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Review on evaluation of using piezoelectric ultrasound surgery versus conventional technique in sinus lifting procedure

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Abstract

The objective of the study is to make a comparison between piezoelectric ultrasound surgery and conventional technique in sinus lifting procedure with simultaneous implant insertion. Perforations of the sinus membrane are more common in direct sinus lifts performed with rotary techniques than ultrasound, but ultrasound offers better implant survival and bone gain. Piezo surgery sinus lifting treatment generates less postoperative pain and swelling, while ultrasound enables precise bone removal with reduced risk of injury or perforation. Piezo surgery is time-consuming but effective in safe sinus membrane elevation, reducing perforation risk, and improving patient comfort.

Introduction

The use of dental implant has become a common treatment to replace missing teeth [1]. Usually natural resorption occurs after extraction which causes deficiency in bone volume, thus augmentation of the alveolar ridge before implant placement may be needed [2]. Dental implantology at the beginning of the third millennium can replace tooth defects almost always if they occur in an adult individual who is willing to cooperate and to provide a financial contribution there [3]. A patient must have enough bone in the maxillary and mandibular ridge to support dental implants to be a candidate for the treatment. Flat palatal vault, insufficient alveolar height, insufficient posterior alveolus, and greater pneumatization of the maxillary sinus, which leads to the sinus's near approach to the crestal bone, are all anatomic restrictions associated with the posterior maxilla [4]. Maxillary bone, primarily medullary and trabecular, has less quantity and bone density than the premaxilla or mandible [5]. Compact bone's adjacent cortices are often relatively thin, offering low strength [6].

Due to resorption and/or loss of buccal bone, there is an initial decrease in alveolar breadth following maxillary posterior tooth extraction [7]. An rise in antral pneumatization occurs as a result of continual bone remodeling, lack of stimulation, and loss of bone height and density [8]. The maxillary sinus pneumatization is caused by progressive hollowing out of alveolar process of apical aspect mediated by osteoclasts and by increase in positive intra-antral pressure [9]. The remaining vertical bone height is reduced in this case, making normal implant placement challenging [10].

To adapt, circumvent, and treat this local physiological as well as anatomical limitation, maxillary sinus floor elevation has become an important pre-placement procedure in dental implant treatment planning. Various methodologies have evolved to increase the thickness of maxillary sinus floor. The treatment goal of all such procedures is to increase residual bone height.

Few of the techniques involve simple minimal elevation of maxillary sinus membrane, Schneiderian membrane, while others include placement of various type of grafts including allografts, autografts, bone morphogenetic proteins, and hydroxyapatite crystals [11]. The sinus lift surgery, also known as subantral augmentation, was created to enhance the amount of bone in the posterior maxilla. Before prothetic rehabilitation, sinus floor augmentation has become a common surgery to adjust maxillary bone to the needs of endosseous implants [12].

Several methods have been developed and are currently used for sinus lifting and augmentation [13]. Caldwell-Luc osteotomy is historically the first main technique where the maxillary sinus floor is grafted to provide a sufficient quantity of bone for the placement of endosteal dental implants [14]. The axial approach employs the summers osteotomy, which was created to make the sinus-lift procedure easier by allowing simultaneous sinus floor elevation and implantation without the need for a surgical sinus cavity opening [15]. This approach relies on the Schneiderian membrane's innate osteogenic characteristics to replace the lost millimeters of bone around the implant's tip. This less invasive procedure aims to keep the grafting volume to a bare minimum, generating only the amount of bone needed for the implants to osseointegrate and anchor well [16]. Implant stability in the remaining bone height, as in the one-stage lateral sinus lift, is a major concern, and the use of implants with a microthreaded and/or tapered collar may be a viable alternative for stabilizing implants in a limited bone volume [17].

The choice of procedure, whether a lateral approach with the Caldwell-Luc osteotomy or an axial approach with the Summers osteotomy, is largely determined by the alveolar ridges' residual bone height [15]. Currently, most simple cases can be treated with the summer's osteotomy technique, which implies less pain and no waiting time between grafting and implantation. However, the lateral approach offers a better control of the surgical site, particularly in a severely resorbed maxilla or when extensive implantation is needed [14]. A third technique, based on the concept of directed bone regeneration, was recently developed. A full sinus lift can be accomplished utilising the lateral method using whole blood as the sole filling material [18]. The Schneiderian membrane must be pushed to the highest possible position utilising implant tips as tent pegs, and the implants must be stabilized in the residual bone height (especially by using implants with tapered and microthreaded collars). This bone regeneration idea results in a highly natural bone repair around implants [14]. However, this technique requires a very skilled surgeon because a perfect sinus membrane lifting without tears is necessary to maintain its osteogenic potential.

Sinus elevation allows maxillary bone augmentation and thus facilitates implant rehabilitation in patients with severe posterior maxillary atrophy [19]. In direct maxillary sinus lift a vestibular osteotomy is performed, a bone window is prepared, and access is gained to the maxillary sinus for elevation of the membrane. The bone puncture can be done with a standard rotary osteotomy drill or with ultrasonic tips [20].

The most common complication when elevating Schneider's membrane with the rotary approach is perforation of Schneider's membrane, which occurs in 10-35 percent of all such surgeries and usually occurs during the osteotomy drilling phase while constructing the window for sinus access. Vestibular osteotomy with ultrasound has been recommended to lower the risk of perforating Schneider's membrane, since it reduces the chance of soft tissue injury and membrane perforation to 7% [21]. Some studies in the literature provide preliminary descriptions of the technique, while others present solitary cases, which are followed by case series, with no significant differences between the two techniques being observed [22].

