



WHITE PAPER ON THIRD MOLAR DATA

A [Task Force](#) was convened by the American Association of Oral and Maxillofacial Surgeons in March 2007 to review the current literature with regard to selected aspects relating to third molars and their removal. Databases reviewed included Ovid Medline, PubMed, Google Scholar, and the Cochrane Database. Case reports were excluded. ([Bibliography](#))

The topics addressed are:

- Natural History of Third Molars
[Conclusions](#)
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1. The Natural History of Third Molars

Clinical Question: Can the course of an unerupted third molar be predicted?

Background: The ability to accurately predict third molar eruption would allow clinicians to improve third molar treatment strategies. Several factors have been proposed to play a role in determining the likelihood of eruption, including tooth angulation, degree of root development, depth relative to the occlusal plane, size of the tooth, and the available space

for eruption (generally described as the mandibular ramus [Xi point] and the distal of the second molar). A shortcoming of most available studies is the absence of a periodontal examination of patients with erupted third molars.

The following points are supported by the literature:

- The most significant variable associated with third molar impaction is inadequate hard tissue space, with the vast majority of impacted third molars having space/crown width ratios of less than 1. (Ganss 1993, Forsberg 1989, Hattab 1999)
- It is possible to measure space for eruption to the occlusal plane using a variety of radiographic techniques. (Ganss 1993, Venta 1997)
- Unerupted teeth can change position even beyond the middle of the third decade of life. (Venta 2004)
- Because there is no completely reliable way to predict pathologic changes associated with impacted teeth, the life cycle of impacted teeth should be monitored periodically with radiographs. (Kahl 1994)
- Eruption to the occlusal plane does not ensure proper periodontal support, that is, adequate osseous space does not guarantee adequate physiologic space for the maintenance of a tooth in good health. (Nance 2006, Gungormus 2002)

Conclusions

While it is not possible to predict eruption of third molars in all cases, adequate space between the anterior border of the mandible and the distal of the mandibular second molar seems to be necessary to allow successful eruption to the occlusal plane. Assessment of this space can be determined using a variety of radiographic techniques. However, eruption to the occlusal plane does not imply a good state of health, particularly with respect to soft tissue support. Finally, third molars that remain impacted after the age of 25 may still change in position.

2. Periodontal Considerations in Third Molar Removal

Presence of a Third Molar: The potential for pathologic sequelae associated with impacted third molars has long been a concern and was the focus of a 1988 NIH conference, “Removal of Third Molars.” A retrospective study of panoramic radiographs revealed a relatively low incidence of periodontal ligament damage and bone loss (4.5%) and resorption of the distal surface of the second molar (3.1%). (Stanley 1988) Assessment of root resorption on the distal surface of the second molar adjacent to non-erupted third molars using periapical radiographs indicated a much higher frequency of root resorption (24.2%) that was positively correlated with age. An even higher prevalence (42%) of disruption of the periodontal ligament without root resorption was noted by Nemcovsky. (1996) Resorption of the distal of the second molar is associated with both mesioangular and horizontal impactions. (Knutsson 1996) A greater probability of probing pocket depth ≥ 5 mm on the distal of the second molar when a visible third molar is present has been found in large scale national studies, e.g., National Health and Nutrition Examination Survey (NHANES) III and the Artherosclerosis Risk in Communities study (Elter 2004, Elter 2005). In similar clinical circumstances, pocket depth ≥ 5 mm has been shown to be associated with loss of attachment ≥ 1 mm. (Blakey 2002)

Conclusion

The presence of impacted third molars adversely affects the periodontium of adjacent second molars as reflected in disruption of the periodontal ligament, root resorption, and pocket depth associated with loss of attachment.

Third Molar Removal: Virtually all of the literature regarding the impact of third molar removal on the periodontium of adjacent teeth has focused on the mandibular third molar. The effect of third molar removal as assessed by attachment levels, pocket depth and/or alveolar bone height on the distal surface of the adjacent second molar has been reported as being detrimental. (Kuang-Yao 2001, Kugelberg 1991, Quee 1985, and Kan 2002) The existence of an intrabony defect on the distal of the second molar, age at the time of surgery (older adults more likely to have adverse outcomes), the size of the third molar/second molar contact area, and inadequate post-extraction plaque control have been identified as being associated with loss of periodontal attachment following third molar removal. Conversely, others have reported no deleterious effects. (Krausz 2005, Richardson 2005) A Medline literature search identified 2 cohort studies and 6 randomized clinical trials with a minimum of six month follow-up that satisfied the inclusion criteria for pre and post operative measurements of attachment level or pocket depth on the distal of the second molar. (Richardson 2005) Collectively, these studies did not demonstrate negative changes in attachment level or pocket depth beyond the >2 mm adopted as the threshold for clinical significance. However, patients with a healthy pre-operative periodontium were at increased risk for loss of attachment or increased pocket depth after third molar surgery. One year postoperative comparisons of age groups ≤ 20 years v. ≥ 30 years demonstrated the advantage of early removal, and longer term (2 and 4 yrs.) comparisons of improvement in intrabony defects following third molar removal assessed radiographically were seen primarily in younger (≤ 25 years) patients. (Kugleberg 1991, Kugleberg 1990)

Conclusion

The removal of impacted third molars can negatively impact the periodontium of adjacent second molars. The preoperative existence of an intrabony defect, age of the patient, and level of plaque control may serve to predict adverse outcomes.

