Review Article

Latest Innovations in Intraoral Autogenous Bone Harvesting Techniques–An Elaborative Review

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Abstract

Adequate bone width and height is the basic requirement for either periodontally affected teeth or for any permanent replacement of teeth. Even though various causes such as traumatic extraction, fractures, and prolonged periodontal diseases result in deficient bone, there are various techniques available to overcome. Bone augmentation is a procedure which involves adding bone grafts to the defective site to improve the quality of bone. Even though different types of bone grafts available according to the source, autogenous grafts are having higher osteogenic, osteoinductive, and osteoconductive properties when compared with other grafts. Apart from biological advantages, it is more cost-effective when in comparison with the other grafts. Earlier techniques had difficulty in obtaining autogenous grafts due to a lack of sophisticated instruments and techniques. In this review article, we have summarized the latest innovations in procuring autogenous bone grafts.

Keywords: Autografts, Piezotome, Bone scrapper, LASER

Introduction

Periodontal disease is a global public health problem-affecting majority of the adult population. Dental plaque appears to be the primary etiology for the development of gingivitis which when untreated leads to progressive destruction of the supporting structures of the teeth. Alveolar bone loss is one of the most important and obvious features of periodontitis. Resorption of alveolar bone can occur in both horizontal and vertical aspects after normal extraction and other various causes such as trauma, dental caries, periodontitis, and cysts/abscess. Implant placement in those sites will be challenging for the practitioner without adequate bone. Bone grafting will be an ideal method to improve the height of the alveolar bone which may utilize autografts (same individual), allografts (same species different individual), xenografts (animal source), and alloplastic materials (synthetic).

Autografts are considered gold standard among all the graft materials[1] because of its osteogenic, osteoinductive and osteoconductive potential. It can be harvested either in the form of block graft or may be milled (grinded) to form a particulate graft. Irrespective of the form of autografts, there is no risk of disease transmission.

Autografts can be procured from intraoral sites such as maxillary tuberosity, mandibular ramus, symphysis, retromolar area, healing extraction wounds, edentulous sites, exostosis, and extraoral sites such as iliac, tibia, and calvarium.

Various instruments and techniques have been used in the past for harvesting autogenous bone grafts which includes chisel and mallet, saw, and surgical burs. These have their own advantages and disadvantages. Recently, newer instruments such as bone scrapper, trephines, piezotome, and lasers have been used for harvesting autogenous bone grafts for better placement of dental implants. This review highlights about the journey of autogenous bone graft harvesting from the past to the present.

Why Autografts?

An autograft is tissue transferred from one position to another within the same individual. It is osteogenic (able to form or develop new bone), osteoinductive (contains bone morphogenetic proteins that convert the neighboring cells into

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osteoblasts, which in turn form bone), and osteoconductive (the matrix of the graft forms a scaffold that encourages outside cells to penetrate the graft and form new bone). The autograft is the gold standard of bone grafting procedures. It is cortical, cancellous bone and marrow, or a mixture of these tissues, harvested from intraoral or extraoral donor sites.[2]

Intraoral Autogenous Graft

Multiple intraoral locations have been used to harvest bone grafts, including the maxillary tuberosity, exostosis, healing wounds, and extraction sites. Evian *et al*.[3] in 1982, in a study conducted in humans to evaluate the osteogenic activity of bone removed from healing extraction sockets stated that a substantial quantity of mature bone is present by 8–12 weeks after extraction that contains osteoblasts and osteoid. This is the ideal time to harvest bone from a healing extraction site for optimal time period to secure bone from a healing extraction site for grafting purposes.[3]

Another source includes harvesting bone during osteoplasty or ostectomy and mixing it with the patient's blood to form an osseous coagulum. An apparent limitation of this technique is the difficulty in controlling bone particle size and quantity, in addition to clinical management of graft material.[4] A bone blend is formed by placement of intraoral cortical and/or cancellous bone in a sterile amalgam capsule where it is triturated for 60 s. This is considered to yield a clinically manageable and predictable graft material of larger particle size (100–200 μm). A mean increase in bone height of 3.44 mm was reported with intraoral bone grafts.[5]

Background for Usage Autogenous Bone Grafts in Periodontal Defects

Autogenous bone grafts have been used for managing periodontal defects from the early 19th century. Literature shows tibial bone grafts were harvested and used in the reconstruction of horizontal defects in human patients by Hegedus in 1923.[6] Osteogenesis was observed at the end of 4th week after grafting.

