Vozza I, Rispoli L, Polastri C. Split crest and immediate implant placement with ultrasonic bone surgery (piezo-surgery): 3-year follow-up of 180 treated implant sites. Quintessence Int 2010; 41(6): 463–469. PMID: 20490388

38. Jensen OT, Cullum DR, Baer DJ. Marginal bone stability using 3 different flap approaches for alveolar split expansion for dental implants: a 1-year clinical study. J Oral Maxillofac Surg 2009; 67(9): 1921–1930. https://doi.org/10.1016/j.joms.2009.04.017 PMID: 19686930

39. Enislidis G, Wittwer G, Ewers R. Preliminary Report on a Staged Ridge Splitting Technique for Implant Placement in the Mandible: A Technical Note. Int J Oral Maxillofac Implants 2006; 21(3):445–449. PMID: 16796289

40. Suh JJ, Shelemay A, Choi SH, Chai JK. Alveolar Ridge Splitting: A New Microsaw Technique. Int J Periodontics Restorative Dent 2005; 25(2):165–171. PMID: 15839593

41. Basa S, Varol A, Turker N. Alternative Bone Expansion Technique for Immediate Placement of Implants in the EdentulousPosterior Mandibular Ridge: A Clinical Report. Int J Oral Maxillofac Implants 2004; 19(4):554–558. PMID: 15346753

42. Sethi A, Kaus T. Maxillary Ridge Expansion with Simultaneous Implant Placement: 5-Year Resultsof an Ongoing Clinical Study. Int J Oral Maxillofac Implants 2000; 15(4):491–99. PMID: 10960981

43. Yilmaz S, Efeoğlu E, Kiliç AR. Alveolar ridge reconstruction and/or preservation using root form bioglass cones. J Clin Periodontol 1998; 25(10):832–839. PMID: 9797057

44. Rambla-Ferrer J, Peñarrocha-Diago M, Guarinos-Carbó J. Analysis of the use of expansion osteotomes for the creation of implant beds. Technical contributions and review of the literature. Javier Med Oral Path Oral Cir Bucal 2006; 11: E267–71.

45. Hollstein S, Hoffmann E, Vogel J, Heyroth F, Prochnow N, Maurer P. Micromorphometrical analyses of five different ultrasonic osteotomy devices at the rabbit skull. Clin Oral Implants Res 2012; 23: 713–718. https://doi.org/10.1111/j.1600-0501.2011.02185.x PMID: 21488969

46. Moher D, Shulz K, Altman D. The CONSORT statement: Revised recommendations for improving the quality of reports of parallel group randomized trials. Clin Oral Investig 2003; 7: 2–7. PMID: 12673431

Magnetic **Mallet**™

www.magneticmallet.it

info@metaergonomica.it

T. +39 0331 890280