Reduction in Post-Operative Loss of Periodontal Attachment: Flap design does not appear to negate periodontal attachment loss on the adjacent second molar. (Quee 1985, Rosa 2002) Employment of a buccal window and a specific approach to tooth division have been advocated as ways to prevent periodontal defects, but these approaches have not been subjected to randomized controlled clinical trials. (Motamedi 2006, Montamedi 1999) A comparison of distolingual alveolectomy and tooth division techniques favored the former in terms of pocket depth and attachment levels, depending on the position of the impaction in relation to the occlusal plane or cervical line. (Chang 2004),

Guided tissue regeneration (GTR) has not been shown to result in periodontal attachment level gains, pocket depth reduction, or other differences between experimental GTR and control sites. (Oxford 1997, Karapataki 2000, Dodson 2004) There was a tendency for

greater attachment level gains in sites with deep impactions, defined as >6 mm probing depths on the mid-distal surface of the adjacent second molar. (Oxford 1997) The use of demineralized bone powder (DBP) does not appear to offer an advantage, except for patients considered to be at high risk (age \geq 26 yrs., pre-existing attachment loss \geq 3 mm, mesioangular or horizontal impaction), of minimizing development of second molar periodontal defects (Dodson 2004, Dodson 2005). Debridement of the distal root of the second molar at the time of third molar removal has been shown to result in shallower pocket depths post-operatively. (Leung 2005) Scaling and root planing of the exposed root surfaces and post-operative plaque control may have masked the ability to demonstrate an added beneficial effect of GTR or DBP in other than high risk patients. (Oxford 1997, Karapataki 2000, Dodson 2004, Dodson 2005)

Conclusions

- *No single surgical approach to the removal of third molars that will minimize loss of periodontal attachment was identified.*
- *GTR and/or DBP may be beneficial in instances where there is evidence of significant pre-existing attachment loss.*
- *Scaling, root planing, and plaque control have the potential to reduce post-operative loss of attachment.*
- *Further research is needed to clarify under what conditions GTR and/or DBP can contribute to minimizing post-operative periodontal defects.*

Risk Factor: An additional dimension to the topic of periodontal implications of third molars is whether the presence of a third molar, asymptomatic or otherwise, *per se*, influences the risk for adjacent teeth to develop periodontitis.

Unfortunately, the majority of epidemiological studies of periodontal status of adults, as well as studies seeking to assess the validity and reliability of partial mouth examinations, have chosen to exclude third molars, presumably because of a concern for reproducible measurements, a concern recently shown to be unwarranted (Brown 1990, Tu 2004a, 2004b, Bhat 1991, Stoltenberg 1993 and Brown 1996, and Borges-Yanez 2004, Moss 2006). The exclusion of third molars increases the probability for underestimation of the prevalence and severity of periodontitis.

There are at least four (4) types of information that could support a hypothesis that the presence of third molars negatively influences the progression and/or severity of periodontitis effecting adjacent teeth:

- 1) An association of third molars with greater periodontal disease severity.
- 2) An association between the presence of third molars and progressive loss of attachment on non-third molars with emphasis on second molars.
- 3) The influence of third molars on periodontal micro flora, especially the putative pathogens, and on molecular markers of inflammation.
- 4) The effect of third molar removal on 2 and 3 above.

Periodontal Disease Severity: As described above, greater probing pocket depth on second molars adjacent to impacted third molars, before and after third molar removal, has been

reported in individual studies. (Kugelberg 1990) Large national studies, e.g., NHANES III and the Arthrosclerosis Risk in Communities study, found a greater probability of probing pocket depth ≥ 5 mm on the distal of second molars when a visible third molar is present. (Elter 2006, Elter 2005) In similar circumstances, pocket depth ≥ 5 mm has been shown to be associated with loss of attachment ≥ 1 mm. (Blakey 2002) Patients with visible third molars have been shown to have greater overall (absent, mild or severe) levels of periodontal disease severity, based on assessments of pocket depth and bleeding on probing. (Moss 2007)

Periodontal Disease Progression: The presence of third molars has been associated with pocket depth ≥ 5 mm on the distal of the second molar or around third molars in a significant proportion (25%) of patients. (Blakey 2002) Moreover, periodontal disease progression in third molar regions is associated with pocket depth and bleeding on probing at baseline. (Moss 2007) Equally important, non-third molar pocket depth has been shown to be progressive, even though the patients' third molars were asymptomatic. (Blakey 2007) Pocket depth was assessed in patients with 4 asymptomatic third molars followed over an average of 5.9 years and a minimum of 4 years. A significant increase was found in the proportion of subjects with at least 1 pocket ≥ 4 mm in depth in non-third molar regions. This relationship takes on added significance given findings in a 10-year assessment of factors purported to contribute to estimations of prognosis, where molar teeth were 1 of only 3 factors to have prognostic value. (Muzzi 2006)

Bacteria and Mediators of Inflammation: Understanding of the bacterial etiology of periodontitis has evolved from a characterization of the pathogenic sub-gingival flora as simply being composed of predominantly gram-negative organisms, to a set of putative pathogens organized as a biofilm, to a more defined description of clusters of specific bacteria associated with more severe periodontal disease as reflected in deeper pocket depths and bleeding on probing, and refractory disease (Socransky 1998, Socransky 2002). Following the approach developed by Socransky, White found these pathogenic clusters of organisms associated with periodontitis in pockets ≥ 5 mm with loss of attachment at sites on third molars and distal of the second molar in association with asymptomatic third molars in young adults. (White 2002) In addition, biochemical mediators of inflammation were found to be elevated in similar clinical circumstances. (White 2002) Furthermore, when patients with asymptomatic third molars were followed over an average of 2.2 years, an increase in pocket depth of at least 2 mm was found in 24% of patients. (White 2006) The likelihood of change was related to pocket depth ≥ 4 mm and the presence of bacterial complexes associated with periodontitis at baseline.

