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RESEARCH ARTICLE

BIOLOGICAL DRILLING PROTOCOL IN DENTAL IMPLANTOLOGY - A REVIEW

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Abstract

This review's objective is to inform readers of a creative substitute for traditional drilling techniques that keeps host bone in the greatest possible biological shape for implant placement. 4 Optic and electronic microscopy have also demonstrated that the bone obtained through this method is live bone. This is crucial since clinical studies have indicated that autogenous bone is the best filler for defects. This method of gathering bone may make it easier to manipulate than other methods, and it can also offer the adhesive and signalling proteins needed for bone healing.

Introduction:-

Dental implantology has advanced significantly over the previous few decades. The ease of placement and prognosis of dental implants have both improved as implant dentistry has advanced thanks to new materials and techniques.1 Dental implants are a popular option nowadays and make a great solution for both single and multiple tooth prosthetics.1Several benefits of implants include better function, higher patient comfort, the ability to replace missing teeth while maintaining the adjacent teeth, preventing the loss of alveolar bone after tooth extraction, and maintaining proprioceptive feedback after tooth loss. One of the requirements for obtaining a successful result is the surgical method utilised to prepare the implant osteotomy.2 Currently, conventional rotary instrumentation is used to prepare the osteotomy site.1 The gold standard for most implant systems is the Bränemark-described conventional drilling method at 1500 rpm.3

A concept known as the "Biological drilling technique", has been brought out as an alternative to the traditional method.3 Dental implant osteotomy preparation methods such as biological drilling use low-speed drilling (50rpm) without irrigation. Because it assists in gathering viable bone fragments during drilling that might be utilised for grafting, hence it is called "biological." The low rotation speed employed mitigates any potential bone overheating impact brought by the lack of irrigation.2

It is well known that bone tissue is least affected by high-speed drilling with water cooling. However, low-speed drilling without water-cooling has been suggested as an alternative to conventional drilling in recent years due to a number of benefits. Low-speed drilling makes it simpler to alter the path if necessary, enabling the operator to drill

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more precisely. Furthermore, because low-speed drilling produces less heat than high-speed drilling does, it can be done without the usage of water.5 As a result, the concern of patient discomfort and the difficulty in securing visibility owing to the presence of water can be resolved. Other benefits include being able to extract a bone chip without coming into contact with saliva while drilling, which is important for bone grafting requiring a small amount of bone graft material.5 The manufacturers have currently incorporated this idea into a number of guided implant surgery techniques.5

This review's objective is to inform readers of a creative substitute for traditional drilling techniques that keeps host bone in the greatest possible biological shape for implant placement. 4 Optic and electronic microscopy have also demonstrated that the bone obtained through this method is live bone.4 This is crucial since clinical studies have indicated that autogenous bone is the best filler for defects.4 This method of gathering bone may make it easier to manipulate than other methods, and it can also offer the adhesive and signalling proteins needed for bone healing. 4

Methodology:-

The initial biological drilling process and the drilling equipment were developed at the Biotechnology Institute in Vitoria, Spain. 4 The cortical layer is drilled with an extremely sharp design drill at a speed of about 800 rpm since the drilling method needs to be adjusted to the features of the particular location to be drilled. 4 Applying serum irrigation is necessary at this stage. The remainder of the cavity (alveolus) holding the implant is formed in the following steps while trying to preserve as many of the natural characteristics of the host tissue as possible. 4 Drills of many sizes and shapes are utilised to do this. 4(as illustrated in Fig 1). Without irrigation, this is carried out at slow speeds (20 to 80 rpm). 1 Eventually, saline irrigation is abandoned in favour of low speeds of 20 to 80 rpm during the countersinking phase. 4. Directly from the drill, the bone is removed. It is possible to store and later retrieve dislodged tissue or cut trabecular bone using the twist drills' retentive thread design (deep grooves). 4 Controlling the drilling pressure is important; once the deposited bone starts to resist, it should be withdrawn. 4

