



Myringoplasty outcomes of Indigenous Australians in the West Kimberley region of Western Australia

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Background: Chronic suppurative otitis media (CSOM) is a significant cause of hearing loss in remote Aboriginal communities of Australia. Myringoplasty aims to prevent otorrhoea and improve hearing loss associated with CSOM by closing tympanic membrane perforations. This study aims to review myringoplasty outcomes for Indigenous Australians in the West Kimberley region.

Methods: Retrospective chart review of clinical, operative, and audiometric data at Broome and Derby hospitals from 2004 to 2014 found 419 myringoplasty operations were performed on 327 patients. The primary outcome “success” was defined as closure of the perforation with an air-bone gap of less than 25 dB at 6 months or greater post-surgery.

Results: Of the 419 ears undergoing myringoplasty, only 90 (21.5%) had complete follow-up. Simple closure was seen in 39% of ears with complete follow-up, with higher rates seen in female patients, small to medium perforations, and ears with normal pre-operative hearing. Closure of the tympanic membrane with normal hearing was seen in 29% of ears with complete follow-up, with higher success rates seen in those with dry ears pre-operatively.

Conclusions: Follow-up and outcomes for myringoplasty remain poor for Indigenous people in the West Kimberley region. Standardised prospective data recording and integration will minimise data attrition. Patient attrition will remain a challenge requiring ongoing investment and education. Improvements in ear and hearing outcome are more likely to arise from health care system improvements over patient selection and operative technique.

Keywords: Indigenous population; tympanoplasty; otological surgical procedures; outcome studies; aborigines; Australian

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Introduction

Indigenous Australian children and adolescents residing in rural locations have a high prevalence of middle ear disease (1,2). Hearing loss associated with chronic suppurative otitis media (CSOM) can adversely affect language and cognitive development which can result in an educational and employment disadvantage, and this in turn has been associated with over-representation in the criminal justice system (3). Approximately 60% of Indigenous children by 2 years of age will have had at least one tympanic membrane (TM) perforation (4).

Myringoplasty aims to prevent otorrhoea and improve hearing loss associated with CSOM by closing the perforation. Previous studies to assess the success rate

of myringoplasty in the Australian Indigenous rural and remote populations have demonstrated a lower TM perforation closure rate when compared to non-Indigenous city counterparts (5,6). To the best of our knowledge, there have been no recent reviews of myringoplasty outcomes in the West Kimberley region. In 2000, Mak *et al.* reported on myringoplasty outcomes in Indigenous Australians in this region (7). Only 68 of 212 patients had complete follow up, and of those 68, a 53% success rate was reported [success was defined as TM closure at more than 6 months with an air-bone gap (ABG) of less than 25 dB]. In a subsequent prospective study of 78 paediatric Indigenous myringoplasty outcomes in Western Australia, complete follow-up was achieved in 78% of ears, but with a similar success rate of 49% (8).

The Kimberley region in far north-western Australia is a vast and sparsely populated region. The estimated population in this area was 38,801 in 2015. *Table 1* and *Figure 1* demonstrate the geographical and demographic diversity of this region (11). It is serviced by the Kimberley Aboriginal Medical Service (KAMS) and the Western Australia Country Health Services (WACHS). Both organisations employ Ear Nose and Throat (ENT)

Table 1 Geographic and demographic features of West Kimberley (9,10)

Location	Area (km ²)	Population	% of Indigenous Australians
Broome	54,632	17,308	29.1
Derby	119,842	8,903	48.1

