Atraumatic Tooth Extraction Techniques for Immediate Implant Placement – A Literature Review

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ABSTRACT

Advances in clinical techniques and biomaterials have facilitated a great expansion in the indications for dental implant treatment options. The timing of implant placement has become an important factor in the dental community in the past 15-20 years.According to conventional guidelinesimplants were submerged for 3-6 months after which the final prosthetic loading was done. Today, immediate implant placement at the time of tooth extraction has been commonly utilized thus shortening this treatment period to achieve faster functional and esthetic resultswith a high success rate. A crucial aspect of immediate implant placement is the atraumatic extraction of the tooth to conserve as much surrounding bone as possible and to establish primary stability. As the loss of bone height and thickness can affect the three-dimensional implant position, the rehabilitation of esthetic areas by means of osseo-integrated implants can be quite complex.For this purpose, different techniques for atraumatic tooth extraction have been advocated in literature.This review summarizes various techniquesthat preserves the integrity of the alveolus thus facilitating immediate implant placementalong with the available evidence regarding the techniques. The choice of the technique should be done by the operator based on the ease, feasibility, time and the availability of the resources.

Keywords: Atraumatic tooth extraction, Dental Implant, Immediate implant placement, Tooth extraction.

INTRODUCTION

Dental implants have been in practice since decades. The adapted conventional implant placement protocol is a time-consuming process since the implant is submerged beneath the soft tissue for a period of 3-6 months for osseointegration before a second stage surgery is performed for exposing the dental implant for further loading of prothesis. Today, immediate implant placement at the time of tooth extraction has been commonly utilized thus shortening this treatment period. Implant placementimmediately or soon after tooth extraction has shown to be a reliable therapeutic approach with a high success rate. Immediate implant placement has several advantages over conventional protocol such as reduction of the number of surgical treatments, reduction of the time between tooth extraction and placement of the definitive prosthetic restoration, prevention of bone resorption, and preservation of the alveolar ridge in terms of height and width, which in turn has esthetic and functional benefits.One crucial factor in immediate implant placement is the atraumatic tooth extraction in order to preserve a maximum amount of bone around the tooth and to attain primary stability.[1]As the loss of bone height and thickness can affect the three-dimensional implant position, the rehabilitation of esthetic areas by means of osseo-integrated implants can be quite complex. Therefore, the maintenance of hard and soft tissues and the preservation of the local topography has become highly relevant matters especially in front-tooth restoration using esthetic treatments. Maintaining the integrity of the labial plate during tooth extraction is a critical determinant of whether an immediate implant can be placed and is also a significant predictor of esthetic result. In addition, a high percentage of patients have a thin buccal bony plate.[2] Huynh-Ba *et al* found that the mean width of the buccal bony walls was 1 mm and the palatal was 1.2 mm. More specifically, for the anterior sites (canine to canine), the mean width of the labial bony wall was 0.8 mm, while for the posterior (premolar) sites, it was 1.1 mm.[3] These results were later confirmed by a clinical study by Braut *et al* with cone beam computed tomography (CBCT) images.[4] The extraction of teeth by standard techniques or the surgical removal of retained root fragments by conventional surgical methods (elevators and forceps) may result in damage to the labial plate of alveolar bone. Therefore, it is accepted that efforts should be made to extract each tooth atraumatically and preserve the integrity of the alveolus as much as possible. The first step in immediate implant placement after case selection is atraumatic extraction. For this purpose, different techniques have been proposed in literature such as the use of rotary burs, periotomes, powertomes, piezoelectric devices, the Easy X-Trac System, removal of the root fragments with the implant drills during implant site preparation and vestibular extraction technique. The aim of this review is to describe the various techniques available for atraumatic tooth extraction thus preserving the integrity of the alveolus as much as possible.

Periotome[5]

Periotomes are specially designed extraction instruments that employ the mechanisms of “wedging” and “severing” to facilitate tooth removal while maintaining the alveolar housing (Fig 1). They are composed of very thin metallic blades that are gently wedged down the periodontal ligament (PDL) space in a repetitive circumferential fashion. In addition to minimally invasive luxation, the periotome blade severs Sharpey’s fibres that secure the tooth within the socketreducing potential trauma to adjacent bone and associated gingival structures thereby preventing the fracture of the alveolus. Disadvantages encountered are the fracture of the instrument tips and/or trauma to the adjacent soft tissues due to the force required to advance the instrument, provider fatigue along with addition of a significant amount of time to the extraction procedure.

