A Comparative Study on the Diagnostic Utility of Ultrasonography with CT Scan/Conventional Radiography in Detection of Fractures of The Facial Skeleton

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Abstract: The importance of imaging in maxillofacial trauma cannot be underrated. Traditionally CT scans have been considered the gold standard even though they have disadvantages like associated radiation hazards, high cost factor, unavailability in rural health care set up, etc. This has compelled ongoing research to seek imaging modalities that circumvent these aspects. Ultrasonography is a quick, inexpensive, non-ionizing radiographic modality which offers several advantages over conventional use of CT or plain film radiographs. We aimed to explore the versatility and efficacy of the use of Ultrasonography and compare it to CT/conventional radiographic modalities in detection of fractures of the midface and mandible. 40 patients with maxillofacial trauma underwent radiographic assessment using ultrasound and CT/conventional radiographs. We observed a high correlation between Ultrasonography and CT scan in the detection of maxillofacial fractures. Sensitivity and specificity was 100% with a high PPV. Apart from a few limitations, such as difficulty in interpretation of a film without a report or clinical correlation, and examiner variability, the advantages associated with its use probably outweigh the shortcomings. Further research in the technical aspects and training in the application of this method to trauma is likely to witness USG becoming the modality of choice as an initial screening tool for detection of uncomplicated fractures.

Keywords: Maxillofacial trauma, Imaging, Ultrasonography, Computerized tomograms, plain film radiographs.

INTRODUCTION

Trauma is a major cause of morbidity and mortality worldwide, especially in developing nations and is the leading cause of death of younger individuals under the age of 45 [1]. Imaging forms an essential component in the management of the traumatized patient. It bolsters all aspects from establishing the diagnosis to planning a surgical treatment to assessing outcome and evaluation of the post-operative condition of the patient.

Historically, the introduction of x-rays by Sir Wilhelm Conrad Röntgen in 1885 led to the development of plain film radiographs which made assessment of underlying fractures of the craniofacial skeleton easier. There were shortcomings and drawbacks in these conventional modalities that were recognized early [2].

These were eventually replaced by Computed tomograms, introduced in the 1970’s by Sir Godfrey Hounsfield. They were made popular immediately and even now considered the ‘gold standard’ in imaging and trauma care. Ultrasonography is a rapid, dynamic, non-invasive and inexpensive radiographic technique that has traditionally been employed in the field of medicine for evaluation of pathologies or study of solid organs in the visceroperitoneum. Rapid development in engineering, biophysics and technology have facilitated advancement in the computing hardware of ultrasonography in the last three decades by leaps and bounds, making them applicable not only to soft tissues but also to the musculoskeletal system [3].

These advantages have led to an increased interest in evaluating ultrasound imaging as an alternative to conventional radiography and/or CT in the diagnostic evaluation of uncomplicated maxillofacial fractures.
A prospective study was carried out on 40 patients who reported to our emergency department at KMC Hospital (Mangalore, India) with suspected facial fractures [32 males (82%) and 8 females (18%) aged between 19-64 years] Each patient was examined clinically and referred to the Department of Radiodiagnosis and Imaging for radiographic evaluation after obtaining written informed consent to participate in the study. All patients were subjected to scanning by CT and USG.

- CT scanning unit was GE Hi speed DXI single slice scanner and 16 slice MDCT GE Brivo385 unit.
- Ultrasonography was performed using GE Wipro Voluson 730 Expert USG model with the SP6-12 H linear transducer probe with frequency 3.0-11 MHz or Philips Envisor Unit with L12-3 linear transducer with 3 – 12 MHz extended frequency range by a single experienced radiologist who was blinded to the CT findings.

The total time required for both imaging modalities was recorded, starting from positioning of the patient, to reporting and printing the films.

The radiologist was asked to report on the presence or absence of a fracture. The observations were entered in rows and columns in a Microsoft Excel sheet. The presence of a fracture was designated the symbol ‘+’ and the absence with ‘−’. The resultant data was statistically analyzed using SPSS ver 15 software and compared using the χ² tests and Fisher exact test. Sensitivity, specificity and the positive predictive value was calculated.

RESULTS

- The total time taken for the evaluation with USG; starting at application of the transducer to reporting was in the range of 5-12 minutes for all patients. Mean value being 8.5 minutes. The report was given immediately with the printed film.
- Whereas the time taken for CT scan, from positioning the patient in the gantry for the exposure, to printing the film took over 10-15 minutes (average being 12.5 minutes). Reporting required additional 5-10 minutes.
- USG was considerably cheaper than a regular CT scan.
- USG was able to identify all the fractures in all the patients and had a strong correlation with CT.
- The comparative analysis of the data collected revealed 100 % sensitivity and 100% specificity of USG to be able to visualize a fracture in the midface or the mandible. This was comparable to the CT findings.
- CT was able to identify all fractures in all patients but certain fractures required reformatted coronal and sagittal images.

