A maximally sensitive clinical decision rule to reduce the need for radiography in mandibular trauma

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ABSTRACT

INTRODUCTION To identify clinical symptoms and signs that exclude the presence of mandibular fracture in patients presenting with mandibular trauma and thus devise a clinical decision rule that will rule out the need for radiography in some patients.

PATIENTS AND METHODS A prospective study was conducted of consecutive patients with a possible diagnosis of mandibular fracture who attended a city-centre emergency department between July 2000 and December 2001. Clinical symptoms and signs were recorded for each patient using a predesigned proforma. Radiographic evaluation of a suspected mandibular fracture consisted of lateral-oblique and postero-anterior mandibular views. The presence of a fracture was based on the interpretation of the X-rays by a radiologist who was blinded to the clinical probability of a fracture. Data were initially analysed using the chi-square test. Recursive partitioning was then performed to create a maximally sensitive decision tree.

RESULTS 280 patients were included in the study, 65 of whom had a mandibular fracture. A maximally sensitive decision rule was found that identified 5 parameters (malocclusion, trismus, broken teeth, pain with mouth closed, step deformity) whose absence excluded mandibular fracture. This rule has a sensitivity of 100% and specificity of 39% in identifying patients with mandibular fracture. If applied to our patient cohort, this rule would have saved 83 radiographs without missing any fractures.

CONCLUSIONS A simple decision rule is presented that can be used to exclude the need for radiography in a subset of patients with mandibular trauma.

KEYWORDS

Mandible – Fractures – Diagnosis – Cohort studies

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Clinical decision rules are increasingly setting the standards by which patients should be treated in emergency departments. The ability of the 'Ottawa Ankle rule' to reduce safely the number of ankle radiographs in emergency departments has been reported in the *British Medical Journal*.^{1,2} In addition, rigorous methodological standards have been detailed by Stiell *et al.*,³ who described the development of clinical decision rules, from identification of the need, through derivation and validation, to implementation and dissemination. It is hoped that as well-conducted clinical decision rules continue to be produced to the highest methodological standards, clinical quality and cost effectiveness will increase with a

marked reduction in unnecessary investigations, delays in management and uncertainty amongst junior physicians.

Facial injury is a common presentation, especially amongst young men, with up to 5% of trauma patients suffering significant facial injury. However, only 30–40% of patients presenting with mandibular trauma have mandibular fractures.^{4–10} These patients are often seen by junior physicians whose experience of mandibular trauma may be limited. Therefore, the lack of guidance as to who should undergo radiography leads to over-investigation in this group. There is currently little information as to which combination of clinical symptoms or signs may be safely used to predict or exclude the presence of a

mandibular fracture and, therefore, which patients should undergo radiological examination.^{11–15}

The aim of this study was to determine the clinical symptoms and signs that will exclude a mandibular fracture and to devise a clinical decision rule that will guide radiological investigation.

Patients and Methods

Design

This was a prospective observational cohort study.

Setting

The study was conducted at the emergency department of the Manchester Royal Infirmary, between July 2000 and December of 2001. This is an inner-city hospital, seeing 100,000 patients per year that receives mandibular trauma mainly from blunt injury after assault. All physicians seeing patients in the emergency department were given a 1-h training session in the use of a mandibular trauma proforma. This proforma was completed every time a patient with mandibular trauma was seen, before the results of a radiograph were available. The proforma contained questions about the symptoms and signs elicited at the consultation (see Table 2). The examining doctor also recorded his/her overall impression of the likelihood of presence of mandibular fracture based on examination findings (categorised as low, moderate or high).

All patients entered into the study received a radiograph. Radiographic evaluation of the suspected mandibular fracture consisted of lateral-oblique and postero-anterior mandibular views. The emergency physicians initially interpreted the films. A radiologist who was blinded to the clinical probability of a fracture also interpreted the films. The radiologist's interpretation alone was used as the gold standard for confirming or excluding a mandibular fracture. All mandibular fractures including dento-alveolar fractures were considered to be positive for a fracture. A detailed and comprehensive retrospective audit of all patient records was conducted after the study to identify the demographics of those not entered into the study.