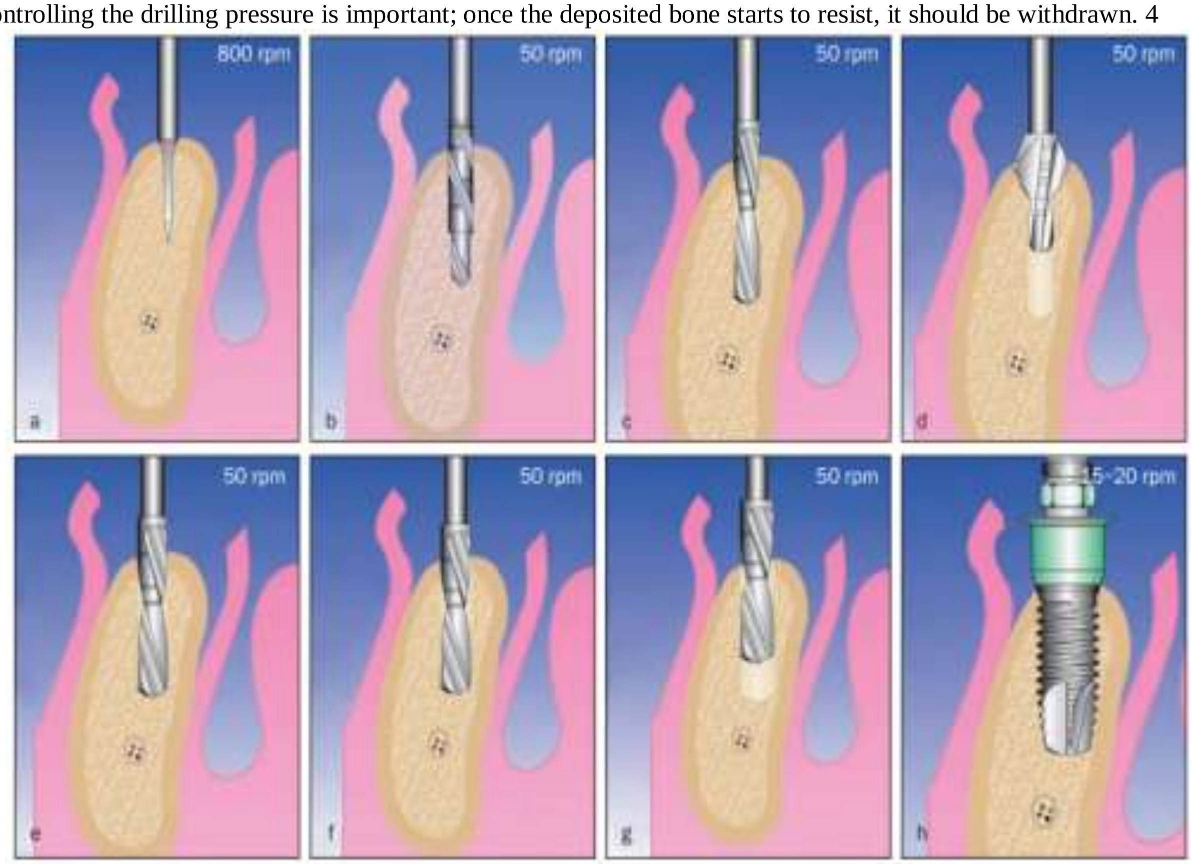

Fig 1 An innovative drilling procedure designed to preserve the peri-implant tissue. *(a)* The tip of the initial drill is very sharp. This drill rotates at 800 rpm with irrigation. *(b to d)* The pilot drill *(b)*, the countersink drill *(d)*, and *(c; e to g)* twist-type drills of different diameters (2.5 to 3.8 mm) are shown. Except for the initial drill, all drills are used at 50 rpm without irrigation. *(h)* The implant is placed at 15 to 20 rpm without irrigation.

Picture courtesy: Anitua E, Carda C, Andia I. A novel drilling procedure and subsequent bone autograft preparation: a technical note. International Journal of Oral and Maxillofacial Implants. 2007 Jan 1;22(1):138.

