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Optimal follow-up time following lower third molar coronectomy – a clinical audit and literature review

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Abstract:

Background and objectives: The complete surgical removal of lower third molars where the apices of the roots are intimate with the inferior alveolar neurovascular bundle may place the patient at higher than normal risk of neurosensory disturbance. A surgical alternative is coronectomy of the tooth. The crown is removed but the roots are left in situ so as not to disturb the neurovascular bundle. This technique has been well described and outcomes are generally positive, supporting the use of the technique. However, the quality of reporting in terms of follow-up and recommendations is variable. The aim of this paper was to review follow-up periods for coronectomy patients in order to present a rational review protocol based on findings from the literature and a comparative clinical audit of coronectomy patients at the School of Dentistry, University of Otago.

Methods: We conducted a retrospective audit of all patients who underwent a coronectomy procedure of at least one lower third molar through the oral and maxillofacial surgery service at the School of Dentistry, University of Otago. Patient files were accessed and the clinical notes, radiographs and follow-up appointments were reviewed. A non-systematic literature review was performed to compare findings and recommendations from other similar studies.

Results: Over a 9-year period (2010 – 2018), 18 patients were identified as having one or more lower third molar coronectomy procedures. There were twelve female and six male patients with an age range from 22 to 63 years of age. Three patients had bilateral coronectomies. The average follow up period was 8.7 months, ranging from one month to 42 months for post-operative review.

Conclusion: The clinical findings and follow–up period from our retrospective audit is consistent with the literature, including a highly variable schedule of post-operative reviews. Based on the literature review, we propose that a follow-up period of not longer than 3 years is adequate, with radiographic imaging indicated only with symptomatic clinical findings and not at every review visit.

Introduction

The surgical removal of impacted lower third molars is one of the most common procedures performed in oral surgery. The prevalence of lower third molar impaction ranges between 27 – 68% (Haidar and Shalhoub, 1986; Hattab et al., 1995; Quek et al., 2003) with mesioangular impactions being the most common (Hashemipour et al., 2013; Al-Anqudi et al., 2014).

A recognised complication of lower third molar surgery is injury to the inferior alveolar neurovascular bundle (IAN) with an incidence ranging from 1.3 – 5.3% (Goldberg et al. 1985; Batainieh 2001). This may increase to as high as 19% if the tooth roots are in very close proximity with the IAN (Renton et al., 2005).

Radiographic indicators such as darkening of the root apices, diversion of the IAN canal and narrowing and interruption of the cortical outline of the canal are well described on plain films (Rood and Shebab, 1990; Gulicher and Gerlach, 2001). However, clinicians may wish to request further imaging using cone-beam computed tomography (CBCT) which arguably is more accurate in anatomical diagnosis but exposes the patient to increased radiation and financial cost (Hatano et al., 2009; Cilasun et al., 2011; Goto et al. 2012; Monaco et al. 2012).

The technique of coronectomy was proposed as a surgical option to minimise injury to the IAN in the mid to late 1980s (Ecuyer and Debien, 1984; Knutsson et al., 1989). The crown of the tooth is removed but the roots left in situ. There have been numerous studies which show that coronectomy procedures significantly reduces the risk of IAN injury (Freedman, 1997; O'Riordan, 2004; Pogrel et al., 2004; Renton et al., 2005; Dolanmaz et al., 2009; Hatano et al., 2009; Leung and Cheung, 2009; Cilasun et al., 2011; Leung and Cheung, 2012; Kouwenberg et al. 2016), which also include four systematic reviews (Long et al., 2012; Martin et al., 2015; Cervera-Esper et al., 2016; Dalle Carbonare et al., 2017).

The follow-up of these patients is highly variable with no real consensus. Most follow-up periods ranged from no review after 6 months - unless symptomatic, to 25 months or longer (Fareed et al., 1989; O'Riordan, 2004; Pogrel et al., 2004; Renton et al., 2005; Monaco et al., 2015; Pedersen et al., 2018) with the notable exception of Ecuyer and Debien (1984) who followed up for 10 years. Furthermore, the need for radiographic review is also inconsistent with some studies recommending regular radiographs (Ecuyer and Debien, 1984; Pogrel et al., 2004; Dolanmaz et al., 2009; Hatano et al., 2009; Leung and Cheung, 2009; Sencimen et al., 2010; Goto et al. 2012; Leung and Cheung, 2012; Monaco et al., 2012; Monaco et al., 2015; Kouwenberg et al., 2016; Leung and Cheung, 2016) while others recommend radiographs only when symptoms arise (Cilasun et al., 2011). The length of follow-up also appears to be variable depending on such factors as patient compliance, patients moving away, clinical presentation and resources of the clinician and institution.