Because of its efficacy in removing calculus, Ultrasound (US) has been frequently employed in periodontics with favourable outcomes for root surface decontamination [23]. The idea of using an ultrasonic device in surgery showing good healing response compared to rotary bur [24].

Recently, a new type of ultrasonic device developed by Mectron Medical Technology known as piezo surgery broadened the possibilities of ultrasound use in clinical practice [25]. Piezo surgery has been employed in dentistry for clinical crown lengthening, dental extraction techniques, preparation of dental implant sites, maxillary sinus lifting, maxillofacial bone surgery, horizontal expansion of mandibular bone and bone block collection for autogenous grafting [26]. Recently, piezo surgery has been used in other fields of medicine, such as orthopedics (hands and feet), spinal and cranial, due to its excellent cutting properties [27].

The increasing use of piezo surgery is based on its clinical advantages, such as precision due to the micrometric amplitude of the tip oscillation and selective cutting, avoiding soft tissues damage obtained by the vibration frequency of the tip, such as nerves, sinus membrane and dura mater [28]. Furthermore, should be highlighted the excellent visibility during procedures, since the saline solution used for continuous irrigation in engine and hydro pneumatic pressure causes a temporary stagnation of the bleeding for both hard and soft tissues [29].

Today, piezo surgery ultrasonic technology has been widely used in oral and maxillofacial surgery, otorhinolaryngology, neurosurgery, ophthalmology, traumatology, and orthopedics [30]. The introduction of the piezoelectric terminal and its rapid and widespread use in bone tissue surgery came about because of the need to surpass limitations enforced using traditional instruments [31].

The piezoelectric terminal is extremely useful in cases of close contact with structures defined as "sensitive," such as blood vessels, nerves, and sinus membranes, as well as in cases where only a slight traumatic effect on the bony structures is appropriate; thus, the piezoelectric terminal is extremely useful in cases of close contact with structures defined as "sensitive," such as blood vessels, nerves, and sinus membranes, as well as in cases where only a slight traumatic effect on the bony structures is appropriate [32]. Clinical studies and histological evaluations have shown that for the operator, the piezo surgery ultrasonic technique is easier, with less force required than rotary hand pieces [33]. It allows for higher precision cuts, with moving over a spatial range between 60 and 210 m, resulting in a clearer view of the surgical field because of its control of bleeding and protecting delicate anatomic structures [34]. Excellent wound healing of soft tissue injuries has been observed. Patients have described have less anxiety with ultrasonic instruments in surgery compared with a rotary instrument [33]. From a morphological point of view, extremely clean, porous surfaces without fragments have been found to enable immediate bonding with the fibrin, and thus, quicker clinical recovery [31].

Moreover, at histological examination, the cut surfaces showed no signs of necrosis or pigmentation, and the presence of vital osteocytes was observed. However, some studies detected no significant differences regarding the vitality of the bone tissue between piezoelectric and conventional instruments [35].

Anatomy of the maxillary sinus

The maxillary sinus is a pyramid shaped cavity with its base adjacent to the nasal wall and apex pointing to the zygoma [36]. The size of the sinus is insignificant until the eruption of permanent dentition. The average dimensions of the adult sinus are 2.5 to 3.5 cm wide, 3.6 to 4.5 cm height, and 3.8 to 4.5 cm deep. It has an estimated volume of approximately 12 to 15 cm^3 [37].

Anteriorly, it extends to the canine and premolar area. The sinus floor usually has its most inferior point near the first molar region. The size of the sinus will increase with age if the area is edentulous [38]. The extent of pneumatization varies from person to person and from side to side. Nonetheless, this process often leaves the bony lateral and occlusal alveolus paper-thin in the posterior maxilla [37]. The maxillary sinus bony cavity is lined with the sinus membrane, also known as the Schneiderian membrane [39].

This membrane consists of ciliated epithelium like the rest of the respiratory tract. It is continuous with, and connects to, the nasal epithelium through the ostium in the middle meatus. The membrane has a thickness of approximately 0.8 mm. Antral mucosa is thinner and less vascular than nasal mucosa [37].

The blood supply to the maxillary sinus is primarily derived from the posterior superior alveolar artery and the infraorbital artery, both being branches of the maxillary artery [40]. In the lateral antral wall, there are numerous anastomoses between these two arteries. The inferior half of the sinus is likewise supplied by the bigger palatine artery [41]. Significant hemorrhage during the sinus lift technique is uncommon because the blood supplies to the maxillary sinus come from terminal branches of peripheral arteries. The posterior superior alveolar branch of the maxillary (V2) division of the trigeminal nerve provides nerve supply to the sinus [42].

Bone biology

The alveolar process of the maxilla has a compact cortical layer with high density and an inner porous cancellous bone filled with bone marrow [43]. The bone has cylindrical channels called Haversian canals and contains blood vessels that supply the bone with nutrition and oxygen [44]. The outmost layer surrounding all compact bone is called periosteum and the inner surface is called endosteum [45].

The periosteum is more active than the endosteum in the creation of bones. Sutural, endochondral, and intramembranous mechanisms all play a role in bone development. When cartilage is replaced by bone, sutural growth occurs at the sutural borders, and endochondral bone formation occurs [46]. The mesenchyme is intimately involved in intraamembranous bone growth in the jaws [47].

