The Role of Different Techniques to Enhance Periodontal Healing After Third Molar Surgery: A Review Article

*Abdurrahman A. Al-Samman, B.D.S., M.Sc. (OMFS), **Khudhair A. Abd, B.D.S., H.D.D. (Perio.)

*Specialized Dental Center in Tikrit / Salahiddin Health Directorate, Ministry of Health, IRAQ
Adress: Tikrit / IRAQ
e-mail: abd_alsamman@yahoo.com; Phone: +9647721933236
**Ministry of Health, IRAQ
Adress: Beghdad/ IRAQ
e-mail: khudhair@yahoo.com; Phone:009647901369505

Abstract: Impacted third molar (M3) surgery result in periodontal complications on the distal surface of the adjacent second molar (M2). This study was conducted to review the effect of different techniques in terms of periodontal status of the preceding M2 after lower M3 surgery. The PubMed database was searched for the related studies with a minimum follow-up period of three months. In the studies obtained, Bone substitutes and guided tissue regeneration technique show conflicting results, however, they may be valuable in high-risk group of patients. The effect flap design used in M3 surgery on the periodontal status of the M2 is uncertain. Platelet-rich plasma gel along with the curettage of the distal radicular surface of the M2 improves periodontal healing. Anchor suture might be a better technique to use to maintain healthy periodontium after M3 surgery.
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Introduction

Third molars are present in 90% of the population, with 33% having at least one impacted third molar (Scherstein et al. 1989). The retention of impacted third molars, once they have been exposed to the oral environment and dental plaque, may lead to a more rapid periodontal attachment loss than is usually associated with adult periodontitis. Moreover, the communication within the oral cavity allows bacteria to colonize to the distal root surface of the resident second molar and either prevent normal development of the periodontium or aid in its destruction (Ash 1964).

The optimal management of impacted mandibular third molars (M3s) continues to challenge clinicians. An important issue to address is the risk of developing periodontal defects on the distal aspect of mandibular second molars (M2s) after M3 extraction (Dodson & Richardson 2007).

Several well-performed longitudinal studies have documented that extraction of M3 may result in bony periodontal defects on the distal surface of the adjacent second molar (Marmary 1985, Kugelberg 1990, 1990 a, Kugelberg et al. 1991, 1991a). Two years following M3 extraction, Kugelberg (1990) and Kugelberg et al. (1991) showed that 43.3 % of the study sample aged 26 years or older exhibited probing pocket depths >7 mm and 32.1% showed intrabony defects >4 mm.

Risk factors associated with bone loss following lower third molar extraction included age, direction of eruption, preoperative bony defects, and resorption of the M2 root surface (Kugelberg et al. 1991).

While several different treatment strategies have been proposed to decrease the risk for developing periodontal defects following M3 extraction, this study discus the commonly used strategies.

Results

Bone substitutes:

Osseous repair with demineralized bone powder (BMP) is unique (Urist 1965). It do not contain living cells or provide a scaffold for osteoconduction, instead, it induces transformation of local host mesenchymal cells into chondroblast followed by ossification. The sequence of bone formation is similar to that seen in normal endochondreal ossification (Glowacki et al. 1981, Kaban & Glowacki 1981, Reddi 1987). The fact that obligate resorption does not play a role in the early healing by demineralized implants has major implications. This difference in the mechanism of osseous repair may improve the long-term stability of the reconstruction of periodontal defects (Kaban 1982). Multiple human clinical trials have reported the use of DBP to repair bony periodontal defects because of chronic periodontitis (Pearson et al. 1981, Sonis et al. 1983, Yazdi & Schonfeld 1987, Bowen et al. 1989, Mellonig

1990, Guillemin et al. 1993, Masters et al. 1996); these studies have shown the efficacy of DBP in regenerating bone.

Authors proposed placing a graft of DBP at the time of M3 extraction to prevent the development of bony defects on the distal aspect of M2. Dodson (1996) in a pilot study, were 7 young patients enrolled with a mean age of 21.7 ± 3.7years, documented a statistically significant improvement in clinical attachment levels in disto-buccal aspect of M2 adjacent to the DBP grafted M3 extraction sites. This finding suggests that DBP may prevent the formation of periodontal defects around M2 after extraction of M3. The same author in another study (2004) considered only the subjects aged ≥ 26 years and concluded that DBP therapy did not offer predictable benefit in reducing the risk of developing a periodontal defect and there is increased risk of inflammatory complications associated with the treatment groups in 21% of cases. However, when concurrent high-risk factors are present (age ≥ 26 years, mesioangular or horizontal impactions, and preexisting periodontal defect defined as attachment level ≥ 3mm), patients may benefit from the use of DBP placed at the time of M3 extraction to enhance periodontal healing (Dodson 2005). The same results obtained by Hassan et al.(2012) when inorganic xenograft, composed of resorbable inorganic bovine hydroxyapatite, used as graft material in combination with a membrane for high risk subjects. In 2009, Sammartino et al. grafted mandibular third molar extraction sites with only bovine porous bone mineral and with bovine porous bone mineral plus collagen membrane. Their results showed that both treatment modalities are successful in PPD reduction and increased CAL gain. The bovine porous bone mineral with collagen membrane had the best outcome for the prevention of a second molar periodontal defect. However, in the study performed by Etiene et al. (2011) they reported that socket grafting with xenogeneic materials did not change the bone height and bone radiographic density in the long-term. The summery of bone substitute effects on bone regeneration in the different studies appear in (Table 1).