Treatment: Over 20 years ago Rajasus, et al, reported that total bacterial counts at second molar sites decreased after extraction of adjacent visible asymptomatic third molars. (Rajasus 1993) The organisms were identified as "Black-pigmented" gram-negative bacteria and *Actinobacillus actinomycetemcomitans*. The authors postulated that erupting third molars might harbor bacteria that could be harmful to adjacent teeth and the removal of third molars could eliminate potential foci of infection. This concept received little attention until 1996 when elevated bacterial counts were reported to occur in first molar and second molar sites in association with symptomatic visible third molars. (Blakey 1996) Treatment of the third molar reduced symptoms but not the bacterial counts. Following removal, microbial counts

decreased further but not to levels of the controls. Furthermore, scaling and root planing did not result in comparable reductions in total counts of periodontal pathogens for patients with visible third molars as compared to patients without third molars. (Moss 2007)

Conclusions

- *The presence of visible third molars is associated with overall elevated levels of periodontitis and that of immediately adjacent teeth.*
- *In the presence of visible third molars, periodontitis involving adjacent teeth is progressive and only partially responsive to therapy.*
- *The evaluation of a visible third molar for removal should include an assessment of the periodontium associated with both the third molar itself and that of adjacent teeth, and include anatomical limitations to mechanical removal of plaque. The presence of pocket depths of $\geq 4-5$ mm and/or bleeding on probing should be recognized as possible predictors of future progression of periodontitis.*
- *The association of overall increased disease severity in the presence of visible third molars, the progressive nature of periodontitis involving non-third molars when third molars are present, the relationship between visible third molars and bacteria associated with severe and refractory periodontitis, and the negative impact of visible third molars on treatment outcomes all lend support to the hypothesis that third molars should be considered as a possible predictor of periodontitis.*
- *Third molars should be included in studies of periodontal disease prevalence and severity, and in studies assessing factors that may indicate an increased risk for periodontal disease.*

3. The Microflora Around the Second and Third Molars

Inflammation of enveloping mucosa and gingiva are frequently associated with the eruption of third molars. Pericoronitis, an acute infection with clinical symptoms including pain, swelling, erythema, and purulence are not uncommon. In the majority of cases the flora found in an anaerobic atmosphere predominates. The bacteria most commonly detected are α -hemolytic streptococci and the genera *Prevotella*, *Veillonella*, *Bacteroides* and *Capnocytophaga*, all of which can be detected in the gingival crevice surrounding third molars or adjacent teeth. (Sixou 2003) The microbiologic flora associated with pericoronitis is diverse, with over 440 microorganisms implicated, including obligate anaerobic bacteria and facultative anaerobic microflora, which result in suppurative infections. (Peltroche-Llacsabuanga 2000) Pericoronitis can progress to significant life threatening infections. Treatment must be employed to limit morbidity and mortality. Accepted treatment regimens include antibiotic therapy coupled with surgical intervention. Surgical removal of the tooth associated with the infection is curative.

The absence of clinical symptoms (asymptomatic) does not indicate absence of disease or pathology. Microbial complexes (“red” and “orange” complex species) associated with periodontal pathology have been detected in the second molar/third molar region in patients with asymptomatic third molars. (White 2002a) These same subgingival microbial profiles have been associated with periodontitis refractory to periodontal therapy. (Socransky 2002)

The presence of inflammatory mediators (Prostaglandin E₂, Interleukin 1 β) in the gingival crevicular fluid are markers of chronic oral inflammation and have been shown to be associated with periodontitis, which is diagnosed by the presence of periodontal probing depths > 5 mm in the third molar region with associated periodontal attachment loss. (White 2002b) The clinical findings of increased periodontal probing depths and periodontal attachment loss, coupled with colonization of periodontal pathogens, support the concept that clinical and microbial changes associated with the initiation of periodontitis may present first in the third molar region (White 2002a). There is also evidence that chronic oral inflammation leads to a progression of periodontal disease in the third molar region over time. (White 2006) Pathology, as detected by these measures, exists in the third molar area without symptoms noticed by the individual affected.

Periodontal disease progresses in the second molar and third molar region over time in subjects with asymptomatic third molars. Probing depths increased, which indicated a deteriorating periodontal condition. (Blakey 2006) In older adults, visible third molars have been associated with more severe periodontal conditions, including an increased risk of probing depths of \geq 5 mm on adjacent second molars, which suggests progression of disease without symptoms. (Elter 2005)

Third molar periodontal pathology and resultant inflammation may have a negative systemic impact as indicated by research on obstetric outcomes in individuals with asymptomatic retained third molars. (Moss 2006)

Conclusions

Data on microflora and asymptomatic disease in the third molar region show:

- *Absence of symptoms does not indicate absence of disease or pathology.*
- *Pathogenic bacteria (red and orange complexes) in clinically significant numbers exist in and around asymptomatic third molars.*
- *Periodontal disease as indicated by probing depths \geq 4 mm exists in and around asymptomatic third molars.*
- *Indicators of chronic inflammation exist in periodontal pockets in and around asymptomatic third molars.*
- *Periodontal disease progresses in the absence of symptoms.*

4. The Effects of Age on Various Parameters Relating to Third Molars

Symptomatology and Age: A study of 1,151 patients from 13-69 years of age with third molars showed that of those who had symptoms, pain was the most common symptom (35.3%), followed by swelling (21.7%), discomfort from food impaction (3.6%), and purulent discharge (3%). (Punwutikorn 1999) The frequency of each increased generally with age. Slade also noted that 37% of patients presenting with wisdom tooth problems reported pain and swelling as the indication for seeking treatment. (2004) Additionally, this study noted that Health Related Quality of Life indicators were reported more frequently as patients got older.

