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A quantitative study to determine the efficacy of occipitomental facial views in diagnosing fractures by trauma consultants at an academic hospital in Johannesburg

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Abstract

Radiography on patients who sustain facial bone fractures form the largest workload in the trauma department at Charlotte Maxeke Johannesburg Academic Hospital in South Africa. These examinations are performed on patients who are either intoxicated or badly injured thus very little cooperation can be guaranteed. The researchers observed that the trauma consultants make a diagnosis from one or two out of the four projections routinely performed. Depending on the findings from these radiographs, some of the patients are referred for computer tomography (CT); others are managed consecutively. Previous studies on the choice of diagnostic modality to use for facial bone trauma ranged from conventional radiography, CT and ultrasound.

Methods: A retrospective, quantitative, descriptive and cross-sectional study was conducted. Two trauma consultants(#1 and #2) were invited to each analyse 35 plain-film occipitomental (OM) 15° and 35 plain-film occipitomental (OM) 30° images (n=70). The findings of the trauma consultants were related to those of the radiologists, which was estimated to be 90%.

Results and discussion: Kappa statistics were used to analyse the results. Participant #1 achieved 88.57% and participant #2 achieved 80% for a positive diagnosis. Their assessment of the images were similar to published studies.

Conclusion: The results indicated that OM 15° and OM 30° radiographs were sufficient as a screening tool for mid-facial bone trauma. Accurate diagnostic information can be obtained from two instead of the four projections currently performed.

Keywords

facial bones, occipitomental projection, maxillofacial injuries, diagnostic efficacy

Introduction

Skull and facial bone trauma are among the common injuries that are dealt with in a hospital's trauma department[1-3] before patients are referred for radiographic examinations. This study was conducted at the Charlotte Maxeke Johannesburg Academic Hospital (CMJAH). In February 2013, 2716 examinations were performed in the trauma radiography department; 61 were for skull and related structures. Facial bones examinations constituted 37.7% of them.

The facial bone protocol at CMJAH is (i) occipitomental 0° (OM), (ii) OM 15°, (iii) OM 30°, and (iv) submento-vertex (SMV). However, where there is neck injury, SMV is contraindicated. The authors noted that the radiographic quality of some images was suboptimal. Our observation was based on the image analysis criteria described by McQuillen Martensen[4], which focus on positioning and technical quality as well as medicolegal prerequisites. Personal communication with the trauma consultants revealed that they only use information from the most diagnostic projections.

Facial bone trauma studies classify the types of injuries, affected bones, and then the imaging modality of choice to provide a diagnosis that will enable further management.[1, 2] The range of modalities used for radiographic examinations of mid-facial bone injuries are: conventional radiography, computed tomography (CT), and ultrasound (US).[3, 5-8] Performing a minimal number of projections reduces (i) the number of radiographic films used, (ii) radiation dose to a patient, and (iii) the time that radiographers spend with each patient.

This article reports on a study conducted at CMJAH. Two trauma consultants were invited to analyse facial bone radiographs, of patients who had sustained facial injuries, to determine whether diagnostic information could be obtained from only two projections.

Research problem and hypothesis

Referring consultants continue to request all four facial bone projections even when there is also a request for a CT examination on a patient who has sustained facial bone injuries. The research hypothesis was that facial bone fractures can be effectively diagnosed by trauma consultants in CMJAH by means two radiographs: an OM 15º and OM 30º as opposed to departmental protocol of four facial bone projections. The null hypothesis was that facial bone fractures cannot be effectively diagnosed using OM 15º and OM 30º facial bone projections and that a full series of projections is necessary.

Research aim

The aim of this study was first to compare the usefulness of the two projections performed for mid-facial bone injuries, particularly in departments where CT procedures can be performed, instead of the full set of projections. In addition, the aim also was to evaluate whether there were differences in the assessment of mid-facial bone fractures by a radiologist and the two trauma consultants.

Literature review

The topic of this study has not been extensively researched: the cited references are mostly more than 10 years old. The following is highlighted: (a) different imaging systems used for the examination of mid-facial bone fractures, (b) why conventional radiography(film or digital) is still the initial imaging procedure performed before CT, and (c) arguments for the need to reduce the number of projections performed on patients with mid-facial bone fractures.