A new site preparation tool called the OsseoShaperTM, manufactured by Nobel Biocare AB in Gothenburg, Sweden, was recently created.6 Its novel design includes a tapered body with an outside thread profile combined with a cutting flute and an unconventional site preparation protocol. 6After the pilot drill, the osteotomy is shaped with the single-use implant-specific tool OsseoShaper1 (OS1) at low speed (25-100 rpm) and without irrigation using a motorised drill unit with a maximum torque setting of 40 Ncm6 (Figure 2). The process for implant placement is determined by the OS1 torque, which is determined by a drill unit with a real-time torque display.6 The implant can be inserted if the OS1 achieves the necessary depth and location with less than 40 Ncm.6The following instrument should be used to further shape the implant site if the OS1 torque hits 40 Ncm before it reaches the desired location.6 According to early observations of this novel implant system and site-preparation procedure, the OS1 may give clinicians the ability to accurately evaluate bone quality and eventually predict final implant torques.6

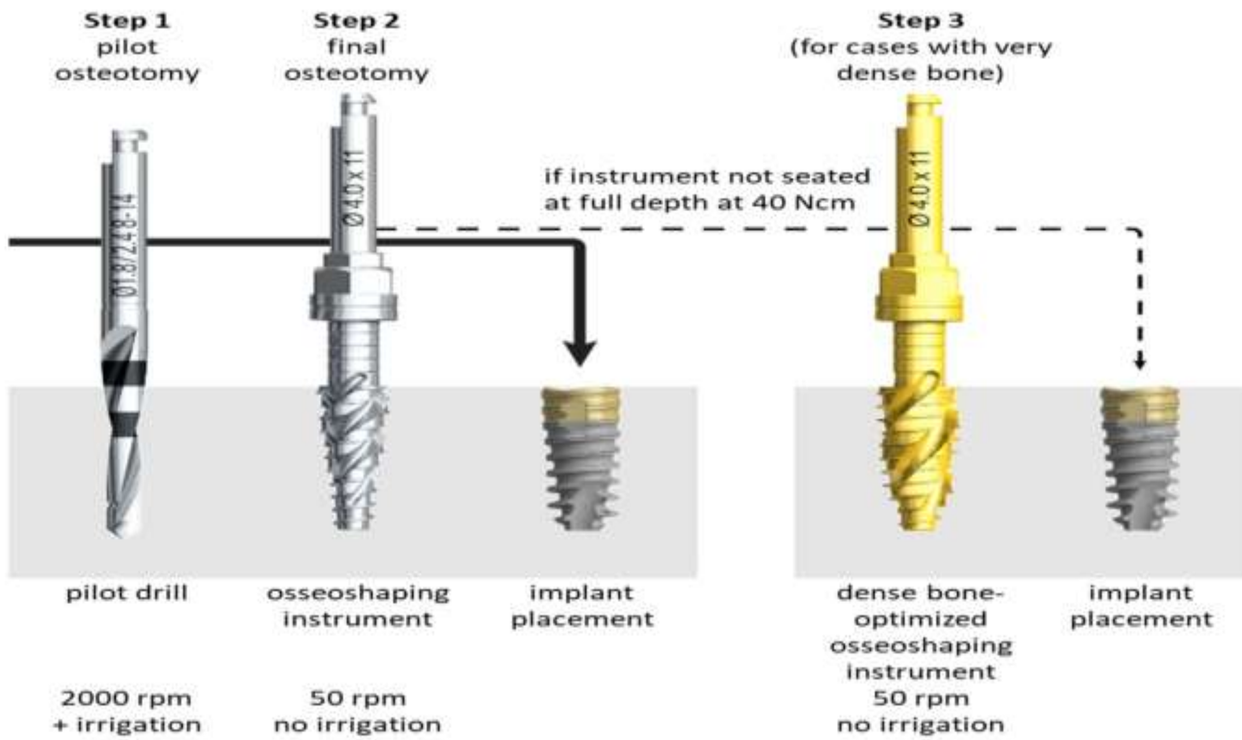

Figure 2:- Osteotomy formation protocol. Implant placement follows a two-step site preparation in cases where the osseoshaping instrument can be fully seated without exceeding the torque of 40 Ncm (left panel). If the instrument cannot be seated, the osteotomy is further enlarged using the dense bone–optimized osseoshaping instrument using a torque of up to 40 Ncm (right panel). If needed the dense bone drill is used.

Picture credit; Fabbri G, Staas T, Urban I. A Retrospective Observational Study Assessing the Clinical Outcomes of a Novel Implant System with Low-Speed Site Preparation Protocol and Tri-Oval Implant Geometry. Journal of Clinical Medicine. 2022 Aug 18;11(16):4859.