Post-operative infection and transient IAN or lingual nerve paraesthesia tend to occur early in the post-coronectomy phase, whereas root migration may occur at two years or later. Studies also report that follow-up periods tended to be shorter when there were no findings of root exposure – in other words, when there were no obvious signs of root migration (Long et al., 2012). There are arguments for shorter or longer review periods in terms of monitoring for infection and root migration, but the timing of reviews and the need for radiographs is inconsistent. A summary of follow-up periods and protocols proposed by different studies is presented in Table 1.

Therefore, the question remains; what is the optimal follow up review period for these patients and should regular imaging be included in the review protocol?

We present a summary of the review periods and protocols reported in the literature and findings from an audit of 18 coronectomy patients seen at the School of Dentistry, University of Otago from 2010 to 2018 in order to compare local protocols with those proposed in the literature.

Table 1. Summary of follow-up times and protocols proposed by different studies.

Reference	Study Type	Follow up regime	Follow up Period
Cilasun, U. (2011)	Prospective Cohort Study	All patients were invited to return for appointments at 1 week and the first, third, and sixth months for clinical and, when needed, radiographic evaluations. After the first 6 months, patients were advised to visit annually unless they became symptomatic	6 - 29 months
Dolanmaz, D. (2009)	Prospective Cohort Study	All patients were invited to return for appointments at 6, 12, and 24 months for clinical and radiographic assessment of the retained root fragments.	6 – 24 months
Ecuyer, J. and J. Debien (1984)	Prospective Cohort Study	Clinically and radiographically twice a year for the first 2 years, once a year for the following 2 years, and then once every 2 years.	10 years
Fareed, K. (1989)	Prospective Cohort Study	none described	12 months
Freedman, G. L. (1997)	Case Series	none described	6 years
Goto, S. (2012)	Prospective Cohort Study	clinical and radiographic at 1, 2 and 3 years	12 months
Hatano, Y. (2009)	Case Control Study	1, 3, 6, 9, and 12 months and then every year postoperatively, with OPG at every visit and dental CT at the 3- and 12-month visits and then annually.	12 months
Kouwenberg, A (2016)	Prospective Cohort Study	Clinical and radiographic review at 6 months, of nerve dysfunction, sooner if problems	6 months
Leung, Y. Y. (2009)	Randomised Control Trial	1 week and at 1, 3, 6, 12, and 24 months OPG taken at 1 week and at 3, 6, 12, and 24 months.	24 months
Leung, Y. Y. (2012)	Prospective Cohort Study	1 week and 3, 6, 12, 24, and 36 months, OPG at each review	36 months
Leung, Y. Y. (2016)	Prospective Cohort Study	1 week, 6, 12, 24, and 60 months with an OPG at each review	6 – 60 months
Monaco, G. (2012)	Prospective Cohort Study	3, 6 and 12 months with a PA radiograph taken each time and an OPG at 12 months	12 months
Monaco, G. (2015)	Prospective Cohort Study	3, 6, and 12 months post-operatively, clinical and radiographic	6 – 36 months
Mukherjee, 2016	Prospective Cohort Study	Clinical and radiographic at 6 month intervals for 2 years	2 years
O'Riordan, B. C. (2004)	Randomised Control Study	No protocol described, 4 patients were followed up for 10 years, 15 for 5-9 years, and 33 for 2-4 years.	24 months
Patel , 2013	Case Series	One month, 3 months, 6 months and annually.	2 – 40 months
Pogrel, M. A. (2004)	Prospective Cohort Study	Radiographs immediately, and 6 months postoperatively. No follow up after 6 months unless symptomatic	6 – 42 months
Renton, T. (2005)	Randomised Control Trial	2-5 days (telephone), 1-2 weeks, 3 months, 6 months, 12 months, 24 months	6 -24 months
Sencimen, M. (2010)	Case Control Study	Radiographic follow up at 1, 3, 6 and 12 months but evaluating endodontic treatment of coronectomy	12 months
Vignudelli, E (2017)	Prospective Cohort Study	Clinically and radiographically at 9 months	9 months

Methods

Case Series

A retrospective audit of patients under the oral and maxillofacial surgery service at the School of Dentistry, University of Otago, who underwent coronectomy procedures for lower third molars from 2010 to 2018 was conducted. Ethical approval and Maori consultation was obtained from the University of Otago prior to the audit. Patients were identified and patient hard copy notes were reviewed including clinical notes and radiographs. The data collected included patient age, gender, procedure, post-operative complications and length of follow-up period. Any pre-existing medical co-morbidities were noted.