Osteogenic cells and osteoclasts are two types of bone cells with differing roles and morphologies. Osteoprogrenitors, preosteoblasts, osteoblasts, and osteocytes are all osteogenic cells [48]. Mesenchymal cells are first converted to osteoprogrenitors and later to preosteoblast cells, which in turn are transformed to osteoblast cells. The osteoblast cells produce osteoid, a non-calcified matrix which contains collagen and non-collagenous protein bone matrix. Osteoblasts also secrete several cytokines and Bone Morphogenetic Proteins (BMP) [11]. The cytokines and hormones play a major part in bone healing and lead to increased bone regeneration. When osteoblasts stop producing matrix they convert into osteocytes and are trapped in the calcified bone. Osteoclasts are large multinucleated cells that resorb bone [49].

Bone healing after graft placement takes place in two phases: Repair with an inflammatory response and bone remodeling [50]. In the first phase a blood clot is formed in the injured area where the outer area of the local bone becomes necrotic, and the capillaries start to develop and further on migration of inflammatory cells. This action restores blood flow and after 1-3 days an inflammatory response is active and granulation tissue is starting to form. The granulation tissue will mature to a collagen matrix and mesenchymal stem cells begin to differentiate into osteoblasts cells forming new bone. During the second phase, the bone remodels, and is replaced by a more mature lamellar bone and a complete regeneration of a defect occurs when all bone is replaced with lamellar bone [51].

Bone graft material

The ideal bone grafting material should have both osteoinductive and osteoconductive properties and be able to Osseo integrate to the implant surface. These properties vary in different bone grafting materials [52]. Osteoinduction is described as the induction of osteogenesis in primitive, undifferentiated, and pluripotent cells that are stimulated to become bone-forming cells via an inductive mechanism [53]. The term "osteoconduction" refers to the growth of bone on a surface. A surface that is osteoconductive permits bone to grow on the surface as well as down into the pits and pores [54].

The grafting material utilised in maxillary sinus floor augmentation is expected to facilitate fresh natural bone growth with capillary infiltration, as well as the ability to replace the bone graft material and provide appropriate bone volume to support the implants [55].

Types of bone graft

Various categories of bone graft materials can be placed in the maxillary sinus, such as autologous bone, allografts, xenografts and alloplasts.

Autogenous bone graft

Although autogenous bone grafting remains the gold standard, clinical results show that it has osteoinductive and osteoconductive capabilities, as well as the presence of growth factors [56]. Intraorally or extra orally obtained autogenous corticocancellous bone cores can be obtained, however this needs a second surgical donor site and significant morbidity. During implant preparation, a bone trap can be utilized to collect bone debris, with additional bone gathered by drilling near to the implant sites or harvesting cortical bone chips from the zygomatic buttress and lateral sinus wall using a bone scraper before opening a bony window [57]. Using this method, autogenous bone can be obtained right next to the surgical site, avoiding the requirement for a second surgical donor site and the associated morbidity. Furthermore, the amount of autogenous bone graft that may be harvested is restricted, and it may not be enough to repair major osseous lesions [58]. Due to the difficulties of harvesting autogenous bone and its scarcity, many surgeons have turned to bone-graft alternative materials [59].

Allograft

Multiple intraoral uses, including as periodontics (infrabony defects), oral surgery (extraction sites), and implant dentistry, have used allograft for grafting (ridge augmentation). Bony tissue from a donor of the same species is known to contain no viable cells in allografts [60]. This allograft can be made by demineralizing bone in hydrochloric acid to expose bone morphogenetic protein, and it can be deemed to have osteoconductivity and osteoinductivitiy. Mineralized human bone allograft was used to enhance atrophic maxillary floors in sinuses of various sizes, and the results demonstrated that this material promoted adequate bone growth [61]. Histologic analysis of mineralized freeze-dried bone allografts for sinus augmentation indicated a mean of 29.1% newly created bone, with graft particles largely in close contact with newly formed bone, primarily with mature bone characteristics such as many osteocytes [62]. Other reports found that the majority of the specimens had newly produced bone and that the interface areas between new and old bone were not apparent. In both studies, there was no indication of an acute inflammatory infiltrate. However, when demineralized freeze-dried bone was utilized in sinus augmentation, histological assessment revealed a persistent inflammatory reaction, prompting the authors to conclude that demineralized freeze-dried bone homograft should not be used alone [63].

Xenograft

Because of its resemblance to human bone, deproteinized bovine bone is one of the most widely explored grafting materials and is employed in the craniofacial region. It has been proved that protein is completely absent, and its safety in terms of disease transmission has been confirmed. After 6 months of recovery, deproteinized cancellous bovine bone was used as a grafting material for sinus floor elevation, and histologic assessment was done [64]. Histologic examination revealed that the bone in the grafted and previously existing areas of the sinus floor was largely of lamellar structure, with close contact between newly created bone and graft particles. Dental implants placed in sinuses enhanced with xenograft had 27 percent to 63 percent bone-to-implant contact, and xenograft was demonstrated to be extremely slowly recovered and behave as a semi-permanent grafting material. When xenograft is combined with autogenous bone, additional benefits may be gained, such as increased graft volume and extended space-maintaining effects due to prolonged resorption [65].

Alloplastic materials

Calcium sulphate, calcium phosphate, bioactive glasses, and polymers are among the many chemically varied synthetic calcium-based biomaterials that make up alloplastic materials. These bone substitutes have osteoconductive capabilities as well [66]. Although autogenous bone grafting remains the gold standard, a study by [67] found that sinus augmentation with a little amount of beta-tricalcium phosphate appears to be a clinically reliable treatment. According to reports, this substance acts as an osteoconductive material, allowing osteoprogenitor cells to proliferate on its surface or within its porosity and differentiate into osteoblasts, resulting in bone formation. When clinically and radiographically assessed, calcium sulphate hemihydrate was offered as a grafting material for sinus augmentation, and it resulted in good, fresh tissue growth within the sinuses. Bone density ranged from 34.3 percent to 55.54 percent, according to histomorphometry research [61]. Other researchers found similar outcomes, and a two-year study revealed a new irregular trabecular design on radiography, as well as normal, vital trabecular bone with woven and lamellar structure in all histologically studied sections [68].