Tissue collection &Autograft Preparation.

Following the removal of the drill bit from the neo-alveolus, the tissue surrounding the twist drills is removed using a periotome or another tool. 4A tiny glass container or another sterile container is used to hold the tissue. 4 Consequently, tissue fragments are immediately gathered without the use of suction filters or other instruments. By blending PRGF with bone fragments, a composite graft is created. 4 Peripheral blood is drawn via venipuncture (minimum 10 mL) and immediately placed into 3.8% (wt/vol) sodium citrate to create the PRGF (1 vol: 9 vol). 4The blood is centrifuged at 460 g for 8 minutes at room temperature, and the plasma fraction, which is immediately above the sedimented red blood cells and excludes the buffy coat, is collected and put in a glass dish4. To start clotting, calcium chloride is added; the clot that forms includes the bone fragments that were gathered (Figs 3a and 3b). 4 The mixture can be injected around titanium implants to overcorrect flaws or used to fill post-extraction areas. 4 A millilitre of the plasma fraction that was at the top of the tubes was transferred to a glass bowl in order to create a fibrin membrane. 4 Calcium chloride is added, and the mixture is then incubated for 20 to 25 minutes at 37 °C. 4 During clot retraction, a fibrin membrane resembling a bowl is created. 4

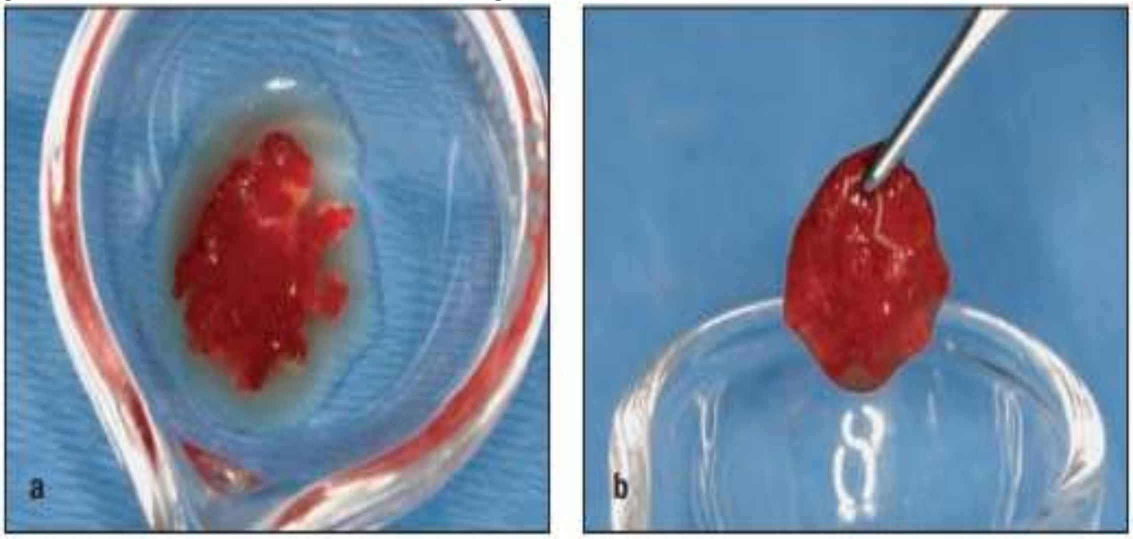

Fig. 3:- (a) & (b) Autograft preparation with bone particles obtained during low speed drilling.
Picture courtesy: Anitua E, Carda C, Andia I. A novel drilling procedure and subsequent bone autograft preparation: a technical note. International Journal of Oral and Maxillofacial Implants. 2007 Jan 1;22(1):138

Evaluation of Collected Bone

Histopathological analysis: Haematoxylin-eosin and Masson's trichrome were used to examine a section of each sample using traditional histological techniques.7Alveolar bone cells were isolated and cultured using biological drilling (entrapped in drills) and high-speed drilling (filter).7Phosphate-buffered saline (PBS) with antibiotics and antimycotics was used to collect the cells.7 Osteoblast medium with 15% foetal bovine serum (FBS, Biochrom AG, Leonorenstr, Berlin, Germany), antibiotics, and osteoblast development supplements (Sciencell Research Laboratories, Carlsbad, California, USA) was used to explant the tissue.7 Alveolar bone cultures were maintained in an environment of humidified 5% CO_2 at 37 °C, with medium changes occurring every two weeks.7