Table 1. Influence of bone substitute on periodontal healing.

Study	Sample size	Age (years)	Variable(s)	Grafting Material	Follow up (Months)	Effect of graft material on variable
Dodson. [26]	7	18-25	AL	DBP	6	Significant
Dodson [27]	12	26-38	AL/ PD	DBP	6	Not significant
Dodson [28]	13	26-48	AL	DBP	6	Significant
Sammartino et al, [30]	30	21-30	AL/ PD	Bovine bone/ Bovine bone+ membrane	72	Significant
Etiene et al, [31]	22	18-25	Crestal bone height	Xenograft	24	Not significant
Hassan et al, [29]	14	30-35	AL/ PD	Xenograft+ resorbable membrane	12	Significant

AL= Attachment level
PD= Probing depth
DBP= Demineralized bone powder

Flap design:

Several different flap designs have been developed to expose impacted mandibular third molars such as envelope (Szmyd), modified envelop (modified Szmyd), and triangular (3-cornored) flaps.

The envelope flap with a distal relieving incision to the mandibular ramus is the most common approach for lower third molar surgery (Jakse et al. 2002). Every preparation of a mucoperiosteal flap is an intervention to the area of the alveolar process and may induce loss of alveolar bone (Tavtigian 1970, Jakse et al. 2002, Kirtiloğlu et al. 2007). Every sulcular incision interferes with the periodontal ligament and may lead to compromised periodontal status (Jakse et al. 2002).

The effects of flap design on the postoperative periodontal health status of second molars were widely investigated by many researchers. Although Stephens et al (1983) have shown a decrease in periodontal pocket depth 3 months following third molar extractions using two types of flaps. However, there was no significant difference between the two flap designs examined. Observations of other studies over one to four years showed that after one year, there was no difference in relation to preoperative bone level of second molars(Grondahl & Lekholm 1973) and after four years there was an improvement in bone defects compared with two years postoperatively (Kugelberg 1990). Jakse et al (2002) in the evaluation of the two different flap designs, demonstrated that the Szmyd flap in lower third molar

surgery considerably influences primary wound healing. The modified triangular flap is significantly less conducive to the development of wound dehiscence when compared with classic envelop flap. Also in 2003, Suarez-Cunqueiro et al compared the effect of two different flap designs (marginal vs. paramerginal flap) on wound healing. The results, when subjected to statistical analysis, showed that the use of the marginal flap in impacted third molar surgery resulted in better primary wound healing at 5-day follow-up than the use of the paramarginal flap. Although the paramarginal flap has less pocket depth in the initial stages, there was no difference after the early follow-ups in that both designs obtained the same positive outcome at 3 months after surgery. These authors concluded ". . . there are no advantages of the use of a paramarginal flap instead of a traditional marginal flap for removing impacted third molars." This was further corroborated by Kirtiloğlu et al. (2007) as they concluded that the modified Szmyd flap has better primary periodontal healing than the 3-cornered flap 4 weeks after surgery, but did not influence it at 12 months. Rosa et al, did not demonstrate any statistically significant differences in measurements of probing depth, clinical attachment level, or bone level for the two types of flaps (Szmyd vs. 3-cornered) used in surgery (Rosa 2002).These results are in agreement with those of Quee et al.(1985) , Arta et al.(2011) and Schofield et al. (1988) who concluded ". . . the selection of a flap design for mandibular third molar surgery does not seem to have a lasting effect on the health of the periodontium on the distal of the second molar." Moreover, Groves and Moore (1970) reported bone loss on the distal aspect of the second molar, using any of three different flap designs.

The effect of flap design on periodontal health in the different studies summarized in (Table2).