Fig 1: Severing periodontal fibres with a periotome

Powertome (Automated Periotome)[5]

This device introduced by White *et al* combines the atraumatic extraction advantages of the periotome with mechanized speed. Powertome is an electric unit that has a handpiece with a periotome blade that is controlled by a foot switch. The automated periotome blade is controlled by a solenoid within the handpiece. Power output to the handpiece is regulated by the controller box and may be adjusted to 10 different power settings. It is operated by selecting a power setting on the controller unit and inserting the blade into the PDL space. User experience has shownthe easeofbeginning interproximally. After inserting the blade into the PDL space, the powertome is activated via the foot switch. Keeping the blade parallel to the long axis of the tooth, the blade should follow the contours of the tooth in a sweeping motion, advancing apically in 2–4-millimeter increments. During activation of the unit, the Powertome blade advances easily with minimal hand pressure yielding much faster and less fatiguing results than traditional periotomes. After employing the powertome, the tooth in question should be gently extracted with forceps in a rotational fashion. Multirooted teeth, on the other hand, may require surgical sectioning to convert the tooth into multiple “single rooted” teeth. Prior to sectioning multirooted teeth, it is recommended to use the powertome in the same fashion as applied to single rooted teeth. In some instances, especially in the cases of fused or convergent roots, multi-rooted teeth may be removed without the need for sectioning. If the roots are flared, sectioning into multiple single rooted teeth will reduce potential damage to adjacent bone.

Fig 2: Powertome

Vertical Trough Method [6]

A fundamental rule is to never place any instrument between the crestal bone and the root i.e. using the crestal bone as a rest to create the necessary leverage to extract the tooth as it will damage the crestal bone and directly affect the final result. Instead, the coronal aspect of the adjacent tooth should be used as a rest to create the necessary pressure and leverage to extract the tooth without touching the crestal bone. To facilitate this, it is crucial to cut the root to be extracted vertically in the middle with a diamond bur, creating an internal trough by which to fracture the root vertically with an instrument toward the center. The central trough creates the space necessary to fracture parts of the root toward the center. This is done by using the adjacent tooth as a rest and the outside boundary of the root to create pressure toward the center until one piece of the root fractures. In general, once the first piece of the fractured root is removed, extracting the remaining part easy due to the availability of more space to dislodge the root fragment. One could argue as to the orientation of the vertical trough: should it be oriented buccolingually or mesiodistally? The advantage of the buccolingual trough is that the possibility of accidentally fracturing the buccal bone plate during extraction is reduced; however, the challenge is to prevent drilling the buccal plate with the diamond bur when cutting the buccolingual trough. To avoid this the trough should not be cut all the way to the buccal aspect of the root; in fact, the trough should never extend all the way through the root but stop about 1 mm short of the bone. With a mesiodistal trough, the chances of causing fractures in the buccal bone are significantly higher, especially in cases where the root is ankylosed to the buccal plate.

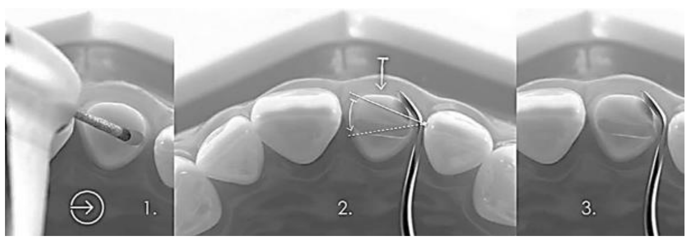

Fig 3A: Step-by-step procedure for extraction with a mesiodistal trough.

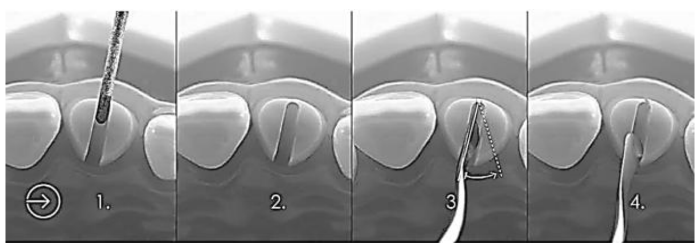

Fig 3B: Step-by-step procedure for extraction with a buccolingual trough.