Technological advancement and digital radiography have resulted in the diminished use of x-ray films due to the presumed improvement in image quality and consequent reduction in the suboptimal images.[9] The reduction in suboptimal images and consequent repeat rate was due to over or under exposure.[9] Advanced technologies, such as high resolution ultrasound (HRUS) and CT, are now the preferred imaging modalities.[5-9] Until the 1980s, conventional radiography was the primary diagnostic tool used for facial bone imaging. High-resolution CT resulted in a new dimension for the radiographic evaluation of a patient with maxillofacial trauma. Druelinger et al.[1] highlighted that CT, when compared to conventional radiography, is superior for screening of facial bone injuries: it is the most valuable initial tool to screen patients with suspected facial bone injuries. CT provides superior diagnostic benefits compared to conventional radiography.[10, 15] CT has however been proven to be a high dose examination; recommendations have been made for its use to be limited where possible.[1, 3, 5-10] Research on the use of HRUS, as an imaging tool for mid-facial bone fractures, shows that it is cheaper and easily accessible: it presents opportunities for providing diagnostic information with non-invasive imaging.[3, 5, 8]

Conventional radiography is readily available in most healthcare institutions in South Africa, community health centres and district hospitals, for example. CT services, however, are usually only available at regional and tertiary hospitals. Conventional radiography is a cost-effective diagnostic imaging tool and provides justification for the need for more focused CT studies. Heiland and Rother[10] indicated that if mid-facial bone fractures are visualised by conventional imaging, it is then essential that CT, with reconstructions, should be performed to help with planning for surgery.

The argument for conventional radiography is supported by Most[2] who indicates that it depends on which bones are affected. According to him CT is the preferred imaging modality to demonstrate the extent (not initial screening) of the injury of maxilla fractures. Conventional radiography remains the gold standard against which other diagnostic information on mid-facial bone trauma can be assessed.[5, 7] Conventional radiography thus continues to be used as a screening tool.

In 1995 a study by Rogers et al.[11] demonstrated that a single radiograph was sufficient for screening facial fractures. They recommended an OM 15° projection only. Their findings were supported in 1998 by Raby and Moore.[12] Both studies concluded that single-screening radiographs, be it OM 15° or OM 30°, can indeed be used in trauma departments. It is for this reason that these two projections were selected for this study.

In 2000 Pogrel et al.[13] studied the necessity of a preliminary four projections screening series of radiographs. They argued that the role of screening radiographs was to indicate whether a patient should be referred for CT to confirm the presence or absence of facial fractures to the mid-face. They concluded that the OM 30° projection provided the most diagnostic information.

Other authors highlight the limitations and weaknesses of using fewer than the standard four projections. The radiation protection guidelines published by the European Commission on cone beam computed tomography (CBCT) for dental and maxillofacial radiology explain why the limitation of dose to the patient is not recommended. Limiting dose may negatively impact on diagnosis and treatment, which may eventually do more harm than good to patients.[14] Statkiewicz et al.[15] emphasise that radiation exposure to patients, radiographers, and members of the public, should be kept at the lowest possible level. They argue that diagnostic efficacy is maximised when essential radiographs are produced. Diagnostic efficacy is the degree to which the diagnostic study accurately reveals the presence or absence of disease or, as is the case in this study, trauma.[15] Their conclusion differs from other literature sources; it thus raises concerns on the possibility of missing injuries on the limited projection provided.

Teaching materials and resources on trauma radiography have evolved over the years. Ballinger and Frank[16] recommended six facial bone projections in their 1995 publication: lateral; Waters (parieto-acanthial); reverse Waters; modified Waters; parieto-orbital oblique; and posterior anterior (PA) axial oblique. In their 2003 edition the latter two projections were replaced by the Caldwell projection.[17] Frank et al.[18] reduced the number of basic facial bone projections to four.[18] The number of projections was reduced to three, namely lateral, Waters and Caldwell, by Bontrager and Lampignano in their seventh edition publication.[19] Additional projections for specific facial bones include modified Waters, if the orbits are involved, and, provided there is no history of neck fractures, SMV when the zygomatic bones are involved.[16] Whitley et al.[20] suggest four projections: OM 0°; OM 30°; modified OM; lateral; and SMV if the zygomatic bones are involved.

Clinical facilities, such as CMJAH, decide on their own projection protocols. In view of the challenges of positioning trauma patients for facial bones, facial bone projections were reduced to a lateral Waters and Caldwell in a 1998 publication.[21] Other special projections can be performed to demonstrate specific injuries: mandible, orbits or zygomatic bones, for example.