Periodontal Pathology and Age: Asymptomatic periodontal defects associated with third molars are more common in patients older than 25 (33%) than those under 25 (17%). (Blakey 2002) Inflammatory mediators and periodontal pathogens were similarly correlated with the periodontal defects. (White 2002) On two year follow-up, 24% of the periodontal defects deteriorated by a further 2 mm. (White 2006). A study of 6,793 persons 52 to 74-years old, found that they had 1.5 times the odds of having a periodontal defect > 5 mm on the adjacent second molar if the third molar was visible. (Elter 2005) A comparison of 5,831 patients aged 25 to 34 with a group aged 18 to 24 showed a 30% greater chance of having a periodontal defect on the adjacent second molar when a third molar was present in the older age group versus the younger age group. (Elter 2004) In a study of 342 subjects with a mean age of 73 who had at least one third molar present at three year follow-up, attachment losses ≥ 2 mm were detected on the third molars in 45% of subjects. (Moss 2007)

Caries and Age: Caries prevalence in 342 subjects with a mean age of 73 years with at least one third molar present showed an increased caries prevalence in the third molars over time. (Moss 2007) Another study of 22 to 32-year-old cohorts followed for three years, showed that caries prevalence in the third molars also increased with time in this younger age group. (Shugars 2005) Caries were also correlated in third molars with the experience in non-third molars. (Moss 2007, Shugars 2005) Shugars suggested that a 40% risk of caries in erupted third molars exists before the end of the third decade. Patients over 25 years of age have a greater caries experience compared to patients under 25 years of age. (Shugars 2004)

Postoperative Risks and Age: A critical review showed lower postoperative morbidity in a younger age group of patients. (Mercier 1991) All risks associated with third molar removal increased from age under 25, to 25 to 35, to over 35. (Bruce 1980). Health Related Quality of Life indicators similarly deteriorated for recovery as correlated with age following third molar removal. (Phillips 2003) A study of 4,004 patients showed a 1.5 times likelihood of a complication if the patient having third molars removed at over 25 years of age with generalized increasing risks with age through age 65. (Strizinas and Dodson In Press) Similarly, in a study of 583 patients, age was correlated with risk. (Bui 2003) Other studies also show that postoperative risks increase with increasing age. (Valmaseda-Castellon 2001 and Bataineh 2001) A consensus of the literature supports the concept that postoperative risks from third molar removal increase with age.

The risk of postoperative fracture following third molar removal may be age related, and one study shows a mean age at fracture to be 45 years. (Krimmel 2000) The incidence of oroantral perforation from upper third molar removal may also increase with age past 21 years. (Rothamel 2006)

Postoperative periodontal defects occur twice as commonly (51%) in patients over 26 years of age, than those under 25 following third molar removal. (Kugelberg 1990) Significant postoperative defects in 215 second molars were three times more common when removing impacted third molars over the age of 25 than under the age of 25. (Kugelberg 1991) Pockets on the second molars in 215 cases were studied two years postoperatively. Persistence of postoperative periodontal defects compared to preoperative defects in these patients were shown to be age related. (Kugelberg 1985) Postoperative periodontal defects after third

molar extraction are two to three times more common over the age of 25, and persistence of defects was age related.

Germectomy or Lateral Trepanation: For the purposes of this document, germectomy is defined as the removal of a tooth that has one third or less of root formation and also has a radiographically discernible periodontal ligament. A study of 15 cases of early third molar removal in patients aged between 13 and 16 years of age showed no postoperative periodontal pocketing and no pocketing developing one year later. (Ash 1962) In a study of 500 lower wisdom teeth removed in patients aged 9 to 16, there were no cases of alveolar osteitis, nerve involvement, or second molar damage, and a 2% infection rate was reported. (Chiapasco 1995) In a study where germectomy was performed in 300 teeth in patients aged 12 to 19 years of age, there were no lingual nerve injuries. (Chossegros 2002) A study of 149 germectomies reported a 2% infection rate and no case of nerve involvement. (Avendano 2005) A study of 86 patients aged 8 to 17 years, having 172 germectomies, reported that three patients developed infection, and no cases of nerve involvement or alveolitis were encountered. (Bjornlang 1987) It does appear that early third molar removal may be associated with a lower incidence of morbidity and also less economic hardship from time off work for the patient.