Table 2. Influence of flap designs on periodontal healing

Study	Sample size	Age (years)	Variable(s)	Flap design	Follow up (Months)	Effect of flap design on variable
Stephens et al, [35]	15	20-26	PD	Envelop/ Triangular	3	Not significant
Quee et al, [40]	25	16-30	AL	Envelop/ Triangular	6	Not significant
Rosa et al, [38]	14	18-25	AL/PD/BL	Envelop/ Triangular	6	Not significant
Jakse et al, [32]	30	15-60	1ry wound healing	Envelop/ Triangular	0.5	Significant
Suarez-Cunqueiro et al, [37]	27	17-31	PD	Marginal/ Paramarginal	3	Not significant
			Wound healing		1/6	Significant
Kirtiloğlu et al, [33]	18	16-32	AL/PD	Mod. Szmyd/ Triangular	12	Not significant
Arta et al, [39]	20	16-18	AL/PD/BL	Envelop/ Triangular	6	Not significant

AL= Aattachment level
PD= Probing depth
BL= Bone level

Guided tissue regeneration:

Authors suggest that cells necessary for the regeneration of periodontal attachment apparatus appear to originate from the periodontal ligament (Nyman et al. 1982, Isidor et al. 1986). Studies on periodontal wound healing have resulted in the development of the treatment modality Guided Tissue Regeneration (GTR) (Nyman et al. 1980 and 1982, Gottlow et al. 1984, Karring et al. 1985, Gottlow et al. 1986). This treatment involves the placement of a barrier to cover the periodontal defect in such a way that the gingival tissues (epithelium and connective tissue) are prevented from contacting the root surface during healing. At the same time, a space is formed between the barrier and the root allowing periodontal ligament (PDL) cells to repopulate the denuded portion of the root and produce a new connective tissue attachment. New cementum with inserting connective tissue fibers as well as new bone will eventually be formed (Karapataki et al. 2000). A variety of GTR materials have been used as Gore-Tex® periodontal material which is a non-resorbable biocompatible membrane composed of expanded polytetrafluoro- ethylene (e-PTFE) and the resorbable polylactic acid (PLA) barrier (GUIDOR matrix barrier®). Resorbable barriers may have a great advantage over non-resorbable barriers provided their efficacy is at least equal. First, only one surgical procedure is required, which saves time and money and is safer and less troubling for the patient. Second, unnecessary trauma to newly formed tissue would be caused by a second intervention and might negatively influence healing is avoided (Karapataki et al. 2000 a). Many clinical trials studied the effectiveness of GTR techniques in the enhancement of periodontal healing distal to mandibular second molars after surgical removal of impacted M3 molars. Oxford et al, [51] used a non-resorbable GTR material in 12 patients with

bilateral soft tissue impacted M3 and concluded that the use of barrier material did not provide statistically significant differences in attachment level gain when comparing experimental versus control sites. However, the benefit of this technique was clinically evident when considering direct distal sites with initially deep probing depths. In addition, there were no significant improvement in probing pocket depth and alveolar bone level in a high-risk group of patients when a resorbable GTR membrane used in M3 extraction sockets by Karapataki et al. (2000). These results were inconsistent with two studies of Dodson (2004, 2005) when suggested that GTR therapy did not offer predictable benefit over no treatment. Conversely, Pecora et al. (1993) demonstrated a clinically and statistically significant benefit of non-resorbable GTR therapy over no treatment in subjects with multiple risk factors for M2 periodontal defects after M3 removal, that is, preexisting periodontal disease (attachment levels > 3 mm), older subjects (age > 26 years), and close proximity of the M3 to the M2 (horizontal or mesioangular impactions). By using resorbable membrane, the same results were obtained by Aimetti and Romano (2007). Also Karapataki et al. (2000 a) in another study, after placing resorbable or non-resorbable membranes in 19 patients their M3 extracted before 5 years or more they found statistically significant differences in the postoperative probing depth and attachment level. The effect of GTR material on bone regeneration in the different studies appear in (Table 3).

Table 3. Influence of GTR technique on periodontal healing

Study	Sample size	Age (years)	Variable(s)	Grafting Material	Follow up (Months)	Effect of graft material on variable
Pecora et al, [52]	10	>26	AL/PD	Non-resorbable membrane	12	Significant
Oxford et al, [51]	12	19-22	AL	Non-resorbable membrane	6	Not significant
Karapataki et al, [49]	20	25-43	PD/ BL	Resorbable membrane	12	Not significant
Karapataki et al, [50]	19	36-50	AL/ PD	Resorbable/ non resorbable membrane	12	Significant
Dodson [27]	12	26-38	AL/ PD	Resorbable membrane	6	Not significant
Dodson [28]	13	26-48	AL	Resorbable membrane	6	Not significant
Aimetti and Romano [53]	11	NA*	AL/ PD	Resorbable membrane	12	Significant

AL= Attachment level
PD= Probing depth
BL= Bone level
*Not assigned

Platelet-rich plasma:

Whitman et al. first introduced Platelet-rich plasma (PRP) to the oral surgery community in 1997. It is a material containing many autologous growth factors, such as platelet-derived growth factors (PDGF) and transforming growth factor-β. It may be used in repairing and preventing periodontal complications at the distal root of the second molar adjacent to the extracted third molar (Whitman et al. 1997, Marx et al. 1998, Camargo et al.2002). The mechanism by which PRP can influence periodontal regeneration is due to the presence of PDGF and TGF-β. Some in vitro studies (Strayhorn 1999) have suggested that PDGF acts principally on osteoblastic proliferation and that, on the other hand, morphogenetic proteins (which are part of the TGF-β superfamily) act as a cellular differentiation agent favoring the expression of markers of mineralization when they are incubated with preosteoblastic cells. This suggests that TGF-β could favor the differentiation of osteoblasts and cementoblasts and the production of fibronectin, a molecule involved in the adhesion of fibroblasts to the radicular surface and in the angiogenic process (Terranova & Martin 1982, Varga et al. 1987, de Obarrio et al. 2000). As the result of its fibrin content, the PRP gel permits stabilized coagulation of the blood, thereby favoring regeneration of the osseous defect, particularly in the early stages (Polson and Proye 1983, Wikesjo et al. 1992). PRP produced by sequential centrifugation of fresh autologous blood, producing plasma with an approximate threefold increase in the concentration of intact platelets. Calcium chloride (10%) added to PRP to initiate the clotting process and activation of the alpha granules of the platelets (Efeoglu et al. 2004, Freymiller and Aghaloo 2004, Gurbuzer et al. 2008).

The researchers studied the value PRP on the periodontal healing of M2 after surgical extraction of M3. Sammartino et al. (2005) showed that PRP is effective in reducing probing depth and improving attachment level, also inducing and accelerating bone regeneration at histological level but not clinically relevant. Nevertheless, it has a non-significant effect on gum recession measured 4 months after surgery.

Similarly, Sammartino et al. (2009) when they compare PRP VS. PPR with resorbable membrane indicating that the use of resorbable membrane did not confer any additional clinical benefit to the reconstructive effort. However, the improvement of bone level and bone density were a documented effect of PRP in other studies (Marx et al. 1998, Mancuso 2003, Kaul et al. 2012, Das et al. 2014). PRP also founded to accelerate wound healing through other studies (Marx et al. 1998, Mancuso 2003, Kaul et al. 2012), but Das et al. (2014) reported no effect on wound healing and this may be attributed to small-sized sample study. The effect of PRP on periodontal health in the available studies summarized in (Table 4).

Table 4. Influence of PRP on periodontal healing

Study	Sample size	Age (years)	Variable(s)	Material	Follow up (Months)	Effect of PRP on variable
Sammartino et al, [66]	18	21-26	AL/PD	PRP	4	Significant
			BR/Gum recession			Not significant
Sammartino et al, [67]	18	21-25	AL/PD	PRP/PRP+ resorbable membrane	4	Significant
			BR/Gum recession			Not significant
Kaul et al, [69]	25	18-70	PD/BL/BD	PRP	6	Significant
			Wound healing		1/4	Significant
Das et al, [68]	12	18-34	BD	PRP	2	Significant
			Wound healing		1/4	Not significant

AL= Attachment level
PD= Probing depth
BR= Bone regeneration
BL= Bone level
BD= Bone density

Scaling and root planning:

Recommendation of scaling and root planning after the extraction of the lower third molar is based on the fact that the distal root surface of lower second molar is often denuded and consequently exposed to bacteria and toxins. The contaminated cementum could impair periodontal healing and bone regeneration (Van-Swol & Mejias 1983, Lobera-Prado et al. 2003). Other authors (Ferreira et al. 1997, Gay-Escoda et al. 2004) recommend using ultrasound and mechanical scaling with curettes on the distal aspect of the lower M2 at the time of M3 extraction in order to obtain a hard, flat surface, thus enhancing periodontal healing. Pons-Vicente et al. (2009) studied the effect of manual versus ultrasonic scaling of lower second molars on pocket depth following lower third molar extraction. Both techniques are valuable in reducing probing depth but no significant difference that favor any one over another. Leung et al. (2005) when they compared the two treatment modalities obtained the same results.

The beneficial effect of scaling and root planning on the distal root surface of the M2 after extracting the M3 in order to improve attachment level and reducing pocket depth were also documented in previous studies (Van-Swol & Mejias 1983, Ferreira et al. 1997, Leung et al. 2005, Pons-Vicente et al. 2009). Scaling and root planning of the distal root surface were also founded to reduce bony defects related to lower M2 were also reported (Gröndahl & Lekholm 1973, Pons-Vicente et al. 2009). However, other reports that found no significant improvement in the periodontal health of the M2 scaled and root planed after M3 extraction (Ash et al. 1962, Osborne et al. 1982). The summery of scaling and root planning effect on periodontal health in different available studies appear in (Table 5).