Various forms of autografts have been used in the past and till date; bone chips were used as grafts in dogs by Linghorne in 1951.[7] He harvested grafts from alveolar bone from the neighboring alveolar process and chiseled it into chips. These bone chips were used for grafting after open flap surgery, the results showed that bone grafts were gradually absorbed and replaced by new bone at the end of 120 days when compared to the non-grafted sites. Nabers and O'leary in 1965[8] in a human study, harvested autogenous bone chips from buccal plate to treat wide deep osseous defect in the mesial surface of maxillary right first premolar, at the end of 6 months, complete repair of the defect was observed.

Cancellous and iliac bone marrow was used by Scallhorn in 1968,[9] for treating osseous craters of depth 4–5 mm, the healing time was 5 months to achieve bone fill.

Osseous coagulum was used to fill the intrabony defects created in rhesus monkey by Rivault in 1969.[10] Osseous coagulum was prepared by mixing blood along with bone chips harvested apical to the osseous defects.

Marrow and cancellous bone from the ilium were used by Schallhorn in 1971[11] to treat crestal and osseous wall defects. Out of the 50 crestal defects treated, bone height was increased by 2.57 mm, eight furcation defects were treated, which showed complete fill with an average increase in height by 4.5 mm and osseous walk defects (one-walled, two-walled, and three-walled) showed positive outcome in terms of bone fill. Similar studies were done by Hiatt (1973),[12] Dragoo (1973)[13] and they concluded that bone fill and regeneration has been observed.

Cancellous alveolar bone was used to treat early furcation defects by Moskow in 1979.[14] Small bone particles were obtained from the adjacent area of the intraosseous defective site. Histological evaluation after 22 weeks showed that organized regular lamellar bone pattern, osteoblastic activity, and in growth of new capillaries associated with the newly grafted bone. The presence of down growing junctional epithelium was also seen between root surface and the bone graft.

Intraoral Conventional Techniques for Autogenous Bone Harvesting

There are various instruments and techniques that have been tried in the past for harvesting intraoral autogenous bone. Autografts can be collected in the form of particulate or chips, block, or various particle sizes depending on the need. Procuring viable autografts depend on the type of instrument, the heat generating during harvesting, and the proper technique.

Hand Chisel and Mallet

Hand chisels are non-rotary instruments and are handheld. It has a spoon shaped end which can be used to incise and widening alveolar ridges. It can also scrape bone tip from cortical bone surfaces. Mallet is a hammer like instrument which has a stainless-steel handle and nylon capping to dampen the force. Both chisels and mallet are used to perform osteotomy. Nabers and OLeary in 1965[8] used hand chisels to remove cortical shavings from intraoral surgical site and used it for grafting periodontal defects and observed a coronal increase in bone height.

Bone Swaging

Bone swaging is a familiar surgical procedure for treating bony defects. This was introduced by Ewen in 1965.[15] An edentulous area neighboring to a tooth with a defect was selected; bone was then pushed from the base toward the surface of the defect to eliminate the bony defect. Care was taken not to fracture the bone to maintain the blood supply to the swaged bone. Bone swaging was technique sensitive limiting its usefulness in clinical practice.

Osseous Coagulum

Earl Robinson in 1969[4] used a mixture of bone dust and blood and named it as Osseous coagulum. Bone dust is obtained using rotary instruments on intraoral bone in the surgical site and then mixing the particles of bone with the patient's own blood. The source for bone dust is from the mandibular lingual ridge, exostosis, edentulous ridge, and bone distal to terminal tooth. The use of this material is based on the rationale that the smaller particle size of bone that gets resorbed and replaced by host bone. The mineralized fragments are also thought to induce bone formation. Added advantages of using osseous coagulum are the ease of obtaining bone from already exposed surgical site and additional surface area which is available for interaction of cellular and vascular elements. Whereas there are few limitations for this technique as well, which includes aspiration problems, and difficulty in obtaining a predictable quantity of bone fragments for grafting larger defects.

Bone Blend Technique

Diem *et al*. in 1972[5] modified the original osseous coagulum developed by Robinson and formed a new technique and named it the bone blend technique. Cortical or cancellous bone was collected in the form bony spicules from extraction sites, exostoses, tori, and edentulous ridges with the help of rongeurs and chisels. The collected bone was then triturated for 60 s in a sterile capsule to convert it into a homogenous mass with a particle size of 100–200 µm. This plastic-like mass was then packed into bony defects. Advantages of bone blend technique were ease of procurement of bone with goodness of both cortical and cancellous bone whereas disadvantage being the use of more extensive armamentarium.