Resorption of grafting material

When repairing the resorbed posterior maxilla, grafting material resorption can lead to uncertain long-term consequences. As a result, non-resorbable osteoconductive bone substitutes may be preferable to autogenous bone grafts. Titanium granules were employed as a bone substitute in patients who needed sinus floor augmentation prior to or concurrently with dental implant insertion [69].

Dental implants

Replacing missing teeth has always been a difficult task for dentists, which led to the invention of dental implants in ancient times. Copper studs have been used to fix teeth as a replacement for lost teeth since 3000 B.C., when Egyptian civilization was at its peak. Replantation and transplanting became more widespread in the 1800s, resulting in secondary infections [70]. Maggiolo J, a French dentist, presented the first modern dental implant procedure, which used an 18-karat gold alloy implant with a porcelain superstructure. By the 1900s, a major shift in implant materials had occurred, with porcelain, cobalt-chromium-molybdenum, and finally titanium alloy being employed. Branemark's concept of osseointegration, which suggested that a direct structural and functional connection can be achieved between implant surface and bone, ushered in a new era in dental implant operations in 1950 [71]. In 1980, during a symposium held at Toronto University, Branemark revealed the findings of his 30-year research by presenting a technique for placing four to six implants in the mental area of the lower jaw in two phases surgical approach with bilateral cantilever prosthesis. The technique spread throughout the world and is still in use today [72]. David Scharf, who said in 1993 that dental implants can have the same success rate if placed under aseptic conditions in regular clinics rather than operating rooms, paved the door for routine dental implants in regular clinics rather than operating rooms [73]. Since then, surveys have shown that dental implants are the most popular treatment option for restoring missing teeth. Nowadays, computer-aided analysis, design, and manufacture, as well as the use of surgical stents, help to accurately orient the implant in the proper location, allowing for optimal stress distribution and stability [74].

Immediate implant

The traditional approach for replacing a hopeless tooth was to extract it and wait several months for the alveolar bone to recover, as well as a load-free interval of 3 to 6 months after implant installation, resulting in an extraordinarily protracted treatment duration. Another important drawback is alveolar bone resorption following extraction, which, if not regulated, can result in severe bone atrophy, resulting in ridge height loss and narrowing, jeopardizing implant stability and aesthetics. Placing the implant right after extraction allows for greater bone preservation, better soft tissue aesthetics, easier implant placement in the optimum position, fewer visits and with less treatment time leading to less cost [75]. A total of 100 cases were studied to compare immediate and delayed implants. Although the instantaneous implant only engaged the socket bone at the apex area at the time of surgery, he determined that full closure of the gap between the implant and socket wall was achieved towards the conclusion of the healing phase, emphasising the need of using a gap filler substance [76].

Further suggested that the implant be placed until it reaches the height of the alveolar bone crest without undergoing radical alveoplasty for optimum bone preservation, as placing it below that level will result in bone resorption [77]. He also limited atraumatic tooth extraction techniques to ensure maximal contact between the implant and the socket wall, as well as the preservation of the buccal bone, which if fragmented, would make an instant implant contraindication. Immediate implant procedure has a 95% success rate and has been proven to be reliable in the replacement of lost teeth. The most important consideration during immediate implant insertion is achieving enough initial stability, which is achieved by contacting the bone at the implant's apical third. The greater the osseointegration and the stronger the eventual stability, the higher the initial stability. In 2014, Mark Rowan and colleagues investigated the biological and mechanical stability of immediate and delayed implants by evaluating their stability as measured by Resonance Frequency Analysis in ISQ values [78]. Although immediate implants had lower mean ISQ values than delayed implants, the ISQ values of immediate implants remained over 65 for the whole 6-month follow-up period, according to the study's findings [79]. Finally, under favorable conditions and with proper surgical technique, the initial and eventual stability of instantaneous implants is reliable. Another worry with an immediate implant treatment is increasing the ultimate cosmetic appearance, whereas mucosal recession is caused by buccal bone remodeling after tooth extraction [80,81].

Examined papilla and marginal mucosa levels around immediate implants, early implants (placed 4 to 8 weeks following extraction), and delayed implants. For six months, the levels of papilla and marginal mucosa were monitored. The results demonstrated that neither technique had an advantage over the other. Despite being proven to be reliable, instant implant surgery is a delicate procedure that requires stringent criteria to achieve the best results. These criteria include a traumatic extraction with maximum respect for soft tissue and bone, removal of pathological tissue through curettage and antimicrobial agent rinse, implant size selection with proper width for bone graft placement and proper length to be 2 to 3 millimeters longer than the socket for primary stability and closing the gap between the implant and the socket wall.