BENEX DEVICE (Vertical Tooth Extraction)[7]

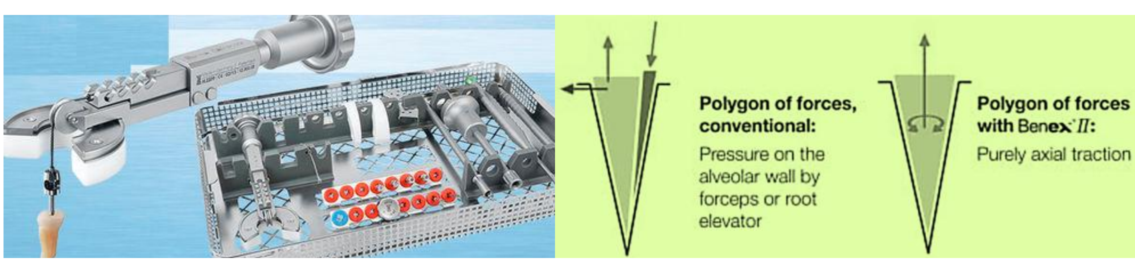

Fig 4: BENEX SYSTEM

Before use of this device the periodontal fibres are severed and the roots are loosened/luxated by axial movements within 30 seconds using a slim elevator/twister without using transversal movements. In case of multi-rooted teeth, the roots are divided and extracted separately. The root canal is then prepared for fixation of the extraction screw (Fig. 5), which is selected based on the diameter of the root canal. The Benex system comes with self-tapping screws and matching diamond burs in 2 different diameters (1.6 mm and 1.8 mm). Two different lengths are available for the smaller-diameter screws.

The diamond bur is used in a straight or contra-angle 1:1 handpiece (KaVo, Biberach, Germany; and Bien-Air Dental, Bienne, Switzerland) to prepare a canal for subsequent screw insertion with the provided screw driver. Drilling with the diamond coated twist drill should be in the axis and center of the root fragment. It should be approx. 7 mm in the hard tissue, deeper drilling will not be necessary. Drilling is performed with water-cooling in order to remove drilling chips more easily, an inward and outward movement is recommended for deep drilling. The recommended rpm is 500-700 rpm.

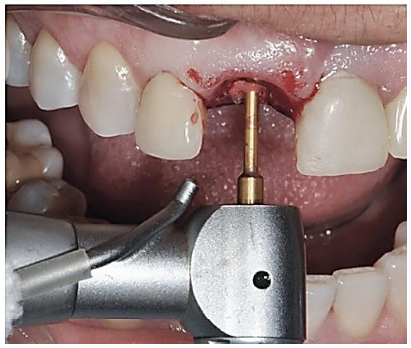

Fig 5: Preparation of the root canal for placement of the tractioning pin

According to circumstances, the short or long extraction screw with screwing support is inserted. A digital wrench is used to position the screw inside the drilled root canal (Fig. 6).

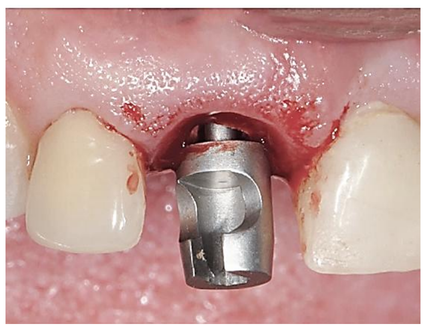

Fig 6: The tractioning pin in position

The extractor is positioned on the adjacent crowns: The opening of the round, revolvable, segment plate is adjusted in vestibular direction ensuring a good view of the extraction screw After the pull-rope has been hooked into the extraction screw, it is guided over the reverse roller and fixed to the hook of the extraction slide. Under sight traction- so that the rope does not hang out the instrument in placed on the adjacent teeth by turning the hand screw. During positioning it is important to see that both the screw and the rope do have the same axial direction. (Fig. 7)

Fig 7: The dental extractor in position for root extraction

Once the extractor is positioned properly, the extraction is carried out with maximal preservation of the alveolar bone vertical level and surrounding soft tissues by turning the hand screw. in case of strong, long roots the periodontal fibres have to be pre-stretched during 30 seconds by applying a sub-maximum traction. (Fig. 8)

Fig 8: Dental extractor and root fixated to the tractioning pin following extraction