Subjects and outcome measures

Our inclusion criteria for entry into this study were as wide as possible and any patient for whom the attending physician had any suspicion of a mandibular fracture was included in this study. We found in a prior pilot study that patients with any suspicion of mandibular fracture were routinely receiving radiography and so our study did not increase the radiography rate. Exclusion criteria were: (i) airway compromise; (ii) GCS less than 15; or (iii) inability to co-operate with clinical history and examination. An initial pilot study was performed prior to this study that identified 18 useful clinical correlates for investigation in this study and determined that about 1 in 5 patients with suspicion of

Table 1 Group demographics

	Non fracture group (n = 215)	Fracture group (n = 65)
Age (years)	Mean 29 (range 5–80)	Mean 28 (range 16–85)
Sex	Male 81%	Male 94%
Mechanism		
Punch	68%	71%
Trip or fall	10%	12%
Projectile	6%	3%
Penetrating injury	0%	0%
Other mechanism	16%	14%
Alcohol consumed	50%	49%
Physician grade	Junior 86% Middle 13%	Junior 80% Middle 19%
Seen within		
3 h	46%	25%
6 h	67%	42%
12 h	74%	59%
Seen after 2 days	8%	15%

a mandibular fracture would have a proven fracture. The patients in the pilot were not included in the final paper.

Data analysis

Initial univariate analysis was performed using the Pearson χ^2 test or Fisher's exact test where any expected cell count was less than 5. Analysis of the data in order to devise a clinical decision rule was conducted using the Data-mining program CART[®].^{14,15} This program uses the technique of binary recursive partitioning to create a decision tree. It is binary as it always splits parent nodes (or decision rules) into two child nodes. It is recursive as it then uses each child node as the parent node to create the next step in the tree. The improvement in the predictive ability of the tree is tested at each stage. The tree is complete when further splitting produces no improvement in the predictive ability of the tree. Before commencing the analysis, we set *a priori* objectives of finding a 100% sensitive rule, with no more than 6 steps in that rule.

Sample size

Although formal power calculations do not exist for recursive partitioning, a commonly used 'rule of thumb' is that there should be 10 outcome events per independent variable in the prediction rule.³ We feel that a rule with over 7 variables is difficult to use thus we aimed to obtain 70 patients with a mandibular fracture. Our pilot study gave an incidence of 25% of mandibular fracture and, therefore, 280 patients were recruited into the study.

Table 2 Univariate association of clinical predictors with mandibular fracture

Clinical symptom/sign	Fracture	No fracture (n = 65)	Sensitivity (n = 215)	Relative risk	Confidence interval
Pain mouth closed	88%	58%	88%	3.90	1.94–7.83
Mastication difficulty	63%	36%	63%	2.35	1.50–3.66
Pain on mouth opening	77%	56%	77%	2.12	1.26–3.59
Bruising	43%	36%	43%	1.26	0.823–1.93
Swelling	78%	47%	78%	3.02	1.76–5.20
Lacerations	9%	18%	9%	0.545	0.251–1.18
Blood in the ear	0	1%	0%	*	P = 0.338
Blood in the mouth	18%	5%	18%	2.66	1.69–4.17
Tenderness	95%	78%	95%	4.60	1.50–14.1
Crepitus	22%	2%	21%	3.77	2.62–5.43
Step deformity	18%	1%	18%	4.30	3.12–5.94
Trismus	23%	4%	23%	3.19	2.14–4.74
Bruising under the tongue	6%	1%	6%	2.56	1.30–5.04
Broken teeth	14%	4%	14%	2.49	1.50–4.12
Lost teeth	17%	6%	17%	2.28	1.40–3.71
Mandibular deviation on opening mouth	8%	2%	8%	2.50	1.34–4.69
Malocclusion of teeth	46%	9%	46%	3.94	2.70–5.76
Inability to move jaw side to side	28%	9%	28%	2.52	1.65–3.82

*Zero cell in this category and, therefore, risk ratio not calculable; P value given.

Ethics

Full ethical approval for this study was obtained from the Central Manchester Local Ethics Committee.

Results

During the study period, 280 eligible patients (236 male, 44 female) were enrolled in the study all of whom were included in data analysis (Table 1). Sixty-five patients were diagnosed by the radiologist as having a fracture. In 10 patients, a fracture on X-ray was diagnosed by the examining emergency department doctor, but not by the duty radiologist. The emergency department doctor missed 7 fractures diagnosed by the radiologist.

Table 2 demonstrates the clinical findings classified by fracture or no fracture. The sensitivity, relative risk ratio and associated confidence intervals were all calculated. Using Data-Mining, a 100% sensitive decision tree was found (Fig. 1). The data were further analysed using logistic regression but no improvement to this rule could be made.