Atraumatic extraction

Extraction that is traumatic the first crucial step in attaining a successful immediate implant with acceptable initial stability, less postoperative problems, a quick healing time, and final perfect stability and aesthetics is to use a minimally invasive extraction technique with great care for soft and hard tissue. The traditional extraction procedure involves either luxating the tooth with forceps, which causes alveolar bone deformation and socket expansion, or raising the tooth using an elevator, which causes damage to the interproximal area. This soft and hard tissue stress will result in post-operative pain, edoema, and a delay in healing. Aggressive extraction may cause the buccal shelf of bone to crack, jeopardizing the immediate implant process, or it may cause the socket to enlarge, causing a greater gap between the socket wall and the implant, jeopardizing osseointegration. Gingival laceration and trauma to the interdental bone can result in vertical bone loss and metal display, resulting in esthetical failure [82]. There are several advanced procedures for tooth extraction, including [83]:

1. Easy X-Trac system: Three successive drills of increasing diameter are used to drill a hole into the root into which a screw is inserted and attached to a ratchet wrench with plates that allow the force to be evenly distributed on both sides. The root is then gradually removed with minimal stress to the sounding's tissues and without the necessity for a flap. Roots having a limited diameter or roots with vertical fracture are the only two contraindications.

2. Benex system: Designed for single-rooted teeth and based on vertical pulling. Benex extractor, impression tray, diamond drill, self-tapping screw, and pull string are all included. Because of the screw's poor retention, the procedure is not recommended for teeth with uneven root morphology or severe cavities.

3. Rubber band extraction: Designed for single-rooted teeth, it is likewise based on vertical pulling. Benex extractor, Impression tray, diamond drill, self-tapping screw, and pull string are among the items included. Because of the screw's poor retention, the procedure is not recommended for teeth with uneven root morphology or extensive cavities.

4. Extraction using implant drill: The pilot implant drill is utilized in single-rooted teeth, followed by sequential drills until the tooth structure is decreased and fragmented. The tooth structure that remains can then be easily removed.

5. Periotome: To sever the periodontal ligament, a sharp fine instrument is introduced between the root and the socket wall. The periotome is progressed until it is two-thirds of the way down the root. After that, the tooth can be extracted with forceps or laxated using a tiny elevator.

6. Powered periotome: To enter the periodontal space, fine metallic blades mounted on a hand piece with a microprocessor unit and foot control are utilized to cut the periodontal ligament. The procedure is flapless, and the buccal and lingual plates are practically never broken.

7. Sonosurgery: For teeth sectioning, a sonic handpiece with various inserts is employed. Low heat generation, clean cutting surfaces, nearly no soft tissue harm, and improved tactile sense are just a few of the benefits. Its drawbacks include a long working time, instrument breakage when handled incorrectly, and contraindication in patients with pacemakers or infections since it can spread the infection.

8. Piezo surgery: Using ultrasonic micro vibration three times more strong than standard scalers, hard tissue can be removed while soft tissue is spared. Internal irrigation is used to compensate for heat generation in the system. It has a clear operating field, better healing due to less damage to surrounding soft tissue, and less postoperative pain and bleeding. Prolonged heat generation increased working time, and a high-cost armamentarium are among its drawbacks. The latest gadget, the ultrasonic bone surgery device, is employed not only for atraumatic tooth extraction but also for the preparation of the socket for rapid implant placement. After employing the arrow-like pilot blade to get access to the periodontal membrane area, four sequenced syndesmoses are employed to gain deeper access. The extraction of the tooth is followed by the condensation of bone and preparation for the implant utilizing sequenced conical shaped drills. Vibrating tips cause cavitation, which has a bactericidal effect, increasing the implant's survival rate in infected sites.

9. Physics forceps: It has two handles, one with a bumper to adapt to the buccal surface and the other with a beak to engage the lingual surface of the tooth, which allows for mechanical benefits. Light pressure exerted buccally is sufficient to extract the tooth with this design, eliminating the requirement for squeezing and rocking movements when using traditional forceps. The advantages of this approach include less power being required, less postoperative pain, and the ability to implant immediately. The downsides include the risk of fracturing of the buccal bone or the crown in the event of excessive force, as well as the expensive cost.

10. Orthodontic extrusion: Two to three months later, atrumatic extraction using physics forceps is performed. Using a periotome to detach the tooth from the bone and cut the periodontal ligament is one of the atraumatic tooth extraction procedures. To cut the gingival attachment in a single rooted tooth extraction, the periotome is first inserted in the gingival sulcus at 20 degrees to the tooth surface. The periotome is then moved in mesial and distal inclination movements to gain access to the periodontal ligament space by advancing a few millimeters. After gaining access, the same movements are repeated until two-thirds of the root is reached. The tooth can then be delivered with forceps by rotating it in the apical direction. To preserve the socket shape, care must be taken not to luxate the tooth in a buccal or palatal direction. Atraumatic extraction with a periotome was compared to standard extraction with elevators and forceps. The periotome demonstrated a high level of proficiency in extracting firm teeth, retained roots, endodontically treated teeth, and crown cracked teeth with minimal hard tissue damage and soft tissue laceration.

Implant size selection

The optimum immediate implant size is chosen to preserve as much buccal bone as possible while yet providing adequate initial stability. The minimum buccal bone thickness to ensure stable buccal bone with little resorption without the requirement for tissue augmentation, according to researchers, is 2 mm [84]. However, most extraction sites in the anterior area have a thin buccal bone plate (less than 1 mm), which without bone augmentation will result in vertical bone resorption and esthetical failure. The buccal bone plate is normally made up of cortical bone with periosteum and periodontal ligament blood supply. During extraction, the blood supply to the periodontal ligament is severed. Bone grafts are used to improve the thickness of the buccal bone plate to compensate for the loss of blood flow [85]. Previous studies have shown that a 3 mm space between the implant surface and the buccal bone is essential for proper bone graft implantation, permitting maximum buccal bone preservation and improving the final cosmetic result. When there is no buccal bone, a 3 mm gap between the buccal surface of the implant and the internal surface of the buccal soft tissue is left. The implant diameter should be around 3.5 mm if the socket is less than 7 mm buccolingualy. The implant diameter should be around 4.3 mm if the socket is 7 mm buccolingualy, and around 5.1 mm if the socket is greater than 7 mm buccolingualy [86].