For the purpose of this study the authors selected two projections: OM 15º and OM 30º. Based on the literature these two projections were recommended as being valuable to demonstrate mid-facial bone injuries.[5, 15-16] These projections are also part of the facial bone protocol at CMJAH.

Research methodology

Approval was first granted by the hospital authorities at CMJAH to access patients' records. The study commenced after ethics approval was obtained from the Faculty of Health Sciences Research Ethics Committee, Protocol number 34/2013.

A quantitative research method was selected with a descriptive, cross-sectional research design because a specific situation was studied.[22] Two trauma consultants from CMJAH were invited to participate in the study. A consultant radiologist was also invited to provide the estimated agreement rate between the trauma consultants and the radiologist prior to the image analysis process. They all signed an informed consent form after the details of the research had been explained to them. An agreement rate of 90% was recommended: an increase or decrease of 10%

Table 1. Data collection sheet

IMAGE EVALUATION SHEET			
X-RAY Serial No:	**NO FRACTURE**	**FRACTURE**	**FRACTURE SITE**
OM 30°			
OM 15°			

was accommodated. The Kappa statistical method was recommended by the statistician for inter-reader agreement.[23]

Data collection and analysis

Facial bone radiographs that were produced in the trauma department of CMJAH during January to March 2013 were used in the study. The images were retrieved from the hospital records department. No particular attention was given to images with or without fractures. A statistician was consulted to advise on the sample size. Assuming the probability of 0.95, a sample size of 35 radiographic images per projection and per reviewer was found to be statistically sufficient for this study.

The two trauma consultants each reviewed 70 images: 35 OM 15° and 35 OM 30° projections, respectively. This was done to determine whether they would be able to provide accurate diagnosis and not to include false positives. They were asked to analyse the images and record their findings on a data collection sheet provided for each radiographic image (Table 1). The data collection sheet was an adaptation of that used by Pogrel et al.[13]

A radiology viewing room (i.e. with dimmed lights) in the trauma department was used by them. Uniformly illuminated standard radiology viewing boxes, with the same brightness and colour,[24] were selected for the study. Viewing boxes were available and the 35 pairs of OM 15º and 35 OM 30º projections, each with a corresponding data collection sheet, were prepared for each session. The trauma consultants were blinded from the radiology reports. The radiologists' reports were used as the 'gold standard' against which radiographic image analysis and diagnostic information were to be made. The data were de-identified and randomised for each reader. The identification of the images was only known to the authors in order for them to use the data to compare the respective findings of the trauma consultants and the radiologists. Only one participant viewed and analysed the images at a time. After each viewing session, the completed sheets (Table 1) were collected. Blank ones were provided to the next participant. The outcome from each participant's respective analysis of the images was compared with the radiology reports.

Table 2. Tabulation of consultant #1 statistics

	FREQ.	PERCENT	CUM.
0	4	11.43	11.43
1	31	88.57	100.00
Total	35	100.00	

Table 3. Tabulation of consultant #2 statistics

	FREQ.	PERCENT	CUM.
0	7	20.00	20.00
1	28	80.00	100.00
Total	35	100.00	

Table 4. Interpretation of K-values

VALUE OF K	STRENGTH OF AGREEMENT
<0.20	Poor
0.21 - 0.40	Fair
0.41 - 0.60	Moderate
0.61 - 0.80	Good
0.81 - 1.00	Very good

Results

Preliminary analysis of the data involved comparing the respective findings of the consultants with those of the radiologists. A "YES/NO" tick list was used by the authors to compare the responses of the participants. The trauma consultants were provided with only two projections while the reports by the radiologists were based on the full set of four projections according to the CMJAH protocol. When the responses of the consultants were compared with the radiologists' reports, the data analysis process commenced using descriptive statistics. The authors relied on the assistance of a statistician.

Inter-rater reliability (radiologist and the trauma consultants) was measured by means of Kappa statistics which involve the creation of a spread sheet where agreement between the observers is made.[25] The "Yes/No" ratings were captured by the authors.

Weighted Kappa statistics was used in this study. It does not take into account the degree of disagreement between observers and all disagreements are treated equally or as total disagreement. By assigning different weights (*w*) to the subjects for whom the raters differed by (*i*), the weights were calculated using the following formula
$W1 = 1 - i/ k\text{-}1$, where there are k categories. [26]

The inter-rater reliability also helped to determine whether the trauma consultants were able to diagnose facial fractures using the two radiographic views presented to them, or whether they were dependent on all four facial bone projections.

