The cost, effectiveness and cost effectiveness of removal and retention of asymptomatic, disease free third molars

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Purpose of investigation The study was undertaken to identify the least costly, most effective and most cost-effective management strategy for asymptomatic, disease free mandibular third molars.

Methods and patients A decision tree model of the outcomes of mandibular third molar retention and removal was constructed. Probability data for possible outcomes were obtained from a comprehensive literature review and entered into the decision tree. The cost to the NHS in treating each outcome was calculated. 100 patients attending the oral surgery clinics, University of Wales Dental Hospital rated the effect of each outcome on their own life. The cost and effectiveness data for each outcome were entered into the decision tree and the analyses were conducted by 'folding back' the decision tree based on the probabilities.

Main findings Mandibular third molar retention was less costly (£170), more effective (69.5 effectiveness units on a 100 point scale) and more cost-effective (£2.43 per unit of effectiveness) than removal (£226, 63.3 and £3.57 respectively). These findings were sensitive to changes in the probability of pericoronitis, periodontal disease and caries.

Principal conclusions Mandibular third molar retention is less costly to the NHS, more effective for the patient and more cost-effective to both parties than removal. However, should the likelihood of developing pericoronitis, periodontal disease and caries increase substantially then removal becomes the more cost-effective strategy.

The indications for the removal of mandibular third molars have been the subject of a great deal of debate. In the past, many dentists and surgeons have recommended that asymptomatic mandibular third molars should be removed to prevent future disease.[1–3] Many others have expressed the opposite view. Published reviews of the risks and benefits of mandibular third molar management have concluded that prophylactic removal is unjustified.[4,5] Decision and cost-effectiveness analyses have strongly supported the appropriateness of retention of asymptomatic, disease free third molars.[6-8] However, these studies have rarely taken account of the patients' perspective or health service costs. As health care evolves towards a patient-centred service, it is increasingly important to consider the patient's perspective in health care decisions.[9] Additionally, decisions must be made concerning the maximisation of effective resource allocation. A method of quantifying the relative costs, effectiveness and cost-effectiveness of particular treatment options is decision analysis. This method depends on clinical knowledge (probability of outcomes) and values attached to different outcomes (patient utilities and health service cost). It permits both objective data and subjective personal preferences to play a part in the decision process. This is consistent with how medical decisions are actually made.[10]

Decision analysis was first described more than three decades ago.[11] It arose from the disciplines of economics, statistics, and psychology and in the case of clinical decision analysis, epidemiology and clinical informatics. Since the 1970s, decision analysis has increasingly been applied to complex medical decisions[12] in clinical, financial and research settings.[13] The increased use of decision analysis in medicine and dentistry[6,8,14–18] possibly reflects the increasing importance of economic costs and quality of health care provision.

Tulloch *et al.* have stated that 'Although performing a detailed analysis for every mandibular third molar management decision may appear complex and time-consuming, an analysis of well-defined outcomes that occur frequently and where there are both uncertainties and risks would be useful'.[19] This study is based on this recommendation, a decision analysis was conducted to identify the least costly, most effective and most cost-effective management strategy for asymptomatic, disease-free third molars from both the health care provider and patient perspective.

Method

The construction of the decision tree and determination of the probability, cost and effectiveness data was carried out in phases.

Phase 1 Construction of the decision tree and determination of the probability data.

The various outcomes of lower third molar retention and removal, together with their incidences were obtained from a comprehensive computerised (Medline) and manual search of the medical literature (1966 to 1998). The detailed outcomes were structured within their own sub-trees, for example with or without pain (Appendix 1). The probability of each outcome was the mean incidence reported from all of the relevant literature. The rates were expressed as a proportion of one relative to the other outcomes within the sub-tree. Collectively, this information formed the basis of the decision tree, which was constructed using decision analysis software[20] (Appendix 1). The decision tree did not include an analysis of differences in surgical morbidity with age or changes in increase of disease with age. Evidence available in relation to these issues is scarce, but such evidence as is available suggests that surgical morbidity does not increase with age.[21] Therefore, these values were not incorporated into the decision analysis.