Studied the parameters that influence ridge change after immediate implant implantation [87]. He discovered that the larger the distance between the implant and the socket wall, the more graft was inserted, and the more newly created bone was formed.

Studied the influence of buccal gap size on alveolar bone change in dogs was investigated using 1 mm, 2 mm, and 3 mm gaps [88]. The results showed that the 3 mm gap group had the thickest buccal bone and soft tissue after two months. The 1 mm and 2 mm gap groups showed a significant decrease in buccal volume after 4 months, but the 3 mm gap group showed bone resorption resistance. The researchers concluded that a 3 mm gap is the best gap for buccal bone preservation.

Evaluated the influence of implant diameter on implant survival rate [89]. They discovered that diameters of 5-6.5 mm and 3-3.5 mm had the highest failure rate while diameters of 3-3.5 mm had the lowest failure rate. As a result, using a tiny diameter implant not only allows for the placement of a bone graft to maintain the buccal bone, but it also increases the success rate. The ideal implant length for immediate implant placement is longer than the extraction socket by 2 to 3 millimeters. This violation to the apical area by 2 to 3 millimeter is to obtain primary stability as the immediate implant mainly engages the socket wall at that area. However, many anatomical considerations should be taken in mind during implant size selection including the adjacent teeth leaving 1.5 mm between each adjacent tooth and implant and adjacent implants leaving 3 mm between each implant and another.

The anatomical features of the maxillary arch include the floor of the nasal cavity anteriorly and the maxillary sinus posteriorly, which may require a sinus left surgery if there is insufficient remaining bone. The inferior alveolar nerve, as well as other less common structures such as the accessory mental foramen, anterior looping of the mental nerve, and bifid mandibular canals, are located in the mandibular arch [90].

Investigated the appropriate implant length and diameter for anterior implants to attain the greatest results [91]. The findings revealed that the ideal implant length is between 11.5 and 13 mm, and the best outcomes are obtained with a diameter of 3.5 mm.

The gap between the implant and the socket wall is being closed. The implant size should leave at least a 3 mm space between the implant surface and the buccal bone to allow for bone regrowth with minimal vertical bone loss. Autogenous bone has been identified as the best option for filling the gap and producing osteoplastic activity due to its osteoconductive, osteoinductive, and osteogenic properties [92]. Autogenous bone, on the other hand, necessitates patient retrieval, which complicates the surgery. As a result, calcium phosphate-based materials are now widely used as grafting materials in immediate implant procedures [93]. Calcium phosphate-based materials provide a number of advantages, including the ability to come in a variety of forms for easier application, biocompatibility with most cells (including fibroblasts and osteoblasts), and osteoconductive behavior through osteoblast migration and adhesion [94].

Studied the impact of tricalcium phosphate on bone density around immediate implants [95]. The gap was filled with tricalcium phosphate mixed with saline after the immediate implant was placed. At 3 and 6 months after surgery, bone density measures were taken. The group that used tricalcium phosphate had more bone density around the implant than the other group, implying that tricalcium phosphate helps to increase bone density.

Investigated the effect of tricalcium phosphate on bone formation and alveolar resorption after premolar extraction was. Tricalcium phosphate was found to be effective in preserving alveolar bone and promoting bone growth [96].

Implant success criteria

Several success factors for dental implants have been described in several research with a considerable deal of agreement among different authors.

Did a systemic review on success of dental implants criteria described by publications. The study summarized the success criteria used by different authors as following [97,98]:

1. Implant level: discomfort Radiolucency Infection of the Mobility Less than 1.5 mm of bone loss in the first year Bone loss is less than 0.2 mm each year.

2. Soft tissue level prior to implant Suppuration Swelling Bleeding Recession Index of plaques Depth of probing less than 3mm Mucosa keratinized with a breadth of less than 1.5 mm.

3. Chair side issues on a prosthetic level Failures in Functional Esthetics.

4. Level of patient satisfaction chewing ability discomfort-tasting ability Paresthesia Appearance These are primarily subjective factors, whereas objective criteria can be described as follows:

1) Stability of the implant.

2) The density of the bone around the implant.

3) The height and thickness of the buccal bone.

4) Measurement of implant stability.

Several methods for measuring implant stability have been published, including both invasive and noninvasive procedures [99,100]. The following are the most prevalent noninvasive methods:

1. Cutting torque resistance analysis: Estimating the amount of energy required by a micromotor to prepare an osteotomy site for implant insertion, which is related to bone density, which is one of the most important factors influencing stability.

2. Percussion test: A ringing sound is produced by tapping the implant with the mirror handle, indicating satisfactory osseointegration and stability.

3. Collision hammer method: Like the percussion test, it relies on the sound produced by the impact between the implant and a hammer, which is measured and processed by a device called a rapid fourier transformer.

4. Insertion torque analysis: Determining the amount of force required to place the implant in the osteotomy site as a test of initial stability.

5. Before abutment connection, do a reverse torque test by applying a particular amount of torque in an unscrewing direction. A failed implant is one that has become unscrewed.

6. Periotest: Originally designed to calculate the contact time between the implant and the percussion rod to determine tooth mobility, it is now routinely used to assess implant stability.

7. Pulsed oscillation waveform: This waveform detects the frequency and amplitude of implant vibration caused by pulsed force and correlates it to the bone implant interface.