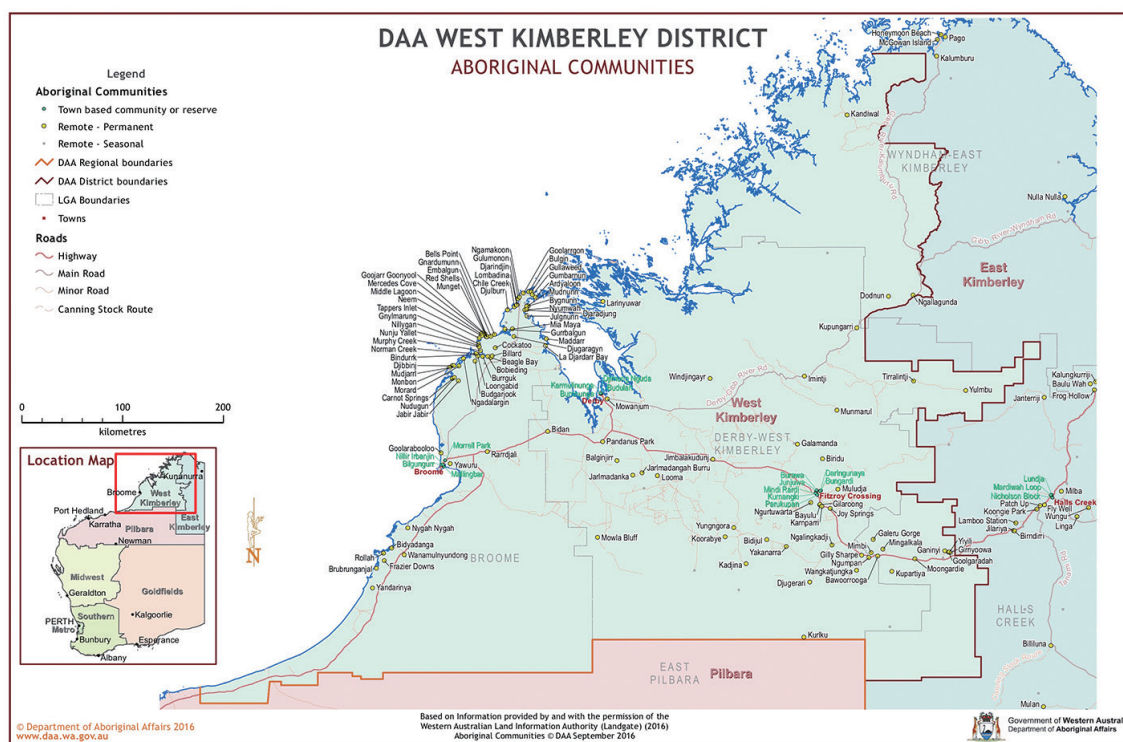


Figure 1 West Kimberley District Aboriginal Communities (11).

Table 2 WHO classification of hearing loss (12)

Air-bone gap (dB)	Degree of hearing loss
<25	Normal
26–44	Mild
45–59	Moderate
>60	Severe

surgeons, audiologists, anaesthetists and Aboriginal health workers who visit Broome, Derby, Kununurra and surrounding communities. Patients with ENT problems are referred by the local Aboriginal health services and general practitioners to the visiting ENT service. The geographical isolation of the region, mobility of the Indigenous population and the limited number of visits by the ENT service make identification of ear pathology, surgical management, and timely follow up of patients challenging.

The aim of this study was to review the outcomes of myringoplasty surgery performed in the West Kimberley region over the last 10 years, and identify factors associated with surgical and audiological outcomes.

Methods

The study was a retrospective audit of all patients undergoing myringoplasty for a TM perforation between 2004 and 2014 in the West Kimberley region of Western Australia. Ethical approval for this study was provided by WACHS, the Western Australian Aboriginal Health Ethics Committee (WAAHEC), Kimberley Aboriginal Health Planning Forum (KAHPF), and University of Adelaide ethics committee.

An operating theatre database prospectively recording all procedures was interrogated to identify cases at the major regional hospitals in Broome and Derby. The terms “myringoplasty” and “tympanoplasty” were used to search the database. The inclusion criteria were all indigenous patients that underwent a myringoplasty (defined by closure of the TM with graft materials such as temporalis fascia, fat, perichondrium, or composite grafts). Any patient undergoing myringoplasty in conjunction with cholesteatoma or other ear surgery (such as atticotomy, mastoidectomy, ossicular chain reconstruction) were excluded.

Individual patient charts were reviewed for demographic, clinical, operative, and audiometric data. Audiometry was conducted under standardized conditions in hearing booths

whenever available. Otherwise audiological testing was performed in the quietest room available with calibrated, noise-insulating over-the-ear or insert headphones.