A study by Muska *et al* in 2013 demonstrated a high overall success rate of 83%with the use of this vertical extraction system for the atraumatic extraction of severely decayed teeth not suitable for forceps extraction. The success rate was higher in single-rooted teeth (89%) than multi-rooted teeth (43%).[8]

ULTRASONIC SURGERY/PIEZOSURGERY [9]

Piezosurgery was developed by Vercellotti in 2004 as a surgical method for dental osteoplasty and ostectomy. However, instruments involved in Piezosurgery are versatile because their novel vibrating tips lead to new therapeutic applications one of which is tooth extraction and implant osteotomy preparation. Vibrating syndesmotomes are the tips for tooth and root extraction which are brought through the gingival sulcus into the space occupied by the PDL between the root and socket to cut the PDL fibres surrounding the tooth socket up to or greater than 10 mm. Thus, when the roots or teeth are mobilized after severing the most apical fibres, the coronal portion of the socket has not been submitted to a violent "rip" which was the case with the extraction forceps and other devices. This device (Resista) works in the 20- to 32-KHz range and its maximum ultrasound power is 90 W. The tips used with this instrument are made of titanium alloy.

Fig 9: Vibrating tips used to cut the PDL fibres.
From left to right: arrow like tip, syndesmotome with teeth perpendicular and parallel to the handpiece long axis, left- and right-angled syndesmotomes without teeth (45 degrees), and large syndesmotome with teeth.

Six different tips are available for adaptation to various clinical situations. The first tip is arrowlike and sharp on both sides; it is used to penetrate the PDL at the coronal aspect of the socket and start sectioning the PDL fibers. To section the PDL fibers deeper in the apical direction, four syndesmotomes are used. Two of them are straight, with teeth, and their cutting directions are parallel and perpendicular to the long axis of the tip. The other two are angled at 45 degrees (one to the right and one to the left) to better adapt to the socket's geometry. The last tip, which also has teeth, is indicated for removal of ankylosed teeth. (Fig 9)

SONOSURGERY[10]

A sonic instrument for bone surgery (SIBS) (Sonic handpiece SF1LM; Komet, Rock Hill, SC) was developed and various inserts (Sonosurgery, Komet) were designed by Dr. Ivo Agabiti, Pesaro, Italy, which can also be used for sectioning teeth and separating the periodontal ligament (syndesmotomy) which allows for atraumatic extraction. The SIBS vibrates at a high frequency of 6 kHz, has wavelength of 240 µm and the tips are 0.25 mm thick, 2.4-3.5 mm wide, and 10 mm long. All 3 inserts have the same size, but different angulations (Fig. 10) to provide the clinician the necessary access when working on different aspects of the tooth. The operator can select the one which will provide the correct angulation without traumatizing the adjacent tissues. It provides an efficient and precise cut as well as allowing the clinician to work close to soft tissue without risking injury.

Fig 10: Specifically designed sonic tips

After incision and flap is raised, the specially designed tips of SIBS are used to section the tooth in a mesiodistal direction up to the apex (Figs. 11& 12).

Fig 11: Sectioning the root in mesio-distal direction with use of Sonosurgery tips.

Fig 12: Sectioned root and widened periodontal ligament space

The periodontal ligament space, with the exception of the area of the labial aspect, is then widened with the SIBS inserts (Fig. 13).

Palatal aspect of the root is removed with an elevator (Elevator #301; Hu-Friedy) (Fig. 13), followed by the labial section, resulting in a socket where the 4 walls were preserved (Fig. 14).