8. Resonance frequency analysis (RFA): A noninvasive, accurate method of measuring implant stability by measuring the resonance frequency at which the implant oscillates. Because the implant's material and length are constant, the frequency is correlated to the supporting structure, allowing the stability and osseointegration to be measured.

Two systems have been produced for measuring implant stability by using Resonance frequency analysis. The original system depended on making contact between the analyzer and the transducer placed over the implant [101]. Magnetic waves communicate between the analyzer and the transducer placed above the implant in the new Osstell Implant Stability Quotient (ISQ) technology, yielding readings between 40 and 80. The higher the device's displayed number, the more stable it is [102,103]. Tested for implant stability measurement, the Penguin Resonance Frequency Analysis (RFA) and Osstell Implant Stability Quotient (ISQ) systems have been shown to be reliable. Forty implants were implanted in various materials, and the two techniques were used to measure stability multiple times. When placed in rigid material, the results showed that both systems are trustworthy, with the osstel system being more reliable than the penguin system. Evaluated Osstell ISQ's device for assessing implant stability was tested for reliability [104]. Several Smart Peg transducers were used to take several measurements for the same implant by the same dentist. After statistical analysis, the results revealed that Osstell ISQ is a "nearly flawless" system in terms of repeatability and reproducibility. Compared the results of insertion torque with the results of resonance frequency analysis (ISQ). The implant is implanted at the end of the osteotomy preparation, and the insertion torque is measured using a ratchet wrench, and an osstell reading is taken. A new osstell reading was taken after 6 weeks, and counter torque was applied with a ratchet up to 32 N cm. The implant is considered a failure if it is moved by the counter torque. The outcome revealed that both strategies produce the same results.

Measurement of bone density around the implant Although Computed Tomography (CT) is a well-established technology for assessing bone density via the Hounsfield Unit (HU), its principal drawback, a high radiation dose, makes it difficult to rely on it in studies that require multiple scans to compare the results. Cone Beam CT (CBCT) has been frequently used to measure bone density utilising grey density value or Voxel Value since it has a considerably lower radiation exposure (VV) [105]. Cone Beam CT (CBCT) provides good resolution, grey density range, dimensional accuracy, and pixel/noise ratio, but its grey density values are not absolute [106,107].

Compared the Hounsfield Unit (HU) acquired from CT and the Voxel Value (VV) obtained from CBCT for the same bone spacemen. The study discovered a linear link between CBCT Voxel Value (VV) and CT Hounsfield unit (HU), allowing for the conversion of grey scale to absolute Hounsfield Unit (HU), resulting in more successful findings. Investigated whether CBCT could be used to measure bone density surrounding implants [108]. In addition to comparing CTs, CBCTs were performed before and after implant placement to evaluate bone density. The findings revealed an increase in density around the implant after insertion, which was linked to bone compression. The results were found to be comparable to those obtained by CT, indicating that CBCT is a trustworthy approach for determining bone density.

Delay vs. immediate implant placement, staging, the timing of implant loading, the need for a bone graft at the implant site, the presence of infection, medical conditions that compromise wound healing, smoking, oral hygiene, the location of implant placement, and the size of the implants are all thought to influence the amount of changes in marginal bone height after implant placement [109,110].

Other mechanical reasons that have been hypothesized include periosteum elevation during surgery, instrument overheating resulting in osteonecrosis, occlusal stress, cantilever effect, and physiologic bone remodeling caused by inflammatory processes and plaque accumulation. One of the most common causes of early implant failure is bone necrosis caused by heat induction during drilling. Due to the sensitivity of bone tissues to heat, an increase in heat induction during a surgical treatment might result in bone injury [111]. The size and shape of the drill, the drill material, the use of irrigation, and bone density all affect the frictional heat generated during bone cutting techniques. Burs of various forms have traditionally been used to adapt the site to the implant's geometry during implant site preparation. Drilling methods can result in mechanical stress to the bone as well as heat-induced bone necrosis, posing a considerable risk of failure [135]. During osteotomies, conventional rotational devices generate excessive heat, which may damage bone cell viability and lead to thermal necrosis [112].

Piezoelectric ultrasound

Piezo surgery, on the other hand, is characterized by a cavitation effect combined with a large amount of cooling solution, resulting in a non-thermal thermal effect and a better biological outcome. Maxillofacial surgeons invented piezoelectric ultrasound. It works by using radio waves to cause ultrasonic tips to oscillate and vibrate, allowing them to divide solid interfaces like bone tissue [113]. Ultrasonic vibrations with an average frequency of 25-29 kHz, an oscillation (amplitude) of 60-210 m, and power up to 50 W describe the piezoelectric device. Ultrasonic instruments can cut mineralized hard tissues like teeth and bone in a highly safe and precise manner, with minimal tissue damage. Because soft tissues like nerves and blood vessels can oscillate at the same speed and amplitude as the cutting tip, the cutting tip has no effect on them [114]. Studies comparing piezoelectric osteotomy to traditional procedures using carbide and diamond series drills found that piezosurgery results in better bone healing [113]. Furthermore, as compared to traditional drill methods, other studies found a decrease in inflammatory cells and an increase in osteogenesis around piezoelectric ultrasound-installed implants [114]. The prospect of using ultrasounds for implant site preparation has piqued people's interest [115].