The primary outcome measures were otoscopic and audiometric. “Success” was defined as closure of the TM and an average air-bone gap (ABG) of less than or equal to 25 dB across 500 Hz, 1, 2, and 4 kHz with a follow-up of at least 6 months post-surgery, in keeping with the Mak *et al.* studies (7,8).

TM perforation size was divided into 4 grades. Small perforations (Grade 1) were defined as an area less than or equal to 25% of the total surface area of the TM, medium perforations (Grade 2) between 26% and 50%, large perforations (Grade 3) between 51% and 75%, and subtotal perforations (Grade 4) between 76% and 99%. The World Health Organisation (WHO) classification of hearing loss severity was used to grade the magnitude of the ABG (see *Table 2*) (12). If a patient underwent bilateral myringoplasties then the ear with the greatest pre-operative ABG was used for analysis of “Success”.

Results

A total of 327 patients identifying as Indigenous underwent a myringoplasty. There were 38 non-Indigenous myringoplasty patients excluded. There were 419 ears identified during the audit period fulfilling the inclusion criteria. There were 92 patients who underwent bilateral myringoplasties. Patient demographics, perforation characteristics, and pre-operative audiometry data was extracted along with myringoplasty operative technique, graft material, and placement.

Only 207 patients (representing 271 operated ears) attended follow-up to assess the surgical outcome. This represented an attrition rate of 36.4% of patients (35.3% of operated ears) lost to any recorded follow-up. One hundred and fifty-one of the 271 operated ears had at least 6 months follow-up post-operatively, however 61 (14.6%) of these did not have complete audiometric data. This resulted in 90 operated ears across 73 patients with complete otoscopic and audiometric follow-up sufficient to evaluate the primary end-point (*Figure 2*) (12).

Patient demographics

The 327 Indigenous patients who had undergone myringoplasty were aged between 4.8 years to 56.5 years. Patients were divided into three groups—young children

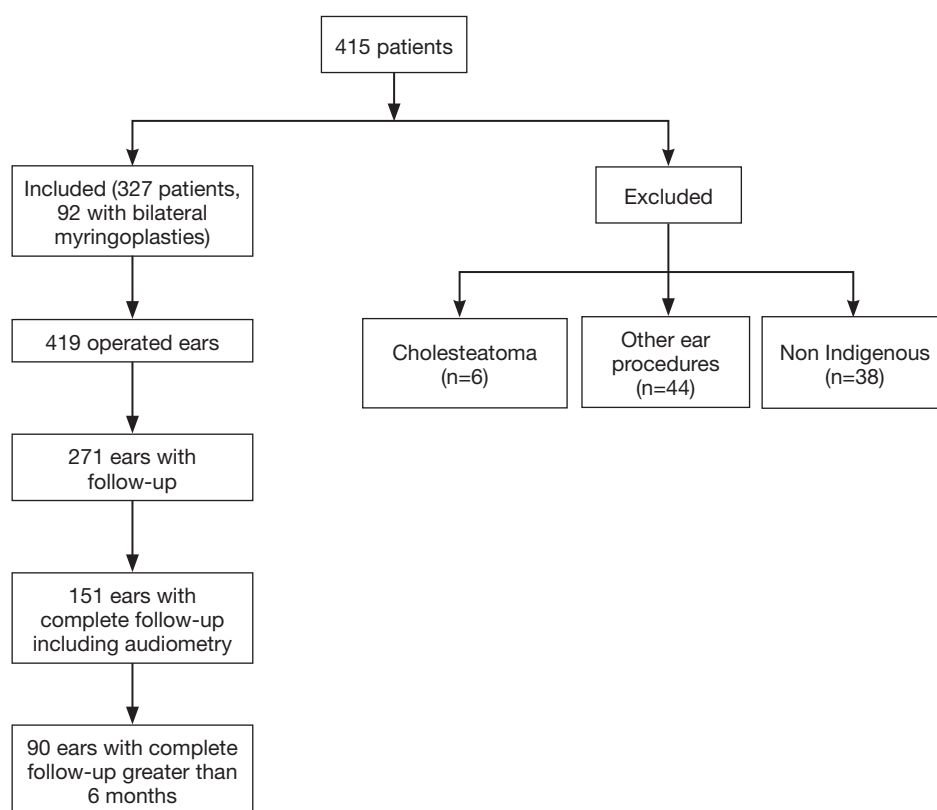


Figure 2 Ninety ears with complete follow-up.