The Presence of Third Molars and Age: One study noted that between 1997 and 2002 there was an increase in patients over the age of 40 requiring third molar removal. (Kaminishi 2006) The number increased from 10.5% to 17.3% of all third molars removed. This was felt to be due to changing demographics in the geographical areas served by this study. It does appear that the eruption of third molars in older patients is more frequent than may be thought, but in some cases, rather than the third molar erupting, it may become visible due to periodontal bone loss and subsequent gingival recession and exposure. (Garcia 1989) Many of these late erupting teeth have pathology, including caries and periodontal disease. (Garcia 1989) A study of 14 to 45 year olds found that 51% of 312 late erupting third molars had periodontal disease in a 2.2 year follow-up. (Nance 2006)

Conclusions

- *Periodontal defects, as assessed by pocket depths, deteriorate with increasing age in the presence of retained third molars.*
- *Caries in erupted third molars increases in prevalence with increasing age.*
- *The incidence of postoperative morbidity following third molar removal is higher in patients > 25 years.*
- *Germectomy may be associated with a lower incidence of postoperative morbidity.*

5. Orthodontic and Prosthodontic Considerations in Removal of Third Molars

Clinical Question: Does the presence of third molars contribute to dental crowding?

Third molars have been postulated to be a cause for incisor crowding for more than 150 years. This concept is accepted by a majority of oral surgeons and orthodontists, not to mention the public at large. (Laskin 1971) Most of the available studies focus on crowding

in the anterior mandible where changes are most obvious. Little attention has been paid to changes in arch width, form, or length.

The following points are supported by the literature:

- The etiology of dental crowding is complex and multi-factorial. (Zachrisson 2005, Beeman 1999)
- Studies can be found that lend support both for and against third molars as contributing to crowding. While most suggest that third molars play at least some role in crowding, their role may not be clinically significant. (Harradine 1998, Lindqvist 1982, Kahl-Nieke 1995)
- No presently available study is designed in a manner that isolates the effect of third molars from all other factors that may be associated with crowding. Therefore, a cause and effect relationship between third molars and dental crowding is difficult to establish. (Sampson 1983, 1995)

Conclusions

Despite good intentions, we are not able to explain, predict, or prevent dental crowding, no matter what the cause. While it is likely that third molars play a role in the etiology of crowding, they are only one factor to consider in making a clinical decision about third molar management. Therefore, it is prudent for clinicians to educate patients that the cause of dental crowding is multi-factorial and, while third molars may play a significant role in some patients, the current state of knowledge does not allow us to identify with accuracy who is at risk.

Clinical Question: Should asymptomatic impacted third molars under an existing or planned removable prosthesis be removed?

Many clinicians recommend removal of impacted third molars under planned or existing removable prosthesis (full or partial dentures). Literature support for this approach is limited and consists primarily of case reports documenting pathology associated with unerupted teeth. No papers provide any reasonable assessment of the incidence of associated problems.

The following points are supported by the literature:

- The natural course of an asymptomatic third molar is uncertain, with change in position or eruption reported even with advancing age. (Venta 2001, Nance, 2006)
- The potential for the development of pathology associated with impacted teeth is well documented. (Curran 2002)
- Not all asymptomatic impacted teeth under removable prosthesis will develop pathology if left in place. (Mercier 1992)
- There is increased difficulty and risk of complications associated with removal of impacted teeth if deferred until later in life. (Chiapasco 1994, Bruce 1980)
- Because there is no reliable way to predict pathologic changes associated with impacted teeth, they should be monitored with periodic clinical and radiographic examination. (Kahl 1994)

Conclusions

The position and disposition of unerupted teeth has been found to be dynamic and unpredictable. Therefore, the ultimate decision regarding the management of such teeth is best made by an expert clinician after clinical examination and review of factors such as the age of the patient, position of the tooth, anticipated difficulty of removal, type of overlying prosthesis, and risks associated with removal.

6. Current Imaging Techniques

Clinical question: “Among patients with impacted mandibular third molars, do those who have preoperative computerized tomographic (CT) imaging, when compared to those who do not, have a decreased frequency of inferior alveolar nerve (IAN) injury after third molar removal?”

Response: A thorough review of the literature failed to provide substantive answers to the clinical question posed above.

At face value, one might imagine that the routine use of CT imaging (generally cone beam CT) would decrease the risk for nerve injury. An alternative hypothesis is that it may increase the risk of nerve injury. The risk for IAN or lingual nerve injury is zero if the tooth is managed nonoperatively. One can envision circumstances where knowing the three-dimensional relationships between the third molar and IAN may tempt some clinicians to remove teeth that ordinarily they may elect to monitor, due to concerns regarding IAN injury. CT data provide no information regarding lingual nerve position; as such, lingual nerve injury risk is unchanged. Further studies are indicated to understand better the role of CT imaging in third molar management.

Numerous studies detail the effectiveness of axial CT with coronal and sagittal reformatting in establishing the three-dimensional relationship of the IAN and the third molar. (Mahasantipiya 2005, Maegawa 2003, Tantanapornkul 2007, Ohman 2006) CT permits localization of the IAN canal in the superior-inferior and medio-lateral positions; detection of an intra-radicular path; determination of the distance between the tooth and IAN canal, and root angulation. In the setting of high-risk findings on the panoramic radiograph and a clinical situation dictating operative management of the mandibular third molar, the CT can provide valuable information to facilitate management. (Susarla 2007) If the IAN is entrapped within the substance of the tooth, coronectomy or monitoring may be indicated. Knowing the IAN canal position relative to the third molar in the vertical, coronal, and axial planes informs the operative approach and may decrease the frequency or severity of IAN injury.