Suturing technique:

The primary closure of the flap avoids suture dehiscence and improves wound healing (Jakse et al. 2002). The simple loop suture (Fig. 2) is a very widely used suturing technique usually preferred by surgeons evaluating the effect of third molar removal on the periodontal health of the adjacent second molar (Suarez-Cunqueiro et al. 2003, Pasqualini et al. 2005, Kirtiloğlu et al. 2007, Sanchis Bielsa et al. 2008). The anchor suture is another suturing technique that has been reported as one of the best suturing techniques to close a flap located in an edentulous area mesial or distal to a tooth. This suture closes the facial and lingual flaps and adapts them tightly against the tooth (Takei & Carranza 2007). Limited studies have evaluated the effect of this suturing technique regarding periodontal health status of second molars. Cetinkata et al. (2009) suggested that anchor suture

might be a better technique to use to maintain healthy periodontium and to prevent periodontal problems after the extraction of impacted third molars. They found that anchor suture technique, when compared with simple loop technique, significantly reduces probing depth and improves clinical attachment level. Kareem et al. (2012) also favoring the use of anchor suture technique over simple loop or figure-eight suturing technique. The previous two studies summarized in (Table 6).

Table 5. Influence of scaling and root planning on periodontal healing

Study	Sample size (N)	Age (years)	Variable(s)	Technique	Follow up (Months)	Effect of technique on variable
Osborne et al, [80]	18	18-25	PD	Scaling & root planning	12	Not significant
Ferreira et al, [74]	28	NA	PD/AL	Scaling & root planning	2	Significant
Leung et al, [77]	16/14*	32 (mean)	PD	Manual scaling/ Ultrasonic scaling	6	Not significant
Pons-Vicente et al, [76]	13/17**	19-52	PD/ BL	Manual scaling/ Ultrasonic scaling	6	Not significant

PD= Probing depth
Al= Attachment level
BL= Bone level
NA= Not assigned
*Manual scaling: Sample size =16, Ultrasonic scaling: Sample size =14
** Manual scaling: Sample size =13, Ultrasonic scaling: Sample size =17

Table 6. Influence of suturing technique on periodontal healing

Study	Sample size	Age (years)	Variable(s)	Technique	Follow up (Months)	Effect of technique on variable
Cetinkata et al 2009	15	16-21	CAL/PD	Loop suture/ Anchor suture	6	Significant
Kareem et al 2012	10	17-22	CAL/PD	Loop suture/ Anchor suture/ Closed anchor suture/ Figure 8 suture	6	Significant

AL= Attachment level
PD= Probing depth

Conclusion

The routine application of interventions to improve the periodontal parameters on the distal of the M2 at the time of M3 removal is not indicated for all subjects. There seems to be subjects at increased risk for periodontal defects after M3 removal (i.e., age ≥26 years, pre-existing periodontal defects [AL ≥3 mm or PDs ≥5 mm], and a horizontal or mesioangular impaction). In the setting of having all three risk factors present, there seems to be a predictable benefit to treating the dentoalveolar defect at the time of extraction (Dodson 2007).

Bone substitutes: There are conflicting results about the effect of bone grafting material; however, they may be valuable in high-risk group of patients.

Flap design: flap design in lower third molar surgery influences primary wound healing but does not seem to have a lasting effect on the health of the periodontium on the distal of the second molar.

GTR therapy: It seems not to offer predictable benefit. However, the benefit of this technique was clinically evident when considering cases with initially deep probing depths.

PRP: Provide a definite improvement in soft tissue healing and effective in inducing and accelerating bone regeneration after M3 molar surgery.

Scaling and root planning of the radicular surface of M2 together with oral hygiene control improves periodontal healing. There are no additional benefits in using ultrasound over the manual scaling and root planning.

Suturing technique: Anchor suture might be a better technique to use to maintain healthy periodontium after the extraction of impacted M3. The clinicians can feel free to choose the suturing technique that works best in their hands until the efficacy of anchor suturing technique is proved by further controlled studies in the larger patient groups (Cetinkaya et al. 2009).

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Corresponding author:
Dr. Abdurrahman Al-Samman
Specialized Dental Center in Tikrit / Salahiddin Health Directorate, Ministry of Health, IRAQ
abd_alsamman@yahoo.com