Our decision rule has a sensitivity of 100% (Table 3). Furthermore, the specificity is 37%. In addition, our decision rule successfully predicted a fracture in all 28 cases in which the attending physician recorded a clinical suspicion of fracture prior to the X-ray as being low or moderate. Our rule, if applied to our dataset, would have avoided 83 radiographs without missing any fractures. Retrospective auditing of patient records after

the study showed that 50% of those eligible for entry into the study were recruited. However, they did not differ significantly from those recruited in terms of age, sex, mechanism of injury, incidence of fracture or grade of physician seeing patient.

Discussion

We have derived a 100% sensitive decision rule that predicts the presence of a mandibular fracture. The rule uses the 5 clinical

Table 3 Classification performance of the rule for

	Mandible fracture on radiological examination		
	Yes	No	Total
Decision rule states fracture	Yes	65	132
	No	0	83
	Total	65	215
		Percentage	Confidence interval
Rule sensitivity		100%	94–100%
Rule specificity		39%	33–45%
Radiography rate		70%	65–75%

correlates shown in Figure 1. The absence of these 5 simple correlates eliminates the risk of the patient having a mandibular fracture. Our rule out-performed our physicians who classified 5 fractures as low probability and 23 fractures as moderate probability; in addition, the rule would have saved 83 radiographs if applied to our study population.

This is the biggest study to look at the diagnostic accuracy of several symptoms and signs in predicting mandibular fractures and to develop a simple scheme that can be used in a day-to-day management of patients with mandibular injuries in the emergency department.

As can be seen from the results, none of the factors examined achieved a high sensitivity or relative risk ratio individually. The observed sensitivity and specificity for clinical signs including swelling, malocclusion, trismus, and crepitus are similar to those reported previously by studies specifically examining these signs. Schwab *et al.*¹² also looked at the clinical accuracy of the tongue blade test in which the patient is asked to grasp a tongue blade between the teeth; the patient's ability to hold the blade against mild resistance by the examiner is recorded. They reported a sensitivity of 96% with a specificity of 64% for

BOX 1 The Manchester Mandibular Fracture Decision Rule

1. Do the patient's teeth meet abnormally (i.e. malocclusion)?
2. Is the patient unable to open his/her mouth normally (i.e. trismus)?
3. Does the patient have any broken teeth?
4. Does the patient report pain while their mouth is closed?
5. Is there a step deformity?

If yes to any of above then request mandibular X-ray

this test. However, we felt that this was a rather specialised test and that in our pilot study junior emergency department doctors were unaware of this test or performed it inconsistently and poorly. Furthermore, the positive result for this test had different definitions in the various studies where it had been used. For this reason, we did not include it as one of the clinical signs looked at in our study.

Only patients with possible mandibular fracture were included in this study; thus patients who presented with trivial injury around the lower face were not X-rayed. Inclusion of patients who would not normally undergo an investigation was not considered to be clinically or ethically justifiable.

We used the mandibular series rather than the panoramic view of the mandible to screen for fractures despite the fact that the panoramic view may have a higher sensitivity in detecting such fractures.^{16–18} In our institution, as well as in most emergency departments in the UK, the standard mandibular series is the first-line radiological investigation for mandibular fractures. In unclear cases, the panoramic view is further used. As the mandibular series is most commonly used in clinical practise, we feel that our results are more relevant to the practising clinician rather than if panoramic views had been used.

A weakness of our derivation study is that the inter-observer variability of each clinical correlate was not formally investigated, although we feel that all the 5 variables in our rule are very simple and, therefore, highly reproducible. However, we intend to investigate this further in the validation phase as we will also be able to assess the inter-observer variability of the rule as a whole at this stage, and perform an economic analysis of implementation.

In our statistical analysis, we used both logistic regression and data-mining techniques. The data-mining was performed using CART®, which is a highly effective, computer-intensive method of finding the best possible decision rule in complex data sets and has been used in other fields.¹⁹ Many investigators have found, as we have, that data-mining is

superior to logistic regression when the object of the rule is to provide maximum sensitivity.²⁰

Conclusions

The decision rule that we have derived (Box 1), if applied to our dataset, would have saved 83 radiographs without missing any fractures in our cohort of patients who would normally have undergone a mandibular X-ray series. We believe that this decision rule will also be easy to use and recall in the setting of a busy emergency department. This rule will now be validated in a separate population and thereafter recommended for general use.

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