When a conventional radiograph was made, the identification of the fracture sites was often difficult to interpret as it relied heavily on the technician skill and inherent drawbacks in the projection geometry. Pattern of displacement could not be gauged from the 2-dimensional aspect that the radiograph provided.

DISCUSSIONS

Trauma is the leading cause of mortality and residual morbidity in patients younger than the age of 45[1]. A large majority of these victims have associated head injuries and injuries to the maxillofacial region. The rules regarding management have remained constant over the years as per the ATLS protocol [4].

Imaging forms the backbone in management of the traumatized patient. Commonly employed diagnostic tools for screening in trauma to the head and neck include conventional radiographs, orthopantomogram, or CT scans. However, in recent times, with the principle of ALARA gaining importance in the ethical treatment of the patient, these forms of ionizing radiation should be reserved for when absolutely needed and strict adherence to radiation exposure reduction techniques should be used [5].

Ultrasounds were introduced into the field of medical practice by Dr Donald during World War II [6] but the first published application of Ultrasonography to maxillofacial trauma was by Ord et al. in 1981 to diagnose orbital fractures. They reported positive findings which encouraged subsequent research [7].

The advantages of USG, as a diagnostic modality include its availability, even at rural health care setting, little dependence on patient cooperation, cost factor and minimal technical sensitivity. The equipment is compact and portable enough to be transported either into the emergency department for a prompt and rapid bed side imaging in the polytrauma patient or into the operating room for intraoperative imaging and evaluation of a satisfactory fracture reduction. There are no associated biological risks; therefore it can be repeated multiple times [3].

Its application in the study of hard tissues as well, has recently been established. Therefore it can be considered as an alternative, especially to conventional radiographs, to rule out trauma, as first line imaging, or as an adjunct to CT thereby adhering to X-ray exposure reduction protocol. The sensitivity of USG to diagnose facial fractures accurately has been studied at various times ever since its introduction into this setting.

In our study, for evaluation of nasal bone fractures, it was observed that USG could detect minimally displaced fractures in accordance with earlier studies which have shown high accuracy and sensitivity ranging from 90% to 100%, specificity of 98–100% and
high predictive values [8-11] establishing ultrasonography as an adequate investigation for clinically suspected isolated nasal fracture.

Orbital fracture detection using USG has been most extensively investigated [12-14]. Whereas Floor, Medial and lateral wall fractures were studied frequently, little work has been reported on orbital roof or supraorbital rim and frontal bone, probably because it makes more sense to perform a CT to rule out intracranial hemorrhage or pneumocephalus.

Forrest et al. [16] reported a sensitivity of 92%, specificity and PPV of 100% for the detection of ZMC fractures using USG and compared it to CT. Similar findings were obtained in our study and no difficulty was encountered in detecting fractures of the bones that comprise the ZMC. We obtained nil false negatives and significant positive agreement between USG and CT. Step-like, displaced fractures were easier to diagnose when compared to minimally displaced fractures and undisplaced fractures. Even a 0.2mm disruption in the fracture site could be identified as agreed by Singh et al. [15]

Gross edema and tenderness over the fracture region are clinical features that form a diagnostic challenge. Mc Cann et al. [17] reported difficulties associated with USG in cases with significant emphysema and observed discrepancies between US and plain film radiography. Similarly, Friedrich et al. [10] documented three patients with massive emphysema which inhibited the identification of bone surfaces and rendered US non-diagnostic.

However, quite contrary to these reports, our study encountered no such problems. This can be attributed to the fact that considerable proportion of the patients in the present study presented for treatment within 24–48 h of injury before development of any gross swelling.

Few authors have investigated ultrasounds for mandibular fractures. Hirai et al. [11] in their case series demonstrated that USG could detect fractures of the mandibular symphysis and angle. Kleineheinz et al. [18] and Friedrich et al [10] reported sensitivity and specificity of 100% and 100%, respectively, and 66% and 52%, respectively, in the detection of mandibular subcondylar/ramus fractures. Friedrich et al. [10] emphasized the limitation of ultrasound as being unable to detect intracapsular condylar fractures due to the superimposition of the zygomatic arch. Contrary to his report, we encountered a case of medially dislocated condylar head fracture where the breach in the continuity of the condylar process was detected promptly.

In the emergency department, time plays the most crucial role. Keeping this in mind, we included the time taken for the investigation to detect fracture in our present study. Not many studies have compared this in past. We found that USG apart from being portable and inexpensive was quicker and less time consuming, with minimal technical issues.

The major disadvantage of USG in diagnosis of facial fractures lies in its inherent inability to identify an undisplaced fracture [19] or differentiating it from a suture. Without a degree of displacement, there is probability that the fracture may not be detected. Another drawback is that USG doesn