(less than 8 years of age), older children (8 to 18 years of age) and adults (over 18 years of age). *Table 3* demonstrates that more patients were operated on in Derby than in Broome and that there were twice as many female patients as there were male.

Preoperative status of the ear and size of perforation

The location of the perforation was defined by its position relative to the handle of malleus. Central perforations were the most common (*Table 3*). In more than 20% of patients the site of the perforation was not recorded at either the time of booking or time of surgery. With regards to size, the majority were medium perforations followed by subtotal perforations. The size of the perforation was not recorded in 14.8% of patients.

The majority of cases were primary myringoplasties (69%), with 22% being revision cases (n=77 one prior attempt, n=16 two or more prior attempts). The number of prior attempts was not documented in 9% (n=38 ears). The middle ear was dry in 83.5% of operated ears at the time of

booking for surgery, with 90.9% dry on the day of surgery.

Pre-operative audiometry

Pure tone audiometry was obtained in 382 (91.2%) ears pre-operatively. However, only 269 ears had air and bone conduction thresholds at 500 Hz, 1, 2 and 4 kHz recorded. In this group, using the WHO classification (*Table 2*) applied to the surgical ear, 91 of the operated ears had normal hearing preoperatively (33.8%), 153 ears had mild hearing loss (56.9%), 23 ears had moderate hearing loss (8.6%), and 2 ears had severe hearing loss (0.7%). Overall, this group had a mean ABG of 30.1 dB (SD =10.9) and bone conduction thresholds ranged between -10 and 40 dB, with a mean of 6.8 dB (SD =7.3).

As expected, larger perforations were associated with a greater ABG. The mean ABG for subtotal perforations was 35.3 dB (SD =10.8, n=55), with 33.5 dB (SD =11.0, n=38) for large perforations, 29.7 dB (SD =10.6, n=90) for medium perforations, and 24.2 dB (SD =8.1, n=51) for small perforations. A one-way independent groups ANOVA

Table 3 Demographic, otoscopic, audiometric, and surgical data for ears with and without complete follow-up

Variables	Complete follow-up (n=73 patients, 90 ears), n [%]	Incomplete follow-up (n=254 patients, 329 ears), n [%]	Total (n=327, 419 ears), n(%)	P value
Demographics ^a				
Age (years)				NS
<8	22 [30]	61 [24]	83 [25]	
8–18	41 [56]	123 [48]	164 [50]	
>18	10 [14]	70 [28]	80 [24]	
Location				<0.001
Broome	12 [16]	112 [44]	124 [38]	
Derby	61 [84]	142 [56]	203 [62]	
Gender				<0.05
Female	53 [73]	155 [61]	208 [64]	
Male	20 [27]	97 [38]	117 [36]	
Unknown	0 [0]	2 [<1]	2 [<1]	
Pre-operative perforation status ^b				
Total number of ears	90	329	419	–
Location				NS
Anterior	23 [26]	83 [25]	106 [25]	
Posterior	12 [13]	26 [8]	38 [9]	
Central	50 [56]	156 [47]	206 [49]	
Not recorded	5 [6]	64 [19]	69 [16]	
Size				NS
Grade 1 (<25%)	13 [14]	73 [22]	86 [21]	
Grade 2 (25–50%)	39 [43]	92 [28]	131 [31]	
Grade 3 (50–75%)	12 [13]	33 [10]	45 [11]	
Grade 4 (>75%)	15 [17]	79 [24]	94 [22]	
Not recorded	11 [12]	52 [16]	63 [15]	
Prior attempts				–
One+	22 [24]	73 [22]	95 [23]	
Not recorded	3 [3]	33 [10]	36 [9]	
Middle ear status				NS
Dry	72 [80]	278 [84]	350 [84]	
Wet	18 [20]	51 [16]	69 [16]	

Table 3 (continued)

Table 3 (continued)