Technical qualities and historical context of Piezoelectric ultrasound

The word "piezo" comes from the Greek word piezein, which meaning "to squeeze tightly." Jacques and Pierre Curie, brothers, discovered "piezoelectricity" in 1880. They discovered that applying pressure to certain crystals, ceramics, or bone resulted in the generation of electricity. Gabriel Lippmann discovered the inverse piezoelectric effect a year later. When an electric field is applied to a crystal, it deforms, as he demonstrated. Different scientists investigated these effects further, and Catuna published an essay on the use of ultrasound on hard tissue in 1953. Various work groups showed the use of ultrasonic vibrating technology for cutting mineralized tissue in the following decades. McFall et al. was one of the groups. They compared rotating equipment to an oscillating scalpel blade to explore the difference in healing. Healing took a little longer in the oscillating scalpel blade group, but there were no serious problems [116]. The first human clinical trial on "piezoelectric bone surgery" in 2000. It was the first time an instance of a split ridge was described, in which an edentulous ridge was divided despite the ridge's narrowness. It would not have been able to retain its integrity with other cutting devices. Piezosurgery®, an instrument that combines ultrasound and the piezo effect, was introduced in 2001 [117].

Biological considerations of piezoelectric ultrasound

Less invasive surgery is a primary goal as technology advances. Piezoelectric surgery is moving in this way, not only because of the benefits of very precise customized cutting, but also because of healing-related variables. The continual irrigation helps to prevent heat damage and so reduces the danger of bone necrosis, and the reduced blood loss promotes healing conditions. Overheating during implant-site preparation has a deleterious impact on the osseointegration process and implant rehabilitation outcomes. The smooth tips provide the lowest temperature, while the sharp tips produce the highest. Other elements, such as the way in which the cutting is done and the characteristics of the bone itself, will also influence the temperature rise. Heinemann et al. examined several sonic and ultrasonic devices with rotating burs in portions of pig jaws in this regard. Piezo surgery had the biggest temperature rise in this investigation, however the osteocytes and trabecular bone appeared to be unaffected, as with the other devices [118]. Furthermore, bone remodeling or cell viability are unaffected by piezoelectric bone cutting. In vitro, both piezoelectrically harvested bone chips and bone chips collected with a traditional revolving drill contained essential cells that will differentiate into osteoblasts [116]. Also looked at the kinetics of bone repair. In terms of "histomorphometrical, immunohistochemical, and molecular analyses," they evaluated the differences between osteotomies performed with piezosurgery and those conducted with a traditional drill [119]. They found no changes in bone healing between the two groups histologically or histomorphometrically, save for a slightly higher amount of newly created bone 30 days after using the piezosurgery equipment.

Mechanism of action of piezoelectric ultrasound [117]

Ultrasonics is a discipline of acoustics that deals with sound vibrations at frequencies above the audible range, i.e. >20 kHz, where sonic refers to a high-amplitude ultrasound wave created by three different methods (Mechanical Method- up to 100 kHz; Magnetostatic Method- 18-25 kHz and Piezoelectric effect-25-50 kHz) [25]. The piezoelectric effect is utilized in piezosurgery to transfer mechanical energy in the form of tension and compression into electric energy [120]. The ultrasonic frequency of piezoelectric ultrasonics is formed by forcing an electric current from a generator through piezo-ceramic rings, causing them to deform. The ultrasonic frequency in dental applications is typically 24-36 kHz, and it can cut mineralized tissue. As a result, the movement caused by the ring's deformation causes a vibration in the transducer, which produces the ultrasound output. These waves are delivered to the hand piece tip, also known as an insert, where longitudinal movement causes osseous tissue to be sliced by microscopic bone cracking [117]. Because it contains a piezoelectric element that translates electric impulses into mechanical vibrations and then mechanical vibrations into electric signals, the transducer is an essential component of the instrument system [121]. Cavitation is a micro boiling phenomenon that occurs in liquids on any solid-liquid contact vibrating at an intermediate frequency, resulting in a rupture of molecular cohesion in liquids and the formation of zones of depression that fill with vapor until they implode. Cavitation occurs when water spray touches an insert vibrating at an intermediate frequency in detartrating instruments [122]. This phenomenon preserves good visibility in the field of operation during ultrasonic osteotomy procedures by spreading coolant as an aerosol and providing hemostasis. By fragmenting bacterial cell walls, the cavitation effect has antibacterial properties, which aids in achieving high predictability and minimal morbidity in bone surgery [117].

Indication and contradiction of piezoelectric ultrasonic [113]

Indication and advantage: This allows for the main advantages of this device, which are soft tissue debridement, smoothening of root surfaces, bone grafting, implant site preparation, removing an implant, sinus lifting procedure, retrograde root canal preparation, apicectomy, cystectomy, extraction of ankylosed teeth, and orthodontic surgeries.

Contradiction: No absolute contraindications except taking precaution with cardiopathy, patients with uncontrolled diabetes mellitus, patient receiving radiotherapy, patients with metal/ceramic crowns and patients with pacemakers.

Conclusion

we can concluded that perforations of the sinus membrane are more common in direct sinus lifts performed with the rotary technique than with ultrasound, and implant survival and bone gain are better with the ultrasound technique. When compared to the traditional rotary technique, the sinus lifting treatment conducted using Piezo surgery generates less postoperative pain and swelling. The use of ultrasound enables for precise bone removal with a reduced risk of injury or perforation of the Schneider membrane. The diamond-coated rotary method used by DASK decreases the risk of sinus membrane perforation while also providing appropriate irrigation. Although piezo surgery is a time-consuming equipment, it has been shown to be effective in executing a safe sinus membrane elevation, with a lower risk of membrane perforation, greater post-surgical patient comfort, and improved patient quality of life. In cases where anatomical structures are an important site is the surgical site, it is recommended to use a piezo surgery device to make a less risky surgery and more certainty for the surgeon, and the advantage of drawbacks should be emphasized.

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