Immunofluorescence was used to identify cells coming from alveolar bone.7 The osteopontin (Sigma-Aldrich) and osteocalcin (Acris Antibodies GmbH, Schillerstr, Herford, Germany) antigens were used to analyse the expression of two osteoblast markers.7 Additionally, Sigma-alkaline Aldrich's phosphatase activity was found in each primary bone culture.7 The strong positivity of the three markers served as confirmation of the osteoblast phenotype in each case.7

Osteoblasts were separated and passed serially after reaching 60–70% confluence, which took about 3–4 weeks.8 Trypan Blue dye exclusion was used to determine the viability of the cells (Sigma-Aldrich, St. Louis, Missouri, USA)7

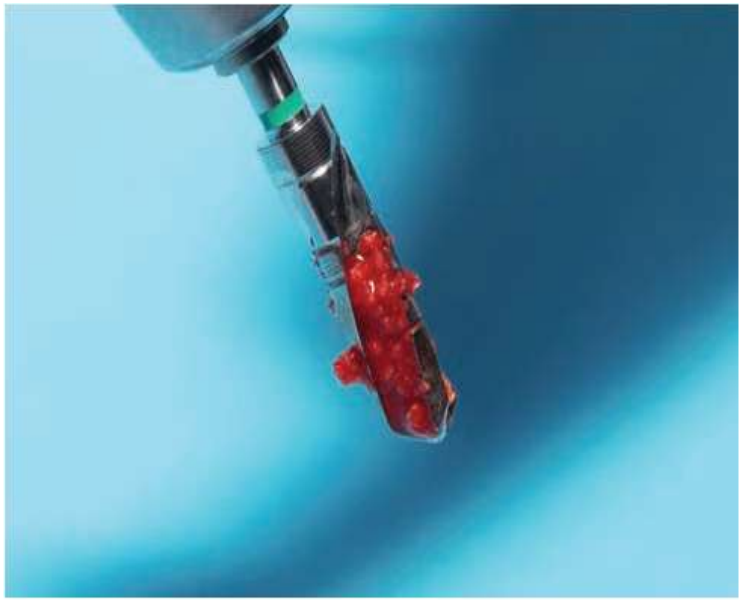

Fig. 4a:- Collection of bone during biological drilling from the bur.

Fig. 4b:- Collection of bone during high speed drilling from the filter.

Picture credit; Anitua E. Biological drilling: Implant site preparation in a conservative manner and obtaining autogenous bone grafts. BalkanJournal of Dental Medicine. 2018;22(2):98-101.

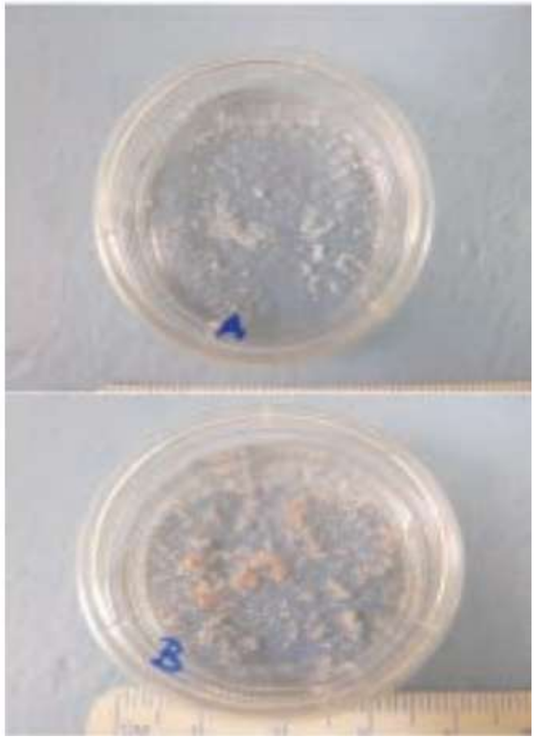

Fig. 5a:- Alveolar bone cultures with osteoblasts.