Trauma consultant number one (#1) obtained an agreement with the radiologists' report on 31 sets of images but was not in agreement with radiologists' reports on four sets of 35 patients' radiographs. The score obtained was 88.57% for a positive diagnosis and 11.43% for a misdiagnosis.

Trauma consultant number two (#2) obtained an agreement with the radiologists on 28 sets of images but was not in agreement on seven out of 35 sets of patients' radiographs; three of which were false positives. The score was 80% for a positive diagnosis and 20% for a misdiagnosis. The results of the consultants' assessments of the radiographs are presented in Tables 2 and 3 respectively.

On the basis of the results presented, and the interpretation of the K-values in Table 4, it is evident that the trauma consultants could positively diagnose an average of 84% of apparent facial bone fractures using only OM 15° and OM 30° projections. This strength of agreement is classified as between good and very good.

Discussions were held with the trauma consultants on completion of their image-viewing period. Both stated that they routinely request CT scans for patients whose plain-film-radiographs indicate a fracture. They further indicated that for plain-film-radiographs, where no fractures were diagnosed, the patients were managed conservatively with a soft diet and pain medication. In cases where the pain persisted, follow-up plain-film-radiographs were requested.

Discussion

The findings of this study are in agreement with a study conducted by Pogrel et al.[13] According to them the role of facial bone radiographs is merely to indicate whether a CT examination should be requested. In terms of this study the use of OM 15° and OM 30° projections to test the hypothesis proved to be correct. The study yielded similar results to the respective studies of Rogers et al[11] and Raby and Moore[12]: each of them indicated that the OM 15° and OM 30° projections were the most useful in a facial bone series of four projections. The latter is the protocol at CMJAH.

Justification for the superiority of these two projections can further be based on the structures that are demonstrated as compared to the lateral and Caldwell projections. The image evaluation described in the literature[14-17] indicates that the left and right side of the face are superimposed on the lateral projection. If the structures demonstrated on the Caldwell projection are taken into consideration it is noted that the petrous ridges overlie part of the maxillary bones and sinuses. Overlying petrous bones will limit visualisation of the mid-facial bones and possible fractures in the region.

Although the study indicated that trauma consultants at CMJAH can effectively diagnose facial fractures using two projections, one cannot ignore the 16% misdiagnosis of subtle non-apparent fractures. These misdiagnoses will no doubt raise concerns about the rate of missed fractures that could possibly occur and consequently compromise the wellbeing of a patient.

Limitation of the radiation dose is not recommended because the effectiveness of the diagnosis and treatment would be compromised.[12] This study also found that 7% of the 16% misdiagnoses were false positives: the trauma consultants diagnosed a fracture when there was no fracture. In such a scenario a patient would proceed to CT to confirm that there was no fracture. Diagnosis would not be compromised, however, such a patient would be exposed unnecessarily to high radiation doses from the CT scans.

Limitations of the study

A number of factors were identified when considering possible reasons for the misdiagnoses. The two trauma consultants were each allocated a maximum of eight hours to view the images. Owing to time constraints, they spent an average of 30 minutes reviewing 70 films: an estimated 25.71 seconds per image as compared to the radiologist who spent an estimated one minute to asses each image.

The trauma consultants did not indicate the exact location or type of fracture identified. They only stated whether there was a fracture or not. It is postulated therefore that if the trauma consultants had spent more time reviewing each radiographic image, their overall performance would probably have improved and the number of subtle fractures that were missed would have been reduced.

Further studies are recommended with a bigger sample, stricter time allocations for the participants, and the utilisation of more statistical methods to determine inter-reader agreement. This would address the time limitations in this study. A further study would also provide validation of the findings and their exact correlation with of those of radiologists.

Conclusion

The results obtained from the study support the hypothesis that the use of OM 15° and OM 30° radiographs, as a screening tool for mid-facial bones trauma, followed by a CT scan, where indicated, is as accurate as the current four projection protocol used at CMJAH.

It is evident that if more time is spent reviewing two projections in comparison to four, the positive results might improve. Eliminating the OM 0° (zero degrees) and the SMV projection in an emergency setting, and only using the OM15° and OM30° projections would prove to be considerably more cost and time effective. Radiation dose to patients would be reduced. The implementation of a two projections imaging protocol would encourage the clinicians to effectively make use of plain-film-radiographs as screening tools to identify problem areas before proceeding immediately to CT.

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