Panoramic radiography is the standard imaging technique for evaluating third molars. There are several radiographic signs assessed on panoramic radiographs that are associated with an increased risk for IAN injury. (Rood 1990, Blaeser 2003, Sedaghatfar 2005, Bell 2004, Smith 1997, Monaco 2004) These include superimposition of the IAN canal and third molar, distance from IAN canal and third molar, loss of the cortical (white) lines of the canal, darkening of the third molar root or narrowing or diversion of the IAN canal where it passes

the third molar root or a dark or bifid root apex. Several studies report the sensitivity and specificity of panoramic imaging to predict exposure of the IAN or IAN injury at the time of third molar removal. (Blaeser 2003, Sedaghatfar 2005, Bell 2004, Smith 1997, Monaco 2004) Notably, the sensitivity of the panoramic radiograph is fair, but the specificity is quite high. From a clinical standpoint, this suggests that in the absence of any high-risk findings on panoramic radiograph, the risk for IAN injury is unlikely and has a high negative predictive value (>90%). The presence of a high-risk radiographic finding, suggests an increased risk for IAN injury, but has poor positive predictive value (30-70%).

One study compared directly the sensitivity and specificity of CT imaging to panoramic imaging in predicting IAN exposure at the time of third molar removal. (Tantanapornkul. 2007) The sample was composed of subjects referred for CT imaging secondary to detecting high-risk finding on panoramic radiograph. In this sample, the sensitivity and specificity of panoramic imaging was 70 and 63% respectively. For the CT findings, the sensitivity and specificity were 93 and 77%, respectively.

Clinical decision-making is rarely based on a single sign or symptom. In a study reviewing the association between panoramic radiographic signs associated with IAN exposure after third molar removal, the clinician, incorporating all of the findings on the imaging, e.g. depth of impaction, root development, or angulation, had the higher sensitivity and specificity than any individual panoramic finding, i.e. sensitivity = 79% and specificity = 86%. (Sedaghaftar 2005) In another study similar findings were noted with the surgeon's prediction of IAN injury on reviewing the panoramic radiograph to have a sensitivity of 72% and specificity of 91%. (Smith 1997). Similarly, one study noted that the presence of two or more radiographic signs, depth of impaction, and horizontal angulation were associated with an intimate anatomic contact between the third molar and IAN canal on CT. (Monaco 2004) Likewise another study noted several clinical and panoramic radiographic predictors associated with an increased risk for IAN injury. (Jerjes 2006)

Conclusions

The exact role and indications for CT imaging for the management of impacted third molars is unclear and evolving. Additional investigations are warranted to better understand and outline the parameters for effective use of CT imaging in the management of third molars.

7. The Possible Role of Coronectomy (also known as partial tooth removal, partial odontectomy or intentional root retention) in Third Molar Removal

Five articles were identified in the literature that reported more than a single patient. Four were case series. (Pogrel 2004, 50 cases; O'Riordan 2004, 95 cases with 52 patients followed up; Freedman 1997, 35 cases; and Knutsson 1989, 33 cases) The fifth article was a randomized controlled trial. (Renton 2004) In all cases, coronectomy was suggested as a technique of partial root removal when Panorex imaging suggested an intimate relationship between the roots of the lower third molar and the IAN nerve and the tooth still needed to be removed. (Note: Cone beam CT was not available at the time the studies were conducted.) All papers suggested that the technique had merit.

- **Antibiotics.** One paper recommended preoperative and postoperative prophylactic antibiotics; one paper suggested postoperative antibiotics only; another paper suggested no antibiotics were necessary; and the other two papers did not mention antibiotics. (Pogrel 2004, O’Riordan 2004, Renton 2004 respectively)
- **Primary closure.** Two papers mentioned that the socket should be closed primarily, whilst three did not mention the method of closure.
- **Lingual retraction.** Two papers stated that lingual retraction was recommended in all cases to protect the lingual nerve. (Pogrel 2004, O’Riordan 2004) Two papers did not use lingual retraction. (Renton 2004, Knutsson 1989) One paper did not mention the technique.
- **Roots inadvertently removed at the time of attempted coronectomy.** Three papers stated a range of between 3% and 9% of patients failing to achieve coronectomy and the roots needing to be removed at the time of primary surgery. (Pogrel 2004, O’Riordan 2004, Knutsson 1989) One paper noted a 38% failure rate at primary surgery, because the roots were only sectioned about half way before an attempt was made to remove the crown. (Renton 2004) This appeared to mobilize the roots in many cases and did result in an 8% incidence of IAN involvement.
- **Later removal.** Two papers mention a 2% and 6% later root removal. (Pogrel 2004, O’Riordan 2004) One paper mentioned a 27% unsatisfactory healing. (Knutsson 1989) The others do not mention it.
- **Root migration.** Subsequent root migration is mentioned in all papers with the percentage varying from 14% to 81% showing later migration of the roots towards the superior border of the mandible. There is no mention of whether any of these roots required removal.
- **Inferior alveolar nerve involvement.** This was reported, due to inadvertent drilling, in 1% of patients in one study. (O’Riordan 2004) One paper with 38% failed primary coronectomy, noted an 8% IAN involvement with failed coronectomy. (Renton 2004).
- **Lingual nerve involvement.** A 2% transient rate was noted in one study, presumably due to lingual retraction. (Pogrel 2004) The other papers do not mention it.
- **Length of follow up.** This varies among the 5 papers from a mean of one year in two papers (Pogrel 2004, Knuttson 1989), two years in another paper (Renton 2004), five years in another paper (Freedman 1997), and up to 20 years in the fifth paper (O’Riordan 2004).