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Table 1 Estimated hospital National Health Service procedure cost for outcomes of third molar removal (all figures rounded to the nearest pound [£])

Outcome	Total procedure cost (removal under LA[1])	Total procedure cost (removal under IVSED[2])	Total procedure cost (removal under GADC[3])	Total procedure cost (removal under GAIP[4])
Pain	62	148	466	1216
Lingual, or labial paraesthesia	76	161	480	1230
Temporary labial anaesthesia	76	161	480	1230
Temporary lingual anaesthesia	76	161	480	1230
Swelling	81	166	485	1235
Temporary lingual and labial anaesthesia	90	175	494	1244
Trismus	93	179	497	1247
Post-operative bleeding	97	182	501	1251
Permanent lingual, Labial or lingual and labial anaesthesia	131	217	535	1285
Alveolar osteitis	148	233	552	1302
Permanent lingual, labial or lingual and labial anaesthesia with pain	616	702	1021	1771
Fractured jaw	1321	1406	517	1267

[1]LA - local anaesthesia, [2]IVSED - local anaesthesia with intravenous sedation, [3]GADC - general anaesthesia /day case
[4]GAIP - general anaesthesia /In-patient.

Cost data were obtained as described in Appendix 2. Examples of how these outcomes were costed are shown in Appendix 3.

Phase 2: Determination of cost data

Cost was measured in terms of direct economic cost in an NHS hospital and incorporated consumables, staff costs, overheads and equivalent annual costs. The strategy used to calculate these can be seen in Appendix 2. The costs for third molar removal (including anaesthetic costs) and retention were calculated to obtain a total cost given a particular outcome (Tables 1 and 2).

Phase 3: Determination of effectiveness data

Effectiveness data were obtained using a questionnaire adapted and modified from research conducted by Armstrong *et al.*[22] The questionnaire consisted of twenty-two scenarios, describing in everyday language all of the various outcomes identified in the literature, for example 'A wisdom tooth erupts at the back of your mouth. Every six weeks or so you experience a few days of aching pain around the tooth and the gum feels swollen', and 'After the extraction you experience pain and your face and mouth are swollen'. Fourteen of the scenarios represented the possible health outcomes following third molar removal (Table 1) and eight scenarios represented the outcomes of retention (Table 2). Accompanying each scenario was a VAS, 100mm in length. The end points of the VAS were 'Things could not be worse' (0mm) and 'I would not be bothered at all' (100mm).

One hundred and two consecutive patients were invited to rate the outcomes after they had completed a consultation in the oral surgery clinic, University of Wales Dental Hospital; however, two refused due to lack of time. As part of normal treatment planning, patients had been informed of all the possible outcomes of removal by the clinician. In addition, to standardise this information, an information leaflet[23] was given to the patient to read at the end of the consultation. Before completing the questionnaire, the patients were asked to read each of the scenarios. This allowed them to become familiarised with the scope of outcomes. Each patient then re-read the scenarios and placed a cross on the VAS at a point they felt represented how they would feel if they experienced each of the scenarios. The patients were allowed as much time as they required to complete the questionnaire. The cross made by each patient on the VAS for each scenario was measured to the nearest millimetre and constituted the measure of effectiveness. The mean effectiveness scores were then calculated (Table 3).

Phase 4: Decision Analysis

NHS procedure costs and mean effectiveness scores were entered into their respective terminal nodes, or outcomes on the tree. Collectively, these values were 'folded back'. This is a decision analysis procedure that takes into consideration the probability of each outcome when determining the average cost, effectiveness and cost-effectiveness of mandibular third molar retention and removal. In addition, the various values were subjected to sensitivity analyses, which allowed the investigation of how changes to the various values could alter the most cost-effective strategy.

Results

The National Health Service procedure cost of outcomes following mandibular third molar management is shown in Tables 1 and 2 and Appendix 3. The average National Health Service procedure cost for mandibular third molar retention (£170) was less than surgical removal (£226) resulting in a marginal cost of £56 (Table 4). The effectiveness of mandibular third molar management was rated as being greater for third molar retention (69.5) than for removal (63.3) giving a marginal effectiveness of -6.2 (Table 4). Taking into consideration both the costs and effects, mandibular third molar retention (£2.43 per unit of effectiveness) was more cost-effective than removal (£3.57 per unit of effectiveness). It thus follows that the strategy of removal was less cost effective over the whole range of cost compared with the strategy of third molar retention (Table 4).

Table 2 Estimated NHS procedure cost for outcomes of third molar retention.