Variables	Complete follow-up (n=73 patients, 90 ears), n [%]	Incomplete follow-up (n=327 patients, 329 ears), n [%]	Total (n=327, 419 ears), n(%)	P value
Surgical techniques ^b				
Bilateral surgery	34 [38]	150 [46]	184 [44]	–
Approach				NS
Transcanal	50 [56]	169 [51]	219 [52]	
Endaural	23 [26]	83 [25]	106 [25]	
Post-auricular	4 [4]	17 [5]	21 [5]	
Not recorded	13 [14]	60 [18]	73 [17]	
Graft Material				NS
Cartilage	28 [31]	67 [20]	95 [23]	
Composite	11 [12]	50 [15]	61 [15]	
Perichondrium	12 [13]	20 [6]	32 [8]	
Temporalis Fascia	35 [39]	155 [47]	190 [45]	
Fat Plug	1 [1]	19 [6]	20 [5]	
Not recorded	3 [3]	18 [5]	21 [5]	
Surgical techniques ^b				
Graft placement				NS
Underlay	61 [69]	213 [65]	274 [65]	
Inlay	24 [27]	54 [16]	78 [19]	
Overlay	2 [2]	11 [3]	13 [3]	
Not recorded	3 [3]	51 [16]	54 [13]	

Totals less than the overall were due to missing data. ^a, based on number of patients n=327; ^b, based on number of ears n=419. NS, not significant.

demonstrated a significant effect for perforation size on pre-operative ABG, $F(3,230) = 11.76$, $P < 0.001$. Post-hoc analysis (Tukey HSD) demonstrated subtotal perforations had a greater ABG than medium ($P < 0.01$) and small ($P < 0.001$) perforations. Large ($P < 0.001$) and medium ($P < 0.05$) perforations also had a larger ABG than small perforations. The state of the middle ear did not affect the ABG except in Grade IV perforations, where wet perforations ($M = 43.0$ dB, $SD = 13.2$, $n = 24$) had 11dB worse hearing than dry perforations ($M = 31.8$ dB, $SD = 7.5$, $n = 70$).

Myringoplasty techniques by operated ear

The transcanal approach was the most commonly used technique and the post-auricular approach the least

common (Table 3). The surgical approach was not recorded in 17.4% of ears. The most common graft material used was temporalis fascia, followed by cartilage, composite grafts, perichondrium, and fat plugs. Graft material was not recorded in 5% of cases. The majority of grafts were positioned using an underlay technique, followed by the inlay technique. The onlay technique was the least common, and in 13% of cases the method of graft placement was not documented (Table 4).

Given the high rate of patients lost to follow-up, the demographic, clinical, audiometric and operative data for the complete follow-up sample ($n = 90$ ears) were compared to the remaining operative sample ($n = 329$ ears) lost to complete follow-up. The complete and incomplete follow-up groups differed in terms of demographic variables of

Table 4 Myringoplasty techniques (approach, graft, placement)

Technique	Number
Transcanal using temporalis fascia placed underlay	78
Endaural approach using temporalis fascia placed underlay	67
Transcanal approach using cartilage/composite as an inlay	55
Transcanal approach using cartilage/composite as an underlay	29
Endaural approach using cartilage/composite as an underlay	26
Post-auricular approach using temporalis fascia as an underlay	17
Other techniques/not recorded	147

location and gender. Derby patients and females were more likely to complete follow-up (see *Table 3*). The groups did not significantly differ on any other demographic, otoscopic, audiometric, or surgery variable.

Follow-up

Of the 207 patients (271 ears) with documented follow-up, clinical review was undertaken at a median of 7.6 months (range, 10 days to 110 months). Of the 271 operated ears, 33 ears (12.2%) were seen less than 2 months post-surgery, 84 (31.0%) between 2 to 6 months, 44 (16.2%) between 6 to 12 months, 57 (21.0%) between 12 to 24 months, and 50 ears (18.5%) seen over 2 years. The date of follow-up was not clearly recorded for three cases.

Complete audiometric follow-up for any ear was defined as patients with a calculated ABG for 500 Hz, 1, 2, and 4 kHz both pre- and post-surgery. This was found for n=152 ears. A further n=62 ears with incomplete audiometry were excluded. Complete otoscopic and audiometric follow-up at least 6 months post-surgery was available for n=90 ears (n=73 patients). This means only 21.5% of the operated ears (22.3% of patients) had adequate follow-up data to evaluate the main outcomes.