Literature review

A non-systematic review of the literature was performed using PuBMed with the key words "coronectomy, lower third molars". A non-systematic approach was undertaken as the aim of this paper was to compare and collate follow-up periods from other published studies and not to validate the efficacy or outcomes of the coronectomy procedure itself. Non-referenced opinion pieces or letters and single case reports were not included in the literature review.

Case Series Results

Eighteen patients were identified as having one or more lower third molar coronectomy between 2010 and 2018. All involved the raising of a full thickness mucoperiosteal flap, bone removal, crown sectioning and primary closure. A CBCT was offered to all patients thought to be at high risk of nerve injury however not all accepted the offer, mainly due to financial constraints.

There were twelve female and six male patients whose ages ranged from 22 to 63 years of age at the time of surgery. Three patients had bilateral coronectomy procedures. The remainder had coronectomies performed on one molar, with more left sided teeth (9 of 15 patients) than right (6 of 15 patients). Three patients had surgical complications post-coronectomy and to date only one patient had root migration. One patient had transient lingual paraesthesia and post-operative infection, one had sensitivity of the adjacent tooth and another had wound break down resulting in non-closure of the healing socket. All surgical complications resolved within the first month.

The patient with paraesthesia and post-operative infection was an older diabetic patient who was managed with local measures and systemic antibiotics. Reoperation was performed in the one patient whose root had migrated to become exposed in the mouth three years after operation. The length of follow up ranged from less than one month to 42 months.

Table 2 shows a summary of the patients, teeth involved, complications and length of follow-up period.

Discussion

The findings from the literature review show a high degree of variability in review protocols and length of review periods. Results from our case series also show a degree of variability and a high proportion of patients with active reviews. The comparison of a local case series with findings from the literature is useful for calibration especially in a teaching hospital environment.

This paper has obvious limitations, the main one being the very small sample size of patients in our audit.

Table 2. Summary of coronectomy patients, complications and follow up periods

Patient Gender	Age at surgery	Third molar involved	Complications	Follow up period
F	22	Lower left	Nil	< 1 month*
F	54	Lower right and left	Left lingual paraesthesia (transient), post op infection (both within first month)	2 years
M	41	Lower right	Nil	2 years
M	40	Lower left	Root migration and pain at 3 years	3.5 years
F	40	Lower left	Sensitivity lower left second molar	12 months
M	45	Lower right	Nil	< 1 month*
M	39	Lower right	Nil	< 1 month*
F	44	Lower right	Nil	3 months (on going)
M	26	Lower right and left	Nil	3 months (on going)
F	25	Lower left	Non closure of socket (first month)	4 months
M	63	Lower left	Nil	8 months (on going)
F	26	Lower right	Nil	< 1 month*
F	44	Lower left	Nil	5 months (on going)
F	39	Lower right	Nil	5 months (on going)
F	52	Lower right and left	Nil	5 months (on going)
F	48	Lower left	Nil	12 months
F	32	Lower left	Nil	12 months
F	22	Lower left	Nil	12 months (on going)

*patients lost to follow up due to moving to another city or failure to attend further review appointments

Possible explanations include surgeon preference and experience, small numbers of symptomatic impacted lower third molars close to the IAN requiring surgical removal (others may be asymptomatic and therefore let in situ) and issues with identifying patients from hard copy file searches. This last issue with identifying patients explains why a number of the patients in our audit have quite recent review periods of an ongoing nature –patients who have had more recent coronectomy procedures have been identified more readily and monitored more closely. Another limitation is that there is no single operator, which introduces a degree of surgical variability and may potentially affect post-operative outcomes and complications.