Conclusions

When imaging suggested an intimate relationship between the roots of the lower third molar and the IAN and the tooth still needs to be removed, consideration should be given to coronectomy with retention of the portion of the roots associated with the IAN. Since there are only five papers in the literature describing more than single cases, there is no standard of care with regard to this technique, and until more information is available this technique should be considered as an alternative only.

8. The Role of Lingual Flap Elevation and Lingual Retraction in the Management of Third Molars

- Most third molars can be removed by utilizing a purely buccal technique. Utilizing this technique, it is not necessary to encroach on the lingual tissues or to remove distal, distolingual or lingual bone. (Gargallo-Albiol 2000)
- However, on occasion where the tooth is malpositioned, or for other reasons, it may be necessary to remove distal, distolingual, or lingual bone.
- If this is necessary, a subperiosteal lingual flap is raised with a suitably curved periosteal elevator that can stay in contact with the lingual plate of bone and not encroach on the lingual soft tissues. (Walters 1995, Pogrel 2004)
- Once a subperiosteal lingual flap has been raised, a lingual retractor is placed. Several studies, mainly from Europe, have shown that the use of a lingual flap and the placement of a lingual retractor can cause transient lingual nerve damage, but does not appear to be a cause of permanent lingual nerve damage. (Gomes 2005) The retractor must be broad enough to provide protection to the lingual soft tissues and the lingual nerve. Many studies have criticized the use of a Howarth elevator (a narrow European periosteal elevator about the width of a Molt #9 periosteal elevator) because, although this can retract the lingual tissues, it does not adequately protect the lingual nerve and the bur can slip in front or behind the elevator and still damage the lingual nerve. (Rood 1992, Robinson 1996) Other articles state that a suitably sized elevator can give an appropriate degree of protection. (Greenwood 1994, To 1994)
- The use of a suitably sized lingual retractor does enable one to have better visualization of the third molar, better access, and the ability to remove distal bone, distolingual bone, and even lingual bone, since protection is provided by the retractor.
- Some studies have failed to show any difference in permanent lingual nerve injuries whether a lingual retractor was used or not, although there was a significantly higher incidence of temporary lingual nerve involvement when a lingual retractor was used. (Pichler 2001)

Conclusions

Raising a lingual flap and the use of a lingual retractor for selected indications is felt to be an acceptable technique for removal of lower third molars. (Moss 1999) The periosteal elevator must remain subperiosteal at all times. A lingual retractor must be broad and without sharp edges so as to protect and not damage the lingual nerve.

9. Should Anything Be Placed in the Socket Following Third Molar Removal?

Clinical Question: “Among subjects undergoing mandibular third molar removal, does an intervention at the time of tooth removal, when compared to no intervention, improve the long-term periodontal health on the distal aspect of the adjacent second molar?”

Response: Routine application of interventions to improve the periodontal parameters on the distal of the second molar at the time of third molar removal is not indicated for all subjects. (Quee 1985, Dodson 2004, Leung 2005, Osborne 1982, Stephens 1983, Dodson 2007, Thronson 2002, Oxford 1997, Chang 2004, Ferreira 1997) There appears to be a subpopulation of subjects having third molars removed that are at “high-risk” for periodontal defects after third molar removal, i.e. age \geq 26 years, pre-existing periodontal defects (attachment level \geq 3 mm or probing depth \geq 5 mm), and a horizontal or mesioangular

impaction. (Pecora 1993) When these three risk factors are present concurrently, there does appear to be a predictable benefit to reconstructing the dentoalveolar defect at the time of extraction. (Pecora 1993, Dodson 2005)

There is a growing body of literature suggesting intervention may be indicated in the setting of “near high-risk” subjects, i.e., those having two risk factors, tooth angulation and a pre-existing periodontal defect. (Sammartino 2005, Aimetti 2007) Of note, age overlapped with the high risk age group, i.e. ≥ 26 years, but the samples included younger subjects as well. In Sammartino, the range was 21-26 years, but the mean was not reported. In Aimetti, the mean age was 24.9, but the range was not reported. In these studies, platelet-rich plasma or a resorbable membrane were more effective than no treatment in producing a clinically and statistically significant improvement in PDs on the distal of the second molar. (Sammartino 2005, Aimetti 2007)

Conclusions

While non-resorbable and resorbable GTR, DBP, and platelet rich plasma (PRP) work in the setting of high or near high-risk third molars, DBP is the simplest to use. (Pecora 1993, Aimetti 2007, Dodson 2005, Sammartino 2005)

10. Nerve Damage – Prevention, Evaluation and Management in Relation to Third Molars

Incidence:

- **Inferior Alveolar Nerve.** The incidence of IAN involvement 1-7 days after surgery is around 1-5%. (Carmichael 1992, Schultze-Mosgau 1993, Gulicher 2001) The incidence of persistent IAN involvement (still present after six months) varies from a high of 0.9% to a low of zero. (Valmaseda-Castellon 2001, Schultze-Mosgau 1993, Gulicher 2001, Queral-Godoy 2005) A mean figure from all studies is around 0.3%.
- **Lingual Nerve.** The incidence of lingual nerve involvement one day after surgery (excluding the use of lingual flap elevation) varies from 0.4% to 1.5%. (Valmaseda-Castellon 2001, Gulicher 2001, Queral-Godoy 2006, Robinson 1996) The incidence of persistent involvement (still present at six months) varies from 0.5% (with the use of a lingual flap) to a low of 0.0%. (Blackburn 1989) Several studies indicate an incidence of 0% persistent paresthesia whether lingual retraction is used or not. (Valmaseda-Castellon 2000, Schultze-Mosgau 1993, Gomes 2005)
- **Long Buccal Nerve.** Anatomical studies carried out on the long buccal nerve show that it is at risk during the initial incision for many third molar procedures. (Hendy 1996) Branches of it are probably frequently cut during the incision process, but the effects are generally not noted. (Merrill 1979) A search of the literature finds no specific reports of long buccal nerve involvement, although one paper did note long buccal involvement when the anatomical position was aberrant, i.e., coming off the IAN once it was already in the canal and coming out through a separate foramen on the buccal side of the mandible. (Singh 1981) Others reported buccal nerve involvement as part of a larger study. (Hillerup 2006)