Outcome measures

There were three outcome measures of interest: success, closure of the TM perforation, and hearing improvement at least 6 months post-surgery. To maintain consistency

and comparability with the studies published by Mak *et al.* (7,8) success was defined as closure of the TM with an ABG of less than 25 dB at greater than 6 months. Hearing improvement was defined as a reduction in ABG of 10 dB or more. Univariate odds ratio analyses for the outcomes are presented in *Table 5*. A dry middle ear at the time of booking surgery was greater than 5 times more likely to succeed than a wet middle ear. Female gender [odds ratio (OR) =4.69, 95% confidence interval (CI), 1.23–17.93], small to medium perforation size (OR =3.24, 95% CI, 1.13–9.33), and normal preoperative ABG (OR =6.77, 95% CI, 1.45–31.62) were significantly more likely to be associated with TM closure. With regards to hearing improvement, no significant associations were found. Notably however, no wet ear at the time of booking recorded an improvement in hearing, which explains why the odds ratio was not calculable.

Table 6 presents the percentage of operated ears classified according to the WHO hearing loss classification both pre and post-surgery. Just over a quarter of ears had normal hearing pre-operatively, however normal hearing was seen in almost half of the operated ears at greater than 6 months.

Hearing outcomes were also classified by change in perforation status (see *Figure 3*). Hearing was significantly improved by 5.4 dB (SD =11.2) when the perforation was closed (n=31), $t(30) = 2.70$, $P < 0.05$. A reduction in perforation size post-surgery was associated with a 5.2 dB (SD =13.1) reduction in ABG (n=21), but this just failed to reach statistical significance. When the perforation remained stable or enlarged, a non-significant change of 2 dB was observed (n=30).

Discussion

Chronic middle ear disease is widely prevalent in Indigenous Australians. Unfortunately, despite the ongoing awareness of its significant morbidity, there are limited studies evaluating the efficacy of interventional strategies offered to this population. The last published study reviewing myringoplasty outcomes in Indigenous Australians residing in remote Western Australia was over a decade ago (8). Our study is the most recent retrospective appraisal of myringoplasty practise and outcome in the West Kimberley region of Western Australia.

Closure of TM 6 or more months after surgery was seen in 39% of ears in our study. This figure rises to 71% if closure and reduction of perforation size are combined. These results are in contrast to the study by

Table 5 Variables associated with success, tympanic membrane closure, and hearing improvement

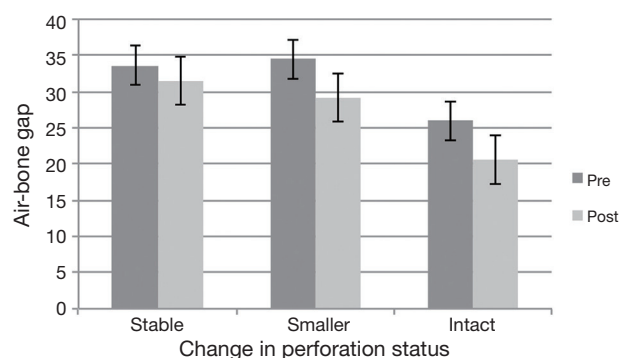
Variables (reference)	Success (29%)	Tympanic membrane closure (39%)	Hearing improvement (29%)
Age (<8 years)	0.77 (0.24–2.51)	0.72 (0.25–2.09)	2.71 (0.93–7.81)
Location (Broome)	0.50 (0.40–5.82)	1.27 (0.36–4.47)	1.85 (0.52–6.63)
Gender (female)	2.45 (0.63–9.55)	4.69* (1.23–17.93)	2.06 (0.60–7.07)
Size of perforation (small/medium)	3.31 (0.99–11.02)	3.24* (1.13–9.33)	1.39 (0.49–3.91)
Prior attempts (nil)	1.10 (0.37–3.24)	0.70 (0.26–1.87)	1.40 (0.45–4.35)
Pre-operative ABG (<25 dB)	9.04* (1.13–71.97)	6.77* (1.45–31.62)	1.54 (0.46–5.21)
Middle ear (dry)	5.24* (1.52–18.04)	2.96 (0.88–9.95)	Not calculable
Approach (transcanal)	0.54 (0.19–1.48)	0.61 (0.23–1.56)	0.94 (0.35–2.55)
Graft (fascia/perichondrium)	1.45 (0.57–3.70)	0.94 (0.40–2.23)	0.59 (0.23–1.53)
Placement (underlay)	0.73 (0.27–1.95)	0.88 (0.35–2.25)	1.63 (0.56–4.68)

Data are presented as odds ratios (95% confidence intervals). *, $P < 0.05$. ABG, air-bone gap.