Fig 13: Palatal portion of root has been removed

Fig 14: Intact facial wall of socket. Granules of allograft material are

In comparison with other conventional techniques for atraumatic tooth extraction, the SIBS may reduce the surgical time compared to the use of periotomes. When comparing sonosurgery to piezosurgery, the study by Heinemann *et al* reported that the average heat generated by the SIBS was close to that by conventional rotary cutting instrument (1.54 to 2.29°C), whereas the piezoelectric device produced a greater rise in temperature (18.17°C). In addition, histological investigations from the same study showed that the bone matrix adjacent to the defect radius presented intact osteocytes with all 3 instruments and a similar wide damage zone diameter at the bottom region. Finally, the SIBS produced smooth cutting surfaces with minimal damage in the upper defect zone. More specifically the defects were narrow and measured approximately 1 by 4 mm. While the upper zone of the defect through the cortical bone showed minimal damage, the lower cancellous zone appeared with partly crushed spongy trabeculae and laterally translocated debris. Furthermore, although the use of the SIBS might require operating times 3 to 4 times longer than the use of conventional rotary burs, the SIBS appears to provide better tactile control, be safer for the integrity of the surrounding tissues, and be an efficient instrument for atraumatic tooth extraction. However, according to the authors' clinical experience, a disadvantage of the described insert is that if it is deformed while it oscillates into the periodontal ligament, then the risk of fracture is high. Common contraindications to sonic and ultrasonic instruments also apply to the SIBS instrument and its inserts. More specifically, these devices have been reported to interfere with the function of older cardiac pacemakers. Currently, patients with recently designed pacemakers can be treated safely, except in situations of a medically compromised patient or electronically defective ultrasonic device. Finally, ultrasonic devices should not be used on patients with known infectious diseases that can be transmitted by aerosols. The water spray creates a contaminated aerosol that fills the operating area, exposing personnel and surfaces.

PHYSICS FORCEPS [11]

Traditional forceps and elevators often result in soft and hard-tissue damage to the loss of the buccal bony plate and interdental bone crest. The physics forceps (Golden Dent, Roseville, MI, USA) provides a mechanical advantage to extract teeth reducing the use of excessive force thus minimizing root or alveolar bone fractures, and helps to preserves the surrounding bone. It has a bumper in the buccal vestibule and a thin beak on the lingual aspect of the tooth, and thus utilizes a first-class lever action by applying constant pressure that slowly elevates the root from the socket. This causes the release of hyaluronidase in the periodontal-ligament (PDL) space, which results in the gradual release of the PDL, and the tooth becomes mobile and can be easily removed.

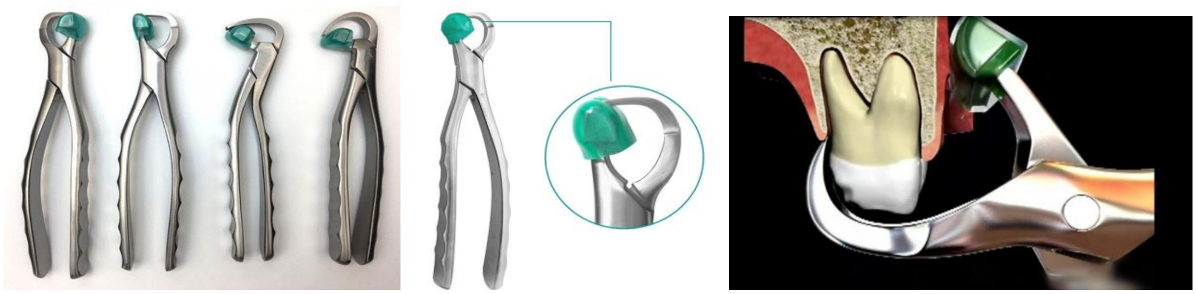

Fig 15: Physics Forceps

THE EASY X-TRAC SYSTEM [12]

This system was developed by Hornig and Offermann in 2005. The Easy X-Trac System eliminates the pulling and pressure associated with traditional extraction procedures, as well as the need for rotation. It incorporates 2 fundamental innovations - instead of relying upon a forceps to grip the tooth root being extracted, the Easy X-Trac approach utilizes a screw that engages the tooth root, thus achieving more secure retention. Second, instead of relying upon the surgeon's muscle power to provide the extractive force, the Easy X-Trac System employs a simple, easy to use mechanical device. It lifts the screw and the root it is embedded in, while simultaneously distributing force over the adjoining oral structures. It is indicated for immediate implant placement especially in the esthetic zone. Contraindicated in molars, vertically fractured roots with fragments that are too narrow to accommodate the extraction screw.

The flapless removal made possible with the system preserves the dental papillae, optimizing esthetic outcomes. This system is composed of parts that interact precisely with each other:

1. A series of 3 color-coded drills, white, red, and blue, in increasing diameters of 1.1, 1.3, and l.5 mm. The drills are used to create a hole through the centre of the root that will accommodate an extraction screw. They can be used in the implant contra angle handpiece.
2. Two X-Trac self-tapping extraction screws of 28 and 33-mm lengths.
3. A ratchet wrench designed for placing the X-Trac screws.
4. Two protective plates (right and left) that disperse the pressure of extraction.
5. The Easy X-Trac extractor, the mechanical device used to slowly lift the screw and root.
6. An instrument block for sterilization.
7. A specially designed 2.0-mm diameter extraction screw is available upon request for endodontically treated teeth.