Outcome	Total procedure cost rounded to the nearest pound (£)
Asymptomatic, disease free third molar	£0
Single episode of pericoronitis	£14[1]
Multiple episodes of pericoronitis	£458[2]
Unresotorable caries of the 3rd molar	£458[2]
Caries of the 2nd molar	£458[2]
Resorption of the 3rd molar	£458[2]
Resorption of the 2nd molar	£458[2]
Periodontal disease	£458[2]
Cystic change	£458[2]

[1]The estimated NHS cost of a consultant clinic appointment.
[2]The average NHS cost of third molar removal.
Cost data were obtained as described in Appendix 2.
Further information can be obtained from the authors.

Table 3 Mean effectiveness scores for outcomes of third molar management

Outcome	Rank: from least to most reduction in health	Management strategy	Effectiveness Score
Asymptomatic third molar	1	Retention	85.0
Occasional minor pain	2	Removal	81.5
Post-operative bleeding/ minor pain	3	Removal	68.0
Moderate pain	4	Removal	64.0
Single episode of pericoronitis	5	Retention	63.0
Reliability: moderate pain	6	Removal	61.5
Swelling/moderate pain	7	Removal	61.0
Lingual, or labial paresthesia/ minor pain	8	Removal	57.5
Cystic change	9	Retention	57.0
Reliability: multiple episodes of pericoronitis	10	Retention	54.5
Multiple episodes of pericoronitis	11	Retention	53.0
Trismus/moderate pain	12	Removal	53.0
Incisor crowding	13	Retention	44.0
Periodontal disease	14	Retention	42.0
Temporary labial anaesthesia/ minor pain	15	Removal	42.0
Caries of the 2nd And 3rd molar	16	Retention	41.0
Resorption of the 2nd and 3rd molar	17	Retention	41.0
Alveolar osteitis/severe pain	18	Removal	41.0
Temporary lingual anaesthesia/ minor pain	19	Removal	38.0
Temporary lingual and labial anaesthesia/minor pain	20	Removal	35.0
Permanent labial anaesthesia/ minor pain	21	Removal	22.0
Permanent lingual anaesthesia/ minor pain	22	Removal	18.0
Fractured jaw/moderate pain	23	Removal	18.0
Permanent lingual and labial anaesthesia/minor pain	24	Removal	13.5

Sensitivity analyses revealed that the model was only sensitive to alteration of the probability values for pericoronitis, periodontal disease and unrestorable caries in the second molar. They had threshold values of 0.40, 0.17 and 0.22, respectively. The threshold values indicate the point at which the most cost-effective strategy for an asymptomatic mandibular third molar would alter from retention to removal. For example, if for a particular third molar, the probability of developing pericoronitis exceeded 40% then it would be more cost effective to remove the tooth than to adopt a conservative approach.

Discussion and conclusions

Cost, effectiveness and cost-effectiveness analyses indicated that third molar retention was less costly to the NHS within the Hospital Dental Service, more effective for the patient and more cost-effective than removal. Although the costs are specific to the HDS, these findings support the findings of previous research suggesting that third molar retention is the optimal management for asymptomatic, disease free mandibular third molars.[4–8,23] It is appropriate to consider the extent to which these results would translate to general practice where different costs would apply. Potentially, more efficient cost control in practice might make the surgical treatment of patients with mild low grade disease more appropriate. However, the optimal treatment for pathology free teeth would not alter since, on clinical grounds alone, they are best treated conservatively.

The findings also suggest that there is only a cost saving or health gain in removing asymptomatic, pathology-free mandibular third molars when there is a substantially increased risk of developing pericoronitis, periodontal disease and caries. Should the chance of a patient developing one of these three diseases be greater than the threshold value identified in this study then removal becomes the more cost-effective strategy. Certain populations are at greater risk of developing pericoronitis/periodontal diseases such as smokers.[23,24]

An additional concern is that the probability values used for this study may be underestimated. The range of reported incidences in the literature suggests that this is possible in some patient groups as the maximum reported probabilities compare with the probabilities that would change the optimal strategy.[25–29] The conclusions drawn from decision analyses depend upon the quality of the information upon which they are based. In this instance, the sources of probability data were of concern as there was a wide range of reported incidences for each outcome suggesting that there were both variations in methodology and biases in results. Ideally, randomised-controlled trials or prospective, longitudinal research needs to be conducted to provide evidence that is more conclusive.