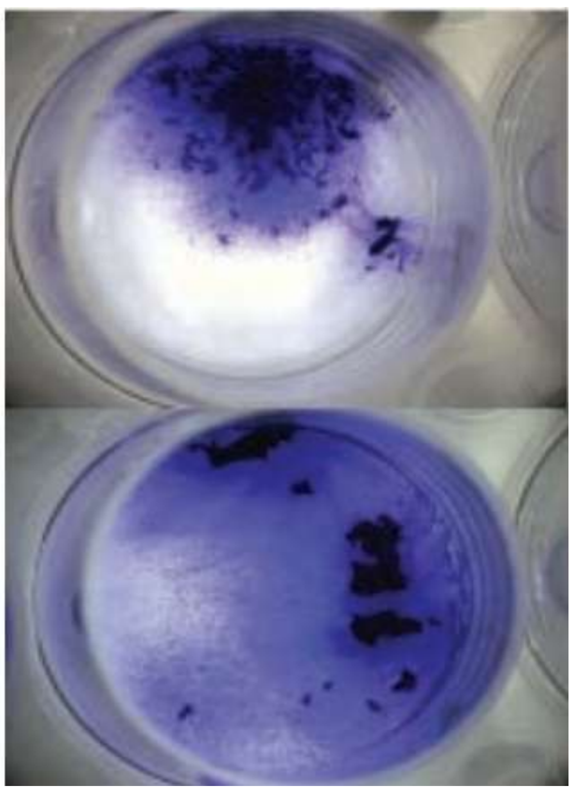

Fig. 5b:- Cell viability tested by Trypan Blue dye exclusion.

Picture credit; Anitua E. Biological drilling: Implant site preparation in a conservative manner and obtaining autogenous bone grafts. BalkanJournal of Dental Medicine. 2018;22(2):98-101.

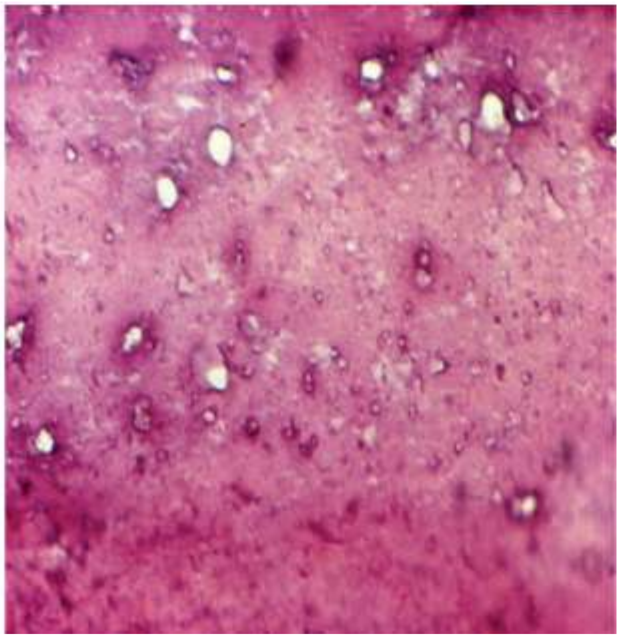

Fig. 6a:- Sample obtained after high speed drilling process. Compact bone (hematoxylin-eosin x10 - Optical Microscopy) - the bone has no cells.

Fig. 6b:- Sample obtained after biological drilling process. In this case the cells are alive (hematoxylin-eosin x60 Optical Microscopy).

Picture credit; Anitua E. Biological drilling: Implant site preparation in a conservative manner and obtaining autogenous bone grafts. BalkanJournal of Dental Medicine. 2018;22(2):98-101.

Heat Transfer During Drilling

Chin-Hao-Chen et al8 compared the temperature generated during cutting with a traditional approach involving several drills and site preparation with the mini OsseoShaper were compared.8 The following briefly describes the variations between the mini OsseoShaper and normal drill models: When using a conventional high-speed drill, the drill tip was moved vertically while a heat flux was applied to the drill hole's edge where it was positioned.8 The heat flux value was set to zero below the drill tip, and irrigation was used above the drill tip.8 However, due to the tapered shape of the drill used in OsseoShaper low-speed drilling, heat flux was given to the drill hole's boundary at and above the tip, causing the points of engagement between the drill and the bone to increase over time as the drill was moved vertically.8