Technique

1. After an appropriate level of anaesthesia has been achieved, the crown (if still present) of the indicated tooth is removed by cutting through the cementoenamel junction with a high-speed handpiece using a 700 or 701 bur.
2. Once this is completed, a slow speed implant contra angle is used with the 3 color-coded burs (white 1.1 mm, red 1.3 mm, and blue 1.5 mm), employing them successively (starting with the smallest) to enlarge the central root canal so that it will accommodate 1 of the X-Trac screws.
3. A pumping motion that utilizes the entire range of the drill threads should be employed to ensure that the canal is bored out thoroughly.
4. The drills should be used at a speed of 8000–10,000 rpm. Holding the shoulder of the 28-mm screw next to the tooth at the level of the cementoenamel junction and assessing the position of the score mark on the screw shaft selects the appropriate length extraction screw (either 28 or 33 mm).

5. The score mark must be superior to the incisal-occlusal edges of the adjacent tooth crowns. If it is not, the longer screw must be used.
6. Once selected, the screw is placed into the prepared canal and tightened first with the fingers, then with the ratchet wrench. The screw threads must be sunk all the way to the shoulder.
7. The appropriate protector plate (right or left) is tried in to confirm that the score mark on the shaft of the extractor screw is visible above the protector plate when the plate is in position.
8. The protector plate is removed, and fast-setting impression material is injected into the tray, taking care not to cover the large hole in the centre of the tray. The plate is then utilized like an impression tray, placing the head of the extractor screw through the central hole.
9. Once the plate is positioned, the angle between the extraction screw and protector surface must be 90°.
10. Before proceeding further, the protector should be removed once again to make sure all the tooth surfaces are within the impression material.
11. Leaving any metal exposed on the plate will place adjacent teeth at risk except over the central hole.
12. With the protector plate in place, the jaws of the X-Trac extractor are positioned between the surface of the protector plate and head of the extractor screw. The Extractor must engage both the top and bottom of the extractor screw head.
13. The knob at the Extractor’s distal end is then turned slowly, causing the extractor screw and tooth root to be elevated atraumatically from the tooth socket.
14. The resistance will end when the tooth has been lifted 1.0 –1.5 mm. At that point, the periodontal ligament will have been detached, and the Extractor and protective plate can be removed. The screw and root can then be simply lifted out of the alveolus with the fingertips.

Fig 16: The X-Trac pilot burs are used to prepare sequentially the residual root for placement of the X-Trac screw

Fig 17: Extraction screw in its final position with the shoulder of the screw engaging the cementoenamel junction of the residual root. The score mark on the shaft should be superior to the occlusal surfaces of the adjacent teeth.

Fig 18: The protector tray is placed over the occlusal surfaces of the right maxillary teeth. The extractor screw protrudes through the central hole and easily displays the score mark on the shaft of the screw.

Fig 19: The knob at the end of the extractor arm was rotated clockwise in order to move the arms closed as the prongs engaging the screw head opened, elevating the screw and accompanying root from the socket.

Fig 20: The extractor instrument in position engaging the head of the extractor screw

Fig 21: The tooth root and extractor screw after elevation out of the socket.

EXTRACTION USING IMPLANT DRILLS [1]

Thinning the walls of the roots before elevation makes it easier to remove the teeth and minimizes the risk of damaging the thin labial wall especially in root fractures where the fracture line is deep in the socket in immediate implant cases. Implant sites are prepared with standard drills using the bony walls as a guide, as palatally as possible.

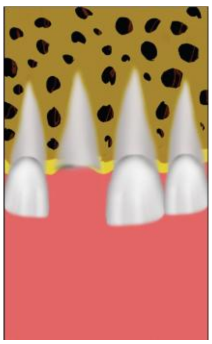

Fig 22A: A broken toothwith the fracture line deep in the socket.

Fig 22B: Thinning the walls of the root with a thin implant drill

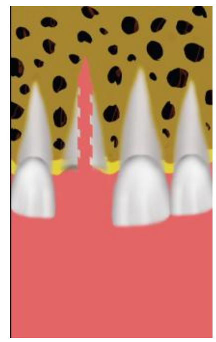

Fig 22C: The root walls after the drill is out.