The benefit of incorporating NHS cost and patient perceived effects when evaluating mandibular third molar management options is that resources can be apportioned so that treatment that does not yield a health gain can be avoided.[8] Cost and effectiveness data collection is straightforward. This would facilitate analyses on a national basis and across various clinical settings. This type of analysis also provides a clearer insight into the economic implications of high volume, high cost procedures, where small changes in treatment may result in large gains in terms of financial and opportunity cost.

This study has highlighted the dynamics of decision making in relation to one high volume surgical procedure. The apparent similarities between the perceived and economic impact of mandibular third molar management options implies that there is some agreement between the patient and the NHS when it comes to developing appropriate criteria for treatment interventions. The likelihood of developing pericoronitis, periodontal disease and unrestorable caries are the only factors that may challenge the philosophy that prophylactic removal should be avoided. Until more knowledge is gained about the risks of developing these, non-surgical manage-

Table 4 Cost-effectiveness analysis of third molar management

Management strategy	Cost	Marginal cost	Effectiveness	Marginal effectiveness	CE	Marginal CE
Third molar retention	£170	£0	69.5	0	£2.43	
Removal	£226	£56	63.3	-6.2	£3.57	Dominated[1]

[1]Dominance report: There was neither a cost saving or utility gain in removing asymptomatic, disease free third molars. Therefore, there was no level of cost at which it became more cost-effective to remove these teeth.

ment of asymptomatic mandibular third molars remains the most cost-effective strategy for the NHS.

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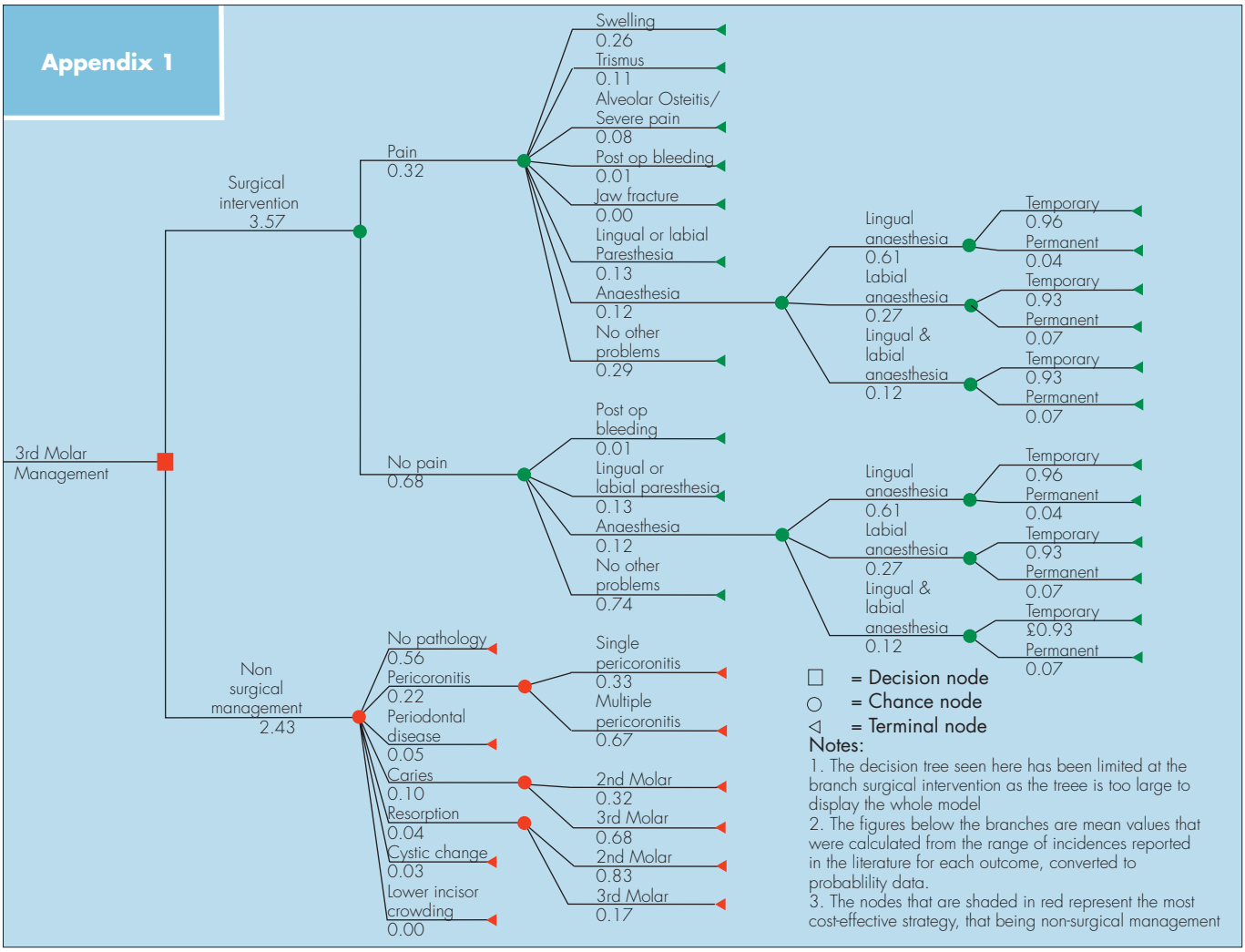
Appendix 1