Table 6 Percentage of WHO classification hearing loss for $n=91$ ears pre- and post-surgery for $n=91$ ears evaluated after 6 months

Hearing level (ABG)	Pre-operative (%)	Post-operative (%)
Normal (<25 dB)	27.8	46.7
Mild (25–40 dB)	54.4	32.2
Moderate (40–60 dB)	17.8	21.1
Severe (>60 dB)	0	0

ABG, air-bone gap.

**Figure 3** Hearing levels pre- and post-myringoplasty across tympanic membrane status.

Mak *et al.* (7), which found a success rate of 49% with 51% hearing improvement, and a mean gain of 9 dB. Hearing improvement of greater than or equal to 10 dB in ABG was demonstrated in 29% of cases in our study in comparison to reported average hearing gain of 9.14 dB in the UK

audit study for primary successful myringoplasty and 9.16 dB for unsuccessful primary myringoplasty (13). Closure or reduction in perforation size was comparable with Mak *et al.* reporting 72% (7). From our analysis, it appears that closure rates have not significantly improved in the last decade for Indigenous Australians in the West Kimberley region.

Our closure rate was lower than international metropolitan studies, including the 10-year UK myringoplasty study with a reported closure rate of 89.5% and the Swedish myringoplasty outcomes study with a closure rate of 88.5% (13–16). This is probably representative of the severity of underlying middle ear disease in Indigenous Australians, and the possible difference in ear anatomy and socioeconomic status that predisposes this population to TM perforations.

Our study identified a significant issue with patients lost to follow up, with less than 22% of the original operative cohort completing clinical and audiometric follow-up for more than six months. This is less than the 32% follow-up rate observed by Mak *et al.* (7), which was obtained with considerable effort, by community health nurses, Aboriginal health workers, and the later visiting ENT teams to locate missing patients. More encouragingly, a follow-up rate of 78% was obtained in a subsequent prospective study conducted by Mak *et al.* (8). The low follow-up numbers are more than likely multifactorial.

Western Australia has the third highest number of Indigenous residents, and the third highest percentage of Indigenous residents in Australian states (17). WA (41%) is only second to NT (81%) in terms of the percentage

of Indigenous individuals living in remote or very remote areas. Despite this and being the largest state of Australia, all specialist ENT services are based in Perth. While visiting specialist trips are more frequent to larger sized Kimberley towns such as Broome, Derby and Kununurra, smaller communities might have specialists visit only once or twice a year. This makes timely follow-up hard to attain.

It is not uncommon for individuals to move from one town to another further hampering efforts to locate patients for post-operative assessment. Anecdotally, separation from community is a major factor affecting attendance. It takes time, patience, and consistency to engage remote patients and communities. We found that patients from the Derby region and females were more likely to complete follow-up. All of these factors provide a unique challenge to the provision of ear health services, including operative and audiology interventions and follow-up.

There is no consensus on the ideal age for myringoplasty but many authors recommend delaying myringoplasty until the child is older than 8 years in order to allow for eustachian tube maturation which is thought to increase the likelihood of a successful outcome (18). The other school of thought, is that attempting to close the perforation in a child with chronic infections has the potential to improve hearing and quality of life (18). Duval found that preschool children have a significantly higher rate of perforations post tympanoplasty which was attributed to re-perforations after successful healing due to persistence of eustachian tube dysfunction or recurrent acute otitis media (19). Other studies have also found myringoplasty was less successful in paediatric populations (20,21). In our study, 25% of patients were under 8 years of age, and age was not associated with successful myringoplasty. Our study did not demonstrate hearing improvement in the setting of persistent perforation. Perhaps, in some cohorts, delaying myringoplasty till age 8 might improve myringoplasty outcomes. The potential benefit of hearing improvement that may occur despite incomplete closure, has been considered sufficient justification to attempt repair. Hearing improvement facilitates better speech, language and behaviour outcomes in turn avoiding developmental delay. However, some caution should be exercised in generalising the results from overseas studies to our relatively unique cohort.