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References

1. Aimetti M and Romano F (2007) Use of resorbable membranes in periodontal defects treatment after extraction of impacted mandibular third molars. Minerva Stomatol. 56:497.
2. Arta SA, Kheyradin RP, Mesgarzadeh AH, et al (2011) Comparison of the influence of two flap designs on periodontal healing after surgical extraction of impacted third molars. J Dent Res Dent Clin Dent Prospects 5:1.
3. Ash M, Costich E, Hayward J.(1962) A study of periodontal hazards of the third molars. J Periodontol 33:209.
4. Ash MM (1964) Third molars as periodontal problems. Dent Clin North Am 8:51.
5. Bowen JA, Mellonig JT, Gray JL, et al (1989) Comparison of decalcified freeze-dried bone allograft and porous particulate hydroxyapatite in human periodontal osseous defects. J Periodontol 60:647.
6. Burcu Ozkan Cetinkaya, Mahmut Sumer, Ferda Tutkun, et al (2009) Influence of different suturing techniques on periodontal health of the adjacent second molars after extraction of impacted mandibular third molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 108:156.
7. Camargo PM, Lekovic V, Weinlaender M, et al (2002) Platelet-rich plasma and bovine porous bone mineral combined with guided tissue regeneration in the treatment of intrabony defects in humans. J Periodontal Res 37:300.
8. Das JR, Parambath PS, Arthur AS (2014) Efficacy of Platelet Rich Plasma in Third Molar Impaction Surgery, PRP in Third Molar Surgery. Universal Research Journal of Dentistry 4:36.
9. de Obarrio JJ, Arauz-Dutari JI, Chamberlain TM, et al (2000) The use of autologous growth factors in periodontal surgical therapy: Platelet gel biotechnology–Case reports. Int J Periodont Restorative Dent 20:486.
10. Dodson TB, Richardson DT. (2007) Risk of periodontal defects after third molar surgery: An exercise in evidence-based clinical cecision-making. Oral Maxillofacial Surg Clin N Am 19:93.
11. Dodson TB. (2005) Is there a role for reconstructive techniques to prevent periodontal defects after third molar surgery? J Oral Maxillofac Surg 63:891.
12. Dodson TB. (2007) Is there a role for reconstructive techniques to prevent periodontal defects after third molar surgery? Oral Maxillofacial Surg Clin N Am 19:99.
13. Dodson TB. (2004) Management of mandibular third molar extraction sites to prevent periodontal defects. J Oral Maxillofac Surg 62:1213.
14. Dodson TB. (1996) Reconstruction of alveolar bone defects following extraction of mandibular third molars: A pilot study. Oral Surg Oral Med Oral Pathol 82:241.
15. Efeoglu C, Ackay YD, Erturk (2004) Modified method for preparing platelet rich plasma: an experimental study. J Oral Maxillofac Surg 62:1403.
16. Etiene AM, Augusto B, Osny FJ, et al. (2011) Bone crestal height and bone density after third-molar extraction and grafting: A long-term follow-up study. Clin Oral Investigat 15:123.
17. Ferreira CE, Grossi SG, Novaes AB, et al. (1997) Effect of mechanical treatment on healing after third molar extraction. Int J Periodontics Restorative Dent 17:250.
18. Freymiller EG, Aghaloo TL (2004) Platelet rich plasma: Ready or not? J Oral Maxillofac Surg 62:484–488.
19. Gay-Escoda C, Piñera-Penalva M, Valmaseda-Castellón E. et al. (2004) Exodoncia quirúrgica. Complicaciones. In: Gay-Escoda C, Berini-Aytés L, editors. Tratado de Cirugía Bucal. Madrid: Ergon; p. 388.
20. Glowacki J, Kaban LB, Murray JE, et al. (1981) Application of the biological principle of induced osteogenesis for craniofacial defects. Lancet 1:595.