Appendix 2

Consumables
The direct economic costs of those consumable items used in third molar management and of possible outcomes were calculated from 1997 data. These included:

- Diagnostic and surgical equipment — Stores and Theatre Supplies Department
- Pharmaceutical supplies - The Hospital Pharmacy
- Surgical supplies - Manufacturer's cost data

Staff Costs.
The gross economic cost of professional staff time was obtained from the Personnel Department, University of Wales College of Medicine. The mid points of the 1997 salary scale for each occupation, along with a 20 per cent addition to cover superannuation, national insurance and pay awards were calculated based on the average time taken for third molar management and the outcomes of third molar retention and removal.

Overheads.
Non-patient related economic costs (25 per cent of staff salaries) associated with administration, management, heating, lighting, laundry, linen and cleaning services were obtained from the Finance Department, University of Wales College of Medicine in 1997.

Equivalent Annual Costs.
The economic cost of major equipment was again obtained from the Finance Department, University of Wales College of Medicine in 1997. This was calculated as a cost per procedure where the annual depreciation on the equivalent annual item was divided by the number of procedures that could be undertaken per annum. The depreciation was calculated from the life expectancy and purchase cost using the following formulas:

$$\text{Cost per year (CPY)} = \frac{\text{Repalacement cost}}{\text{Life of the equipment}}$$

$$\text{Cost per day (CPD)} = \frac{\text{CPY}}{\text{Number of days in the year}}$$

$$\text{Cost per procedure} = \frac{\text{CPD}}{\text{Number of procedures in a day}}$$

Appendix 3

Pain following third molar removal		Cost in pounds (£)
Removal under local anaesthesia:		
Consumables		21.95
Staff Costs		19.15
Overheads		4.79
Equivalent Annual Costs		2.49
	Subtotal	48.38
1week review appointment:		
Consumables		2.42
Staff Costs		7.57
Overheads		1.89
Equivalent Annual Costs		1.87
	Subtotal	13.75
	TOTAL	**62.13**

Notes: Further information can be obtained from the authors.

Temporary lingual anaesthesia following third molar removal		Cost in pounds (£)
Removal under general anaesthesia (day case):		
Consumables		70.50
Staff Costs		304.73
Overheads		76.18
Equivalent Annual Costs		1.05
	Subtotal	452.46
Review appointments x 2:		
Consumables		4.84
Staff Costs		15.14
Overheads		3.78
Equivalent Annual Costs		3.74
	Subtotal	**27.50**
	TOTAL	**479.96**

Notes: Further information can be obtained from the authors.

Jaw fracture following third molar removal		Cost in pounds (£)
Removal under intravenous sedation:		
Consumables		34.30
Staff Costs		60.58
Overheads		15.15
Equivalent Annual Costs		3.74
	Subtotal	113.77
Jaw fixation under general anaesthesia (In-patient)		
Consumables		841.80
Staff Costs		304.73
Overheads		76.18
Equivalent Annual Costs		1.05
	Subtotal	1223.76
Review appointments x 5:		
Consumables		12.10
Staff Costs		37.85
Overheads		9.45
Equivalent Annual Costs		9.35
	Subtotal	**68.75**
	TOTAL	**1406.28**

Notes: Further information can be obtained from the authors.