We found having a normal ABG pre-operatively and a dry middle ear significantly improved the chances of a 'successful' myringoplasty. The effect of a discharging ear on the graft take has not been resolved. Some have proposed that dry, uninfected ears provide optimum conditions for

healing (22), while others have reported comparable closure in the presence of a wet ear (23). The association between a dry ear at the time of surgery booking and success suggests that perhaps only patients with dry ears should be offered a myringoplasty. This can be problematic because the state of middle ear can frequently fluctuate. In our cohort the percentage of dry ears improved from 83% at the time of booking to 90% at the time of surgery. In addition, it can be problematic to cancel surgery when patients have had to travel far with their families to attend specialist care.

The favoured approach is often dependent on the site of perforation and the surgeons' preference. The endaural approach is commonly used for posterior or central perforations, while anterior perforations are often best approached postauricular (18). The transcanal approach, a suitable option for small central perforations has been popular, and is frequently technically suitable in Indigenous Australian ears because the external auditory canal is often well sized to allow good exposure. We noted with interest that the different surgical approaches did not appear to influence outcomes.

A variety of graft materials including temporalis fascia, fat, perichondrium, cartilage, composite grafts, and bio design synthetic grafts are used in myringoplasty. There has been insufficient evidence to indicate successful outcomes associated with any particular graft types (18). Temporalis fascia is the most common graft type reported (18). Temporalis fascia has been generally considered more robust than tragal perichondrium, but less than tragal cartilage or composite grafts. We found that temporalis fascia had the highest rate of closure but the difference between temporalis fascia and tragal perichondrium grafts was not statistically significant.

The state of middle ear disease and hearing loss in the Indigenous Australians is complex, and this should be reflected in any approach to its remediation (2). Our data suggest that myringoplasty outcomes in the Kimberley over the last decade are poor. Furthermore, this study suggests that outcomes from myringoplasty have not demonstrably improved compared to the data reported by Mak *et al.* (7,8). We remain mindful however that our results are based on a minority of recorded procedures due to patients being lost to follow-up and incomplete data recording.

Significant resources are required to access, evaluate, consent, mobilise, operate and follow-up on any surgical case in remote towns and communities. Systems to improve coordination of data as well as post-operative care are needed in addition to clinician led systematic prospective data collection to ascertain the success rate of

outreach services and surgeries, including myringoplasty. Standardised audits will allow for appropriate patient selection and adequate resource allocation and help improve myringoplasty outcomes in disadvantaged Indigenous Australians. It is often commented that middle ear disease is a reflection of the underlying health status of the community (24). There are likely limitations to what can realistically be achieved with patient selection and operative technique in this cohort. It is quite probable that more wide-sweeping changes to living conditions, access to clean water, better nutrition, and health care workers will go further to improve ear and hearing outcomes.

Conclusions

The overall closure rate following myringoplasty surgery in Indigenous Australians was 39% in the West Kimberley region over the last decade. TM perforation closure improved hearing. A standardised and integrated approach to documentation will assist in minimising unnecessary data attrition. Improving patient attrition figures will continue to be a challenge and will take coordination and education to realise. Myringoplasty outcomes will likely remain poor in this cohort until community health standards improve.

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at <http://dx.doi.org/10.21037/ajo.2018.05.05>). EHO serves as an unpaid editorial board member of *Australian Journal of Otolaryngology*. JK serves as an unpaid editorial board member of *Australian Journal of Otolaryngology*. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study

was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Ethical approval for this study was provided by WACHS (No. 2015/23), the Western Australian Aboriginal Health Ethics Committee (WAAHEC) (No. 640), Kimberley Aboriginal Health Planning Forum (KAHPF) (No. 2015/-016), and University of Adelaide ethics committee (No. 2015/23). Informed consent was waived due to the retrospective nature of the study.

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