Microsaw

Microsaw was developed by Khoury *et al*. in 1984.[16] It is used clinically since then for intraoral osteotomy procedures, bone splitting, and blocks bone harvesting. It is made up of high-grade stainless steel with the saw hand piece being designed especially for working in all directions, that is, sagittal, oscillating, or reciprocating movement. Saw hand piece S-8-S is used for making sagittal cuts and cutting direction is parallel to long axis. Whereas S-8-O has an oscillating motion and cutting direction 90° to the long axis, S-8-R works with a reciprocating motion and cutting direction is forward and reverse cutting.

Surgical Burs

Surgical burs are driven by micromotor or air pressure turbines. They bring about mechanical changes in the bone by crushing and shearing the bone with the help of serrated or diamond coated rotational hard-metal bodies of spherical, conical, and cylindrical shapes. The speed of action was dependent on the size and coarseness of the serrated surface. Surgical burs are used for intraoral bone harvesting. Hard metal fissure and round burs were used for making bone cuts and larger barrel burs were used for harvesting bone chips. High frictional heat production causing necrosis of bone was the greatest limitation of surgical burs.[17]

Bone Filter

Bone chips and debris formed during osteotomy procedures can be collected with the help of bone filter which has a suction device attached to it. Strict aspiration protocol is followed to collect only bone, blood, and sterile saline which are used as irrigating the site. The collected bone debris are removed using a sterile curette.[18]

Latest Techniques in Harvesting Autogenous Bone Grafts

Bone scrapper

Zaffe[19] in 2007 used a novel disposable bone scraper (Safescrapers) for collecting bone shavings from different intraoral sites and areas near to the bony defects. The harvested bone chips were used for grafting maxillary sinus, extraction sockets, and also in guided bone regeneration procedures.

A scrapper is a specially designed cortical bone collecting instrument to harvest adequate amount of bone shavings from various intraoral sites. The handle is made of stainless steel which holds a blade. Three different head angles are available (straight, 30° down, and 30° up). Handles are selected in accordance with the intraoral site and operator's convenience. The blade used in scrapper has greater cutting control and shaves bone from cortical surfaces producing short convoluted ribbons. While being cut, shavings combine with blood and flow into the handle's head and get collected in the collecting chamber (Figure 1).

Trephines

A trephine drill is comprised of a tubular body fitted to a contra angle hand piece. The drill is used to make holes in the cortical bone at a low speed turning, and crushed bone gradually fills

Figure 1: Bone scraper

up the trephine tube. A trephine bone drill moves perpendicular to cortical bone within the narrow space used to make a hole to harvest autogenous bone graft[20] (Figure 2).

Bone collecting devices

Guided bone regeneration can be done to regenerate bone in defect areas. Autogenous bone can be collected from other intraoral sites with the help of ACM (Auto Chip Maker). ACM has a handpiece working in the speed of 50–300 RPM with a spring type stopper at 4 mm. It collects high quality bone within 10 s. The particle size can also be adjusted using different diameters and there is an irrigation channel which prevents overheating of bone.

Bone ring technique

The autogenous bong ring transplantation procedure harvests a cortical ring-shaped structural graft from the mandibular symphysis that can be used in augmentation of severely defective post extraction sites. The advantage of this procedure is that both the ridge augmentation and implant placement and is done simultaneously through screws or implants, ensuring an intimation micro motion free fit of bone ring into the socket walls. It also enhances the soft-tissue contour and helps resist soft-tissue contraction when performed in esthetics zone.[21]

Laser

LASERS have been used in the field of dentistry for several decades. Diode LASERS have been employed to perform various soft-tissue surgeries which include frenectomy, gingivectomy, and excision of soft-tissue mass. Since the advent of erbium LASERS, it was possible to carry out procedures such as caries removal and cavity preparation. Usage of erbium, chromium: yttrium-scandium-gallium-garnet (Er, Cr: YSGG) LASER to procure bone has been tried recently and has given better results (Figure 3).

Cameron Lee[22] in his study used Er, Cr: YSGG with a wavelength of 2780 nm and a pulsed duration of 140 μs and repetition rate of 20 Hz to harvest bone from ramus of the mandible along with removal of third molar. He summarized that bone harvested with the LASER was adequately thick with an approximate dimension of 20 mm × 15 mm × 3 mm. Osteotomy cuts made with LASERS were accurate with minimal bleeding, edema, and pain after LASER use.