- **Mylohyoid Nerve.** Damage to this nerve has been reported to be as high as 1.5% following lower third molar removal but this is probably due to the use of lingual retraction. (Carmichael 1992)
- The use of preoperative or perioperative steroids did not appear to influence the incidence of nerve involvement. (Von Arx 1989)
- The spontaneous recovery rate for nerve injuries related to third molar removal is quite variable, ranging from 50% to 100% for both the IAN and lingual nerves. (Carmichael 1992, Schultze-Mosgau 1993, Gulicher 2001) Several papers mention a greater spontaneous recovery rate for the IAN, but this is not well documented.

Evaluation: Evaluation techniques are subjective or semi-objective at best. Suggested techniques include: (Zuniga 1998)

- Mapping out and photographing the area involved.
- Testing light touch or tactile sensation with von Frey's hairs. - tests A beta fibres and pressure receptors
- Testing two-point discrimination. – tests larger myelinated axons
- Testing direction sense. – tests A alpha & A beta fibres
- Testing pinprick sensation (pain sensation). – tests A delta and C fibres
- Testing taste with the four primary tastes.
- Papers do not mention the accuracy or variability of these tests.

Objective testing has been attempted utilizing:

- **Somatosensory evoked potentials.** These have been shown to be difficult to standardize and the results have been unpredictable and hard to reproduce. (Aravi 2006, Maloney 2000) They are not used clinically.
- **Magnetic resonance imaging.** This has not been shown to be capable of consistently identifying the normal lingual nerve. It may be able to identify a large neuroma. (Miloro 1997, Filler 2004)
- **Magnetic source imaging.** This technology shows promise in evaluating nerve injuries, but the technology is available in only a small number of specialized centers and the main company that was sponsoring research in this area is no longer doing so. (McDonald 1996)

Results of Nerve Repair: There are several papers describing the results of nerve repair. For some papers, the lingual and inferior alveolar nerves are considered together and in others they are described separately. The results are rarely analyzed by the techniques employed. Selected papers show the following.

- Of 23 lingual nerves repaired, with the earliest repaired at six months, 50% showed some recovery. Results for patients with dysesthesia were poor. (Blackburn 1992)
- Nineteen patients with the lingual or inferior alveolar nerves repaired at a mean of 4.5 months showed 63% had good recovery. (Susarla 2005)

- Fifty-one patients having both nerves repaired at a mean of 4.5 months showed 55% had some recovery. (Pogrel 2002)
- 32 nerves repaired at the mean of 6.6 months showed that for the inferior alveolar nerve 92% of patients showed some recovery. (Strauss 2006)
- 20 patients with the lingual nerve repaired at a mean of eight months showed that 90% of patients had some recovery. (Rutner 2005)
- Robinson (2000) showed between 50% and 77% of patients showed some recovery for lingual nerve repair.
- Susarla (2007) showed 75% of 60 patients having repair of the lingual or inferior alveolar showed some functional sensory recovery when repairs were carried out after a mean of three and one-half months post injury.
- 55% of 46 patients undergoing repair at a mean of 6.8 months reported overall satisfaction to be good to excellent. (Lam 2003)

Taste recovery: Most studies suggest that even when lingual nerve repair produces some improvement in tactile sensation, taste sensation does not recover. However, two papers do suggest some improvement in taste. Fifty percent of patients with lingual nerve repair showed some taste recovery when repair was carried out at a mean of 5.25 months following injury. (Zuniga 1997) Thirty-five percent of lingual nerve repairs showed some improvement in taste sensation when the repair was carried out at four months. (Donoff 2000)

Timing of repair: Many authors indicate that repairs should be carried out early, but the definition of early is variable and there is little objective evidence to support this. Two studies suggested that the best results were obtained if surgery was carried out within 10 weeks of injury, but results were not statistically significant. (Pogrel 2002, Fielding 1997) A paper describing late repair for the lingual nerve (between 7 and 32 months following injury) showed that 70% of patients still showed some recovery. (Robinson 2000) Another paper showed that repairs on the lingual nerve could be carried out up to 47 months following injury with some good results. (Robinson 1996) In a rabbit animal model, good results were reported when repairs were performed after 12 months. (Eckardt 1990) All papers indicated that repairs carried out for dysesthesia carried a poorer prognosis whatever the timing of surgery.

Conclusions

Occasional damage to the inferior alveolar and lingual nerve occurs following third molar surgery. At least 50 percent of cases recover spontaneously. Attempts to standardize objective evaluation of nerve injuries have been unsuccessful. The results of nerve surgery are variable, but if carried out between 4.5 and 7 months, over 50 percent of patients probably show improvement. Later repairs, up to 47 months post injury, can still show some recovery. It is possible that in some cases there may be some recovery of taste in the case of lingual nerve repair.

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