The technique of coronectomy is well described (Dolanmaz et al., 2009; Leung and Cheung, 2009; Monaco et al., 2012; Monaco et al., 2015) and the two key surgical considerations appear to be the amount of bone removal and how the crown is sectioned (Monaco et al., 2015). Judicious bone removal must be performed that allows surgical visualisation of the tooth but not be below the level of the cemento-enamel junction as this carries a higher risk of root mobilisation (Renton et al., 2005). Sectioning of the crown must also be precise and not leave any enamel as this inhibits bone healing over the root mass (Monaco et al., 2015).

In terms of post-operative pain and swelling, coronectomy procedures are associated with significantly less pain (Freedman, 1997; Renton et al., 2005; Blondeau and Daniel, 2007; Leung and Cheung, 2009; Siddiqi et al., 2010; Monaco et al., 2012; Patel et al., 2013) and swelling (Monaco et al., 2012) compared to complete surgical removal of teeth.

The main reasons for a longer review period post-coronectomy appear to be to monitor for nerve injury, infection and root migration. While co-morbidities such as diabetes and older age can delay healing and increase the risk of infection, there is no evidence that this increases the risk for a coronectomy compared to extraction (Fernandes et al., 2015; Weyand et al., 2016). Due to a relatively decreased surgical morbidity, coronectomy of impacted lower third molars in oncology patients has also been recommended as a safe alternative especially from an infection and pathological fracture standpoint (Alves et al., 2018). In our case series, the coronectomy procedure followed techniques and considerations described in the literature.

Nerve injury

Although the purpose of coronectomy is to minimise the risk to the IAN, nerve injuries still occur and have been reported in both the IAN and lingual nerve. Transient IAN injury post-coronectomy has been found to occur from 0% to almost 10% (Goto et al., 2012; Patel et al., 2013). Permanent IAN injury was found to range between 2% and almost 5% (Fareed et al., 1989; Goto et al., 2012). Differences in IAN injury between complete extraction, successful coronectomy and failed coronectomy has been found to be statistically significant. Failed coronectomies have a higher chance of nerve injury to both IAN and lingual nerves (Renton et al., 2005; Dalle Carbonare et al. 2017). This correlation was also seen by Leung and Cheung (2009) where there was one case of IAN deficit in the coronectomy group (of 155 patients). It was suggested that this was a result of the crown sectioning causing neuropraxia. Transient lingual nerve injury was found in only 1-2% of coronectomy cases (Goldberg et al., 1985; Pogrel et al., 2004; Leung 2016) with no reports of permanent lingual nerve injury in the literature. This was consistent with our case series where only one patient experienced transient lingual nerve dysfunction.

Post-operative Infection

Post-operative infection may be early (within the first week post-surgery) or delayed, which includes infections occurring after the initial post-operative period and recurrent or chronic infections. The incidence of infection of the coronectomy socket site is reported at between 0% and 11% (O'Riordan, 2004; Renton et al., 2005; Dolanmaz et al., 2009; Hatano et al., 2009; Cilasun et al., 2011; Leung and Cheung, 2012; Monaco et al., 2012) with less risk of infection associated with primary wound closure (Knutsson et al., 1989; O'Riordan, 2004; Hatano et al., 2009; Cilasun et al., 2011; Monaco et al., 2012). Tight primary wound closure may lead to an increase in post-operative pain according to one study (Hatano et al., 2009).

A number of studies reported no statistical difference between infection rates in patients who underwent coronectomy compared to those who underwent complete extraction (Alantar et al., 1995; Renton et al., 2005; Hatano et al., 2009, Cilasun et al., 2011).

Leung and Cheung (2016) found that if infections were managed early with local measures, there was no further infection of the retained root or development of chronic infection. Their advice was to manage all patients who presented with infection at follow-up with antibiotics and local measures, including debridement with or without incision and drainage.

It has been suggested that revascularisation occurs in the dental pulp, which provides sufficient immune defence when treated with antibiotics and local measures, preventing delayed or chronic infection. This was shown in animal studies where the decoronated root retained its vitality by undergoing angiogenesis from the surrounding tissues (Plata et al., 1976).

Root Migration

After coronectomy, physiologic movement of the root as described by Marks and Schroeder (1996) may still arise and appears to be variable, affecting anywhere between 2% to 85% of coronectomy patients (Freedman, 1997; Leung and Cheung, 2009).