21. Gottlow J, Nyman S, Karring T, et al. (1984) New attachment formation as the result of controlled tissue regeneration. J Clin Periodontol 11: 494.
22. Gottlow J, Nyman S, Lindhe J, et al. (1986) New attachment formation in the human periodontium by guided tissue regeneration. Case reports. J Clin Periodontol 13: 604.
23. Gröndahl H, Lekholm U. (1973) Influence of mandibular third molars on related supporting tissues. Int J Oral Surg ;2:137
24. Groves BJ & Moore JR (1970) The periodontal implications of flap design in lower third molar extractions. Dent Pract Dent Rec 20:297.
25. Guillemin MR, Mellonig JT, Brunsvold MA (1993) Healing in periodontal defects treated by decalcified freeze-dried bone allografts in combination with e-PTFE membranes. I. Clinical and scanning electron microscope analysis. J Clin Periodontal 20:528.
26. Gurbuzer B, Pikdoken L, Urhan M, Suer T, Narin Y (2008) Scintigraphic evaluation of early osteoblastic activity in extraction sockets treated with platelet rich plasma. J Oral Maxillofac Surg 66:2454.
27. Hassan KS, Marei HF, Alagl AS (2012) Does Grafting of Third Molar Extraction Sockets Enhance Periodontal Measures in 30- to 35-Year-Old Patients? J Oral Maxillofac Surg 70:757.
28. Isidor E, Karring T, Nyman S, et al. (1986) The significance of coronal growth of periodontal ligament tissue for new attachment formation. Ctin. Periodontol 13:145.
29. Jakse N, Bankaoglu V, Wimmer G, et al. (2002) Primary wound healing after lower third molar surgery: Evaluation of 2 different flap designs. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 93:7.
30. Kaban LB & Glowacki J (1981) Induced osteogenesis in the repair of experimental mandibular defects in rats. J Dent Res 60:1356.
31. Kaban LB, Mulliken JB, Glowacki J (1982) Treatment of jaw defects with demineralized bone implants. J Oral Maxillofac Surg 40: 623.
32. Karapataki S, Hugoson A, Falk H, et al. (2000) Healing following GTR treatment of intrabony defects distal to mandibular 2nd molars using resorbable and non-resorbable barriers. J Clin Periodontol 27: 333.
33. Karapataki, S., Hugoson, A., Kugelberg, C (2000) Healing following GTR treatment of bone defects distal to mandibular second molars after surgical removal of impacted third molars. J Clin Periodontol 27: 325.
34. kareem JJ, Jawad K, Badiea RA, et al. (2012) Impact of suturing techniques on the periodontal health status of mandibular second molar after extraction of fully impacted third molars. Tikrit Journal for Dental Sciences 2:154.
35. Karring, T., Isidor, F., Nyman, S. & Lindhe, J (1985) New attachment formation on teeth with a reduced but healthy periodontal ligament. J Clin Periodontol 12**,** 51.
36. Kaul PR. Godhi SS. Singh A (2012) Autologous platelet rich plasma after third molar surgery:A comparative study. J. Maxillofac. Oral Surg. 11:200.
37. Kirtiloğlu T, Bulut E, Sümer M, et al. (2007) Comparison of 2 flap designs in the periodontal healing of second molars after fully impacted mandibular third molar extractions. J Oral Maxillofac Surg 65:2206.
38. Kugelberg CF, Ahlstrom U, Ericson S, et al. (1991) Periodontal healing after impacted lower third molar surgery in adolescents and adults. A prospective study. Int J Oral Maxillofac Surg 20:18.
39. Kugelberg CF, Ahlstrom U, Ericson S, et al. (1991) The influence of anatomical, pathophysiological, and other factors on periodontal healing after impacted lower third molar surgery: A multiple regression analysis. J Clin Periodontal 18:37.
40. Kugelberg CF (1990) Impacted lower third molars and periodontal health: An epidemiological, methodological, retrospective and prospective clinical study. Swed Dent J Suppl 68:1.
41. Kugelberg CF (1990) Periodontal healing two and four years after impacted lower third molar surgery: A comparative retrospective study. Int J Oral Maxillofac Surg 19:341.
42. Leung WK, Corbet EF, Kan KW (2005) A regimen of systematic periodontal care after removal of impacted mandibular third molars manages periodontal pockets associated with the mandibular second molars. J Clin Periodontol 32:725.
43. Lobera-Prado K, Vallcorba-Plana N, Uribarri-Echevarría A, et al. (2003) Niveles de inserción en distal del segundo molar después de la extracción del tercer molar inferior. Rev Eur Odonto Estomatol 15:129.
44. Mancuso JD (2003) Platelet rich plasma: a preliminary report in routine impacted mandibular third molar surgery and prevention of alveolar osteitis. Am Assoc Oral Maxillofac Surg 61:276.
45. Marmary Y, Brayer L, Tzukert A, et al. (1985) Alveolar bone repair following extraction of