Fig 22D: Thinning the walls with a thicker implant drill.

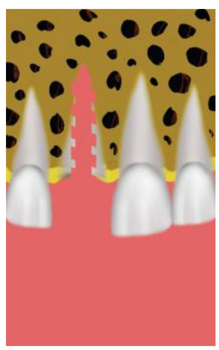

Fig 22E: Thin walls of root in the socket.

Fig 22F: Removal of the thin walls with a forceps after slight elevation.

VESTIBULAR ATRAUMATIC EXTRACTION TECHNIQUE [13]

A 1 cm long vestibular access incision is cut 3–4 mm apical to the mucogingival junction of the hopeless tooth. The vestibular pouch is then dissected in an incisal direction to expose the apical root area and allowing direct undisturbed access to the root surface. Using a long-shanked and small-sized tapered fissure bur, a slit osteotomy is performed at the apical third of the root, separating the coronal two-thirds of the root from the apical one-third. A straight luxator (luxelevator set, Stoma, Storz am Mark GmbH, Emmingen-Liptingen, Germany) is then introduced between the two separated segments, pushing the larger segment coronally, through an axial rotational movement, allowing removal of the root in an incisal direction. The small remaining apical portion is removed using Lucas curette (Stoma, Storz am Mark GmbH, Emmingen-Liptingen, Germany).

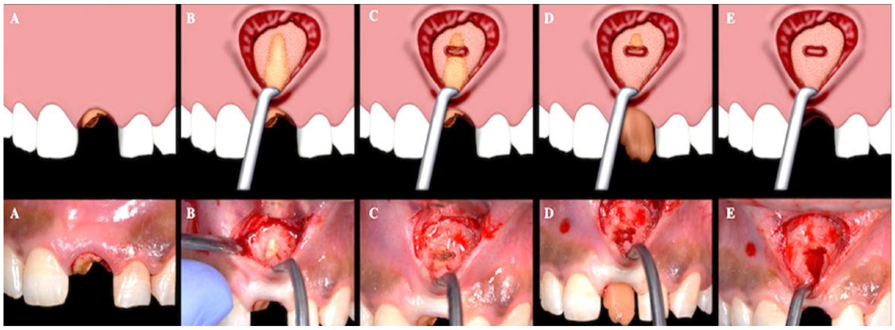

Fig 23: Vestibular extraction technique; A–E
A- hopeless tooth to be extracted
B- vestibular access incision
C- slit osteotomy at the apical third of the root
D- pushing larger segment of the root coronally
E- removal of small segment of the root

Evidence regarding the effectiveness of atraumatic extraction techniques is mainly based on previous case reports or case series while very few studies compared them to conventional tooth extraction. Randomized controlled clinical trials comparing different atraumatic extraction techniques are very scarce, with only one study assessing the clinical efficacy of piezotome versus periotome extractions of non-restorable endodontically treated teeth.

A comparative double blind randomized controlled trial performed by Sharma *et al*[14](2014) to evaluate the efficacy of periotomes (extractions with periotome and conventional extraction forceps) compared to periosteal elevator and conventional extraction forceps in single rooted nonsurgical tooth extractionssuggests the use of periotome to be helpful in reducing post extraction discomfort.

Hong *et al*[15] (2018) conducted a prospective observational clinical study of the vertical extraction system versus conventional tooth extraction techniques using an interrupted time series in line with the Idea, Development, Exploration, Assessment, Long-term Follow-up collaboration framework for surgical innovation. The results suggest that the vertical extraction system may be used with a high success rate for extraction of severely destroyed teethand its use may lead to a marked reduction in the need for flap surgery. However, randomized clinical trials should be performed to confirm these findings.

A randomized clinical trial was performed by Melek *et al*[16]in 2018 to evaluate the efficacy of piezotome versus periotome extractions of non-restorable endodontically treated teeth in relation to prevention of marginal bone loss, operating time of the procedure, and postoperative sequalae. There was no statistically significantdifference concerning the severity of postoperative painas well as between the times required for extraction in both groups, althoughpiezotome group showed slightly longer duration. The piezotome group showed a statistically significant lower value regarding the marginal bone loss when compared to the periotome group. It was concluded that the piezotome was a more efficient choice for preservation of marginal bone in endodontically failed teeth indicated for extractions compared to the periotome.

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