Migration appears to show a discontinuous movement pattern regarding mean movement of the root remnants. More than half of the roots migrated at a high rate for 3–6 months postoperatively and then progressively decreasing in rate within 12 to 24 months (Fareed et al., 1989; Alantar et al., 1995; Freedman, 1997; Pogrel et al., 2004; Hatano et al., 2009; Patel et al., 2013; Leung and Cheung, 2018).

Goto et al. (2012) suggested that factors that correlated significantly with root migration were age, sex and root morphology. Mean migration was significantly greater in female than male patients and also greater in younger patients. Conical roots appeared to migrate significantly more than enlarged or clubbed roots (Renton et al., 2005; Goto et al., 2012; Monaco et al., 2012).

Patients who had migration causing exposure of the root complained of sensitivity to cold or presented with some mild discomfort over the exposed root area (Alantar et al., 1995).

Monaco et al. (2015) reported four cases (4%) of large migration of the roots into the oral cavity necessitating re-operation. They also had five other cases requiring re-operation, one due to pulpitis, three to remove enamel remnants that were affecting bone formation and one to decrease gingival hyperplasia. No IAN deficit was noted supporting the assumption that root migration will be away from the IAN canal. Even when exposed and causing symptoms, there is a much smaller risk to the IAN compared with removing the teeth in total in the first place (Leung and Cheung, 2009). This was also found in a study by Vignudelli et al. (2017) where a second surgery was required for 4 out of 34 third molars (11.8%). This was because of intermittent pain (1 case), eruption into the oral cavity (2 cases) and migration causing further impaction (1 case). In all cases, no neurological defect was noted after the second surgery.

Residual root movement appears to be unpredictable and the re-operation rate owing to infection or root exposure ranges from 0.6% to 6.9% (Plata et al., 1976; Freedman, 1997).

Findings from our case series are consistent with the reported post-operative complication rates except for lingual nerve paraesthesia. Our incidence was 5%, falling outside of the reported range of 1-2% (Goldberg et al., 1985; Pogrel et al., 2004; Leung and Cheung, 2016). This can be explained by the small numbers in our case series (n=18) with the one patient out of eighteen giving a skewed figure of 5%.

Follow-up period

Based on literature review, the post-coronectomy follow up period can be broadly divided into a short-term review for post-operative infection and transient IAN or lingual nerve injury and a longer-term review period to monitor for root migration. Post-operative infection and nerve injury should be identified in the immediate to early post-operative period (within 7 days) to decrease morbidity and identify any issues that may necessitate longer review periods. IAN injuries following lower third molar surgery are reviewed for up to 24 months for example, after which the nerve injury is considered permanent (Vignudelli et al., 2017).

Although there may be variability in the time intervals for review during the follow-up period, most studies advocate radiographic monitoring at regular intervals, the main purpose of which is to monitor migration but also for any bony involvement with chronic infections. The exception to this was Cilasun et al. (2011) who only took radiographs when the patient presented with symptoms. The majority of studies that advocate regular radiographs were either establishing a protocol or monitoring for research purposes during a period when the benefits of coronectomy procedures where not so apparent. Given that the safety of coronectomy procedures is now known, the need for intense follow-up and routine imaging is likely unnecessary. This decreases the social burden of loss of income while being away from work, family care issues and risks from ionising radiation.

Follow up periods and protocols from the studies analysed are documented in Table 1.

To incorporate the commonalities found in literature and our own findings, we propose the following review protocol, suggesting an intensive short-term follow-up period to monitor infection and nerve injury and review period to monitor for root migration of no more than three years (Table 3). Due to concerns with ionising radiation exposure, radiographic imaging should only be performed when symptoms are present or if further surgery is planned, for example when root migration and exposure in the mouth poses an infection risk.

Table 3. Proposed clinical follow up review protocol based on literature findings

Follow up year	Time frame post-surgery	Radiographic review*
1	7-10 days	yes
	1 – 3 months	no
	6 months	no
	12 months	no
2	24 months	no
3	36 months	no

*Radiographs only when there are symptoms or clinical findings that may result in further surgery such as root exposure.

Conclusion

Coronectomy for lower third molars intimate with the IAN is a safe and viable alternative to complete surgical removal. The follow-up period is highly variable and non-standardised. While there are more complications that occur in the short-term – necessitating a more regular short-term follow-up period, the movement of roots and recovery from nerve injury occur mainly in the first two years. The suggested protocol combines the follow-up regimes suggested by many other journals with current evidence.

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