impacted mandibular third molars. Oral Surg Oral Med Oral Pathol 60:324.
46. Marx RE, Carlson ER, Eichstaedt RM, et al. (1998) Platelet rich-plasma: a source of multiple autologous growth factors for bone grafts. Oral Med Oral Pathol Oral Radio Endodl 85:638.
47. Marx RE, Carlson ER, Eichstaedt RM, et al. (1998) Platelet-rich plasma: Growth factor enhancement for bone grafts. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 85:638.
48. Masters LB, Mellonig JT, Brunsvold MA, et al. (1996) A clinical evaluation of demineralized freeze-dried bone allograft in combination with tetracycline in the treatment of periodontal osseous defects. J Periodontol 67:770.
49. Mellonig JT (1990) Periodontal bone graft technique. Int J Periodont Res Dent 10:289.
50. Nyman S, Gottlow T, Karring, T, et al. (1982) The regenerative potential of the periodontal ligament. An experimental study in the monkey. J. Ctin. Periodontoi 9: 257.
51. Nyman S, Karring T, Lindhe J, et al. (1980) Healing following implantation of periodontitis affected roots into gingival connective tissue. J Clin Periodontol 7, 394.
52. Osborne WH, Snyder AJ, Tempel TR. (1982) Attachment levels and crevicular depths at the distal of mandibular second molars following removal of adjacent third molars. J Periodontol 53:93.
53. Oxford GE, Quintero G, Stuller CB, et al. (1997) Treatment of 3rd molar-induced periodontai defects with guided tissue regeneration, J Clin Periodontol 24: 464.
54. Pasqualini D, Cocero N, Castella A, et al. (2005) Primary and secondary closure of the surgical wound after removal of impacted mandibular third molars: a comparative study. Int J Oral Maxillofac Surg 34:52.
55. Pearson GE, Rosen S, Deporter DA (1981) Preliminary observations on the usefulness of a decalcified, freeze-dried cancellous bone allograft material in periodontal surgery. J Periodontal 52:55.
56. Pecora G, Celleti R, Davapanah M, et al. (1993) The effects of guided tissue regeneration on healing after impacted mandibular thirdmolar surgery: 1-Year results. Int J Periodont Restor Dent 13: 397.
57. Peterson L (1993) Principles of management of impacted teeth. In: Peterson L, Ellis E, Hupp J, Tucher M, editors. Contemporary oral and maxillofacial surgery. 2nd ed. St. Louis: Mosby; p. 225.
58. Polson AM & Proye MP (1983) Fibrin linkage: A precursor for new attachment. J Periodontol 54:141.
59. Pons-Vicente O, Valmaseda-Castellón E, Berini-Aytés L, et al. (2009) Effect on pocket depth and attachment level of manual versus ultrasonic scaling of lower second molars following lower third molar extraction.Oral Surg Oral Med Oral Pathol Oral Radiol Endod 107:11.
60. Quee TAC, Gosselin D, Millar EP, et al. (1985) Surgical removal of the fully impacted mandibular third molar. The influence of flap design and alveolar bone height on the periodontal status of the second molar. J Periodontol 56:625.
61. Reddi AH, Wientroub S, Muthukumaran N (1987) Biologic principles of bone induction. Orthop Clin North Am 18:207.
62. Rosa AL, Carneiro MG, Lavrador MA, et al. (2002) Influence of flap design on periodontal healing of second molars after extraction of impacted mandibular third molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 93:404.
63. Sammartino G, Tia M, Eva Gentile E, et al. (2009) Platelet-rich plasma and resorbable membrane for prevention of periodontal defects after deeply impacted lower third molar mxtraction. J Oral Maxillofac Surg 67:2369.
64. Sammartino G, Tia M, Bucci T, et al. (2009) Prevention of mandibular third molar extraction-associated periodontal defects: A comparative study. J Periodontol 80:389.
65. Sammartino G, Tia M, Marenzi G, di Lauro AE, et al. (2005) Use of Autologous platelet-rich plasma (PRP) in periodontal defect treatment after extraction of impacted mandibular third molars. J Oral Maxillofac Surg. 63:766.
66. Sanchis Bielsa JM, Hernández-Bazán S, Peñarrocha Diago M (2008) Flap repositioning versus conventional suturing in third molar surgery. Oral Patol Oral Cir Bucal 13:138.
67. Scherstein E, Lysell L, Rohlin M (1989) Prevalence of impacted third molars in dental students. Swed Dent J 18:7.
68. Schofield ID, Kogon SL, Donner A (1988) Long-term comparison of two surgical flap designs for third molar surgery on the health of the periodontal tissue of the second molar tooth. J Can Dent Assoc 54:689.
69. Sonis ST, Kaban LB, Glowaki J (1983) Clinical trial of demineralized bone powder in the treatment of periodontal defects. J Oral Med 38:117.
70. Stephens RJ, App GR, Foreman DW (1983) Periodontal evaluation of two mucoperiosteal

flaps used in removing impacted mandibular third molars. J Oral Maxillofac Surg 41:719.
71. Strayhorn CL, Garrett JS, Dunn RL, et al. (1999) Growth factors regulate expression of osteoblast-associated genes. J Periodontol 70:1345.
72. Suarez-Cunqueiro MM, Gutwald R, Reichman J, et al. (2003) Marginal flap versus paramarginal flap in impacted third molar surgery: a retrospective study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 95:403.
73. Takei HH & Carranza FA (2007) The periodontal flap. In: Newman MG, Takei HH, Klokkevold PR, Carranza FA, editors. Carranza's clinical periodontology. 10th ed. St Louis: Saunders Elsevier; p. 926.
74. Tavtigian R (1970) The height of the facial radicular alveolar crest following apically positioned flap operations. J Periodontol 41:412.
75. Terranova VP & Martin GR (1982) Molecular factors determining gingival tissue interaction with tooth structure. J Periodontal Res 17:530.
76. Urist MR (1965) Bone formation by autoinduction. Science 150:893.
77. Van-Swol R & Mejias J (1983) Management and prevention of severe osseous defects distal to the second molar following third molar extraction. Int J Periodontics Restorative Dent 3:47.
78. Varga J, Rosenbloom J, Jimenez SA (1987) Transforming growth factor beta (TGF beta) causes a persistent increase in steadystate amounts of type I and type III collagen and fibronectin mRNAs in normal human dermal fibroblasts. Biochem J 247:597.
79. Whitman DH, Berry RL, Green DM (1997) Platelet gel: An autologous alternative to fibrin glue with applications in oral and maxillofacial surgery. J Oral Maxillofac Surg 55:1294.
80. Wikesjo UM, Nilveus RE, Selvig KA (1992) Significance of early healing events on periodontal repair: A review. J Periodontol 63: 158.
81. Yazdi M, Schonfeld SE (1987) Demineralized bone matrix in treatment of periodontal defects. A review of the literature. J West Soc Periodontal 35:105.

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