As an alternative to the standard procedure, low-speed drilling has been proposed. 9This method has advantages like easy drilling route adjustment and disadvantages like prolonged drilling time.9 To maintain the drilling path, it is simple to manage the low-speed drilling's efficiency.9 When a drill runs into a dense cortical bone, conventional drilling can automatically alter its drilling course.9 Low-speed drilling can alert the operator to a changing course, allowing for correction. Ericsson and Albrektsson (1983) demonstrated that heating bone to 47°C for 1 min reduced the amount of bone that grew into the implant.9 They discovered that 47°C is the critical temperature for bone survival during the drilling process for implant sites.9

According to Kim et al., drilling at a low speed of 50 rpm without irrigation may not considerably raise bone temperature, although there may be a direct correlation between bur diameter and bone temperatures.9 This may help to explain why, during implant surgery, we begin drilling with the smallest-sized bur and gradually increase the bur size.9

Bone Chips Versus Bone Debris

It was commonly accepted that the autologous material produced during the cutting and scraping of bone, which was originally referred to as "osseous coagulum," contributed to bone regeneration because it contained what are these cells are now known as osteoprogenitor cells.10 The autologous bone material was removed from the site as a result of the widespread use of irrigation in conjunction with high-speed rotary tools for osteotomy site preparation.10 The procedure was accompanied by a change in terminology, and it was advised that autologous bone material be removed prior to implant placement.10 This material is now referred to as surgical debris or bone debris.10 Regardless its name, it was discovered that autologous bone debris/osseous coagulum produced by slow-speed drilling was advantageous in situations where there were significant gaps surrounding the implant, such as around immediate implants placed in fresh new extraction sockets.10 The osseo-shaping tool may be especially helpful in porous Type IV bone and in extraction sockets that have partially healed due to the way it performs, which efficiently retains autologous material in the cutting flutes and leaves enough gap space surrounding the implant for this material to be inserted.10

Benjamin et al11 in his study compared the chips produced by bone scrapers with the bone chips produced by an osseo-shaping instrument, and concluded that bone chips produced by osseo-shaping instrument are more osteogenic, and the material produced by an osseo-shaping instrument gives rise to new peri-implant bone.11

Discussion:-

The concept of biological drilling presented here has been suggested as an alternative to the conventional procedure.4 It proposes a technique for acquiring autologous bone during surgical site preparation, eliminating away with the requirement to gather bone from a second surgical region.4 The bone tissue becomes less thick and includes more cells after the cortical layer has been punctured with a highly sharp drill.4 Preclinical findings point to a number of biological advantages of this novel site preparation concept, such as enhanced cell viability at the site due to the avoidance of high temperatures during site preparation and preservation of the granulated bone in situ.6

Giocomo Fabri et al in his retrospective observational study assessing the clinical outcomes of a novel implant System with low-speed site preparation protocol.12 He concluded that implant survival rate was 98.0 % in terms of mean marginal bone level change (MBLC).12 Clinician satisfaction with the novel concept system was high.12 The novel concept system offers an easy-to-use implant placement protocol, with most implants placed using two steps.12 The minimal bone remodeling and high survival rate observed across a variety of indications and treatment protocols demonstrate broad versatility and confirm the clinical benefits of this biologically friendly innovation.12

Kim et al conducted a study on acquisition of human alveolar bone-derived stromal cells (hABCs) using minimally irrigated implant osteotomy.13 In his study, bone chips were obtained by minimally irrigated implant drilling technique.13 Isolated cells were studied with respect to their colony-forming efficiency, surface marker expression by immunofluorescence staining, fluorescence-activated cell sorting analysis and self-renewal potency.13 He concluded that human alveolar bone-derived stromal cells (hABCs) is a feasible source of stem cells for dentoalveolar bone tissue reconstruction.13 The cell source has an advantage that the hABCs can be easily acquired during implant surgery.13

In comparison to drilling at high speed with irrigation, biological drilling at lower speeds offers us two benefits.7 The first of these is the precise control of drilling depth because the burst marks are always visible to reduce accidental invasion of anatomical tissues.7 The second benefit is the gathering of several healthy particulate bone grafts without lengthening or complicating the procedure.7 This collection of bone enables us to treat areas that would normally require bone augmentation within the same surgical procedure.7