Piezosurgical technique

Piezosurgery can be carried out using a specially designed device called piezotome. Piezosurgery works under the principle of microvibration at ultrasonic frequency. This is based on the ability of certain materials (ceramics and crystals) to deform when an electric current is passed across them, resulting in microvibration at ultrasonic frequency. There is an enhanced operator sensitivity and control, precision for cutting action. The magnitude of action is within 25–30 KHz and it cuts only the hard tissues sparing the soft tissues[23] (Figure 4).

Discussion

Tooth is safely encased in the alveolar socket with the help of anchoring fibers from the periodontal ligament. When there is an assault/irritation inflicted to the tooth in terms of

Figure 3: Hard tissue laser

Figure 2: Trephines

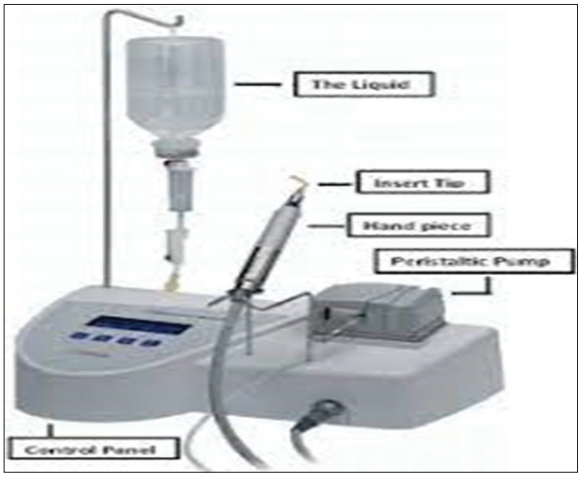

Figure 4: Piezoelectric unit

unrestorable dental caries, chronic periodontal disease with hopeless prognosis, or any eventful extraction of fractured tooth, there is an inevitable loss of the remaining alveolar bone height and width.

Various treatment modalities are available to restore and replace an edentulous area. Very familiar treatment option to permanently replace a missing tooth is by fabricating a fixed partial denture which gets support from the abutment teeth adjacent to the edentulous site. Another treatment option is to replace a missing tooth with a dental implant.

However, inadequate width and height of remaining bone compromise implant placement. To overcome this, augmentation of the defective site with grafts was practiced for several decades.

Autografts are considered ideal for grafting procedures because of their osteogenic, osteoconductive, and osteoinductive property. Autografts contain live osteoblasts and osteoprogenitor stem cells which are helpful for bone regeneration. The advantages of autografts being surgical accessibility and proximity to the donor site. Another added advantage of using autograft is that there is no material cost and no risk of disease transmission.[1]

The clinician is given an opportunity to decide the donor site; the choice of the autogenous donor site depends on the quantity of bone required at the recipient site, physical and biologic quality of donor bone, and the technique of procurement.

Intraoral donor site is preferred when the patient is partially edentulous and requires less quantity of bone. Intraoral bone harvesting can be performed in chairside under local anesthesia with minimal post-operative pain. Although intraoral bone procurement using conventional techniques was practiced for several decades, there were certain disadvantages in the harvesting. Excessive heat production caused by bone cutting burs leading to death of osteoblasts at the donor site and fracture of the bone by increased force and pressure exerted by handheld instruments were the most common limitations.

To overcome these limitations, innovations in instrumentations and techniques were brought in the form of machine operated/rotary handpieces with coolant facility which provides ample irrigation during osteotomy procedures. Furthermore, to decrease the pressure while performing an osteotomy, micro vibration at ultrasonic frequency (piezosurgery) was also employed. These modifications brought about perfect and precise bone cutting producing no harm to the soft tissues.

Conclusion

Clinicians are provided with an array of armamentarium to perform osteotomy and harvest bone from the donor site without causing much complication/difficulty to the patient. It is the prime responsibility of the clinician to choose the best treatment modality for good clinical outcome and for the betterment of the patients. Even though harvesting autogenous graft from the intraoral areas requires second surgical site, the advantages of new bone formation and quality of bone formed are excellent when compared to other graft materials. Technique sensitivity is the barrier for procuring autografts, so the latest innovations in intraoral autogenous bone harvesting techniques will pave a way for building defective edentulous area for the future placement of prosthetic replacements and also dental implants.

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