Conclusion:-

In this review, a unique drill design that is intended to efficiently cut bone at a very low rotating speed, eliminating the requirement for irrigation as a coolant and lubricant is demonstrated. The minimal heat produced by the low-speed cutting helps to retain the viability of the osteoclasts. Due to the absence of irrigation and the special construction of the cutting flutes, autologous bone chips are produced and kept on site. The osteogenic potential of this osseous coagulum is intrinsic. With the new drill design, bone is being formed at rates that are substantially faster than those seen with traditional drilling methods. The clinical preparation of implant sites and the rebuilding of alveolar bone can both benefit from these data.

References:-

1.Baker JA, Vora S, Bairam L, Kim HI, Davis EL, Andreana S. Piezoelectric vs. conventional implant site preparation: ex vivo implant primary stability. Clinical Oral Implants Research. 2012 Apr;23(4):433-7.

2.Bernabeu-Mira JC, Soto-Peñaloza D, Peñarrocha-Diago M, Camacho-Alonso F, Rivas-Ballester R, Peñarrocha-Oltra D. Low-speed drilling without irrigation versus conventional drilling for dental implant osteotomy preparation: a systematic review. Clinical Oral Investigations. 2021 Jul;25(7):4251-67.

3.Pellicer-Chover H, Peñarrocha-Oltra D, Aloy-Prosper A, Sanchis-Gonzalez JC, Peñarrocha-Diago M, Peñarrocha-Diago M. Comparison of peri-implant bone loss between conventional drilling with irrigation versus low-speed drilling without irrigation. Medicina Oral, Patología Oral y Cirugía Bucal. 2017 Nov;22(6):e730.

4.Anitua E, Carda C, Andia I. A novel drilling procedure and subsequent bone autograft preparation: a technical note. International Journal of Oral and Maxillofacial Implants. 2007 Jan 1;22(1):138.

5.Jang HJ, Yoon JU, Joo JY, Lee JY, Kim HJ. Effects of a simplified drilling protocol at 50 rpm on heat generation under water-free conditions: an in vitro study. Journal of Periodontal & Implant Science. 2021 Dec 8;52.

6. Velikov S, Susin C, Heuberger P, Irastorza-Landa A. A New Site Preparation Protocol That Supports Bone Quality Evaluation and Provides Predictable Implant Insertion Torque. Journal of clinical medicine. 2020 Feb 11;9(2):494.

7.Anitua E. Biological drilling: Implant site preparation in a conservative manner and obtaining autogenous bone grafts. BalkanJournal of Dental Medicine. 2018;22(2):98-101.

8.Chen CH, Coyac BR, Arioka M, Leahy B, Tulu US, Aghvami M, Holst S, Hoffmann W, Quarry A, Bahat O, Salmon B. A novel osteotomy preparation technique to preserve implant site viability and enhance osteogenesis. Journal of clinical medicine. 2019 Feb 1;8(2):170.

9.Kim SJ, Yoo J, Kim YS, Shin SW. Temperature change in pig rib bone during implant site preparation by low-speed drilling. Journal of Applied Oral Science. 2010;18:522-7.

10.Coyac BR, Salvi G, Leahy B, Li Z, Salmon B, Hoffmann W, Helms JA. A novel system exploits bone debris for implant osseointegration. Journal of Periodontology. 2021 May;92(5):716-26.

11.Coyac BR, Sun Q, Leahy B, Salvi G, Yuan X, Brunski JB, Helms JA. Optimizing autologous bone contribution to implant osseointegration. Journal of periodontology. 2020 Dec;91(12):1632-44.

12.Fabbri G, Staas T, Urban I. A Retrospective Observational Study Assessing the Clinical Outcomes of a Novel Implant System with Low-Speed Site Preparation Protocol and Tri-Oval Implant Geometry. Journal of Clinical Medicine. 2022 Aug 18;11(16):4859.

13.Park JC, Kim JC, Kim YT, Choi SH, Cho KS, Im GI, Kim BS, Kim CS. Acquisition of human alveolar bone-derived stromal cells using minimally irrigated implant osteotomy: in vitro and in vivo evaluations. Journal of clinical periodontology. 2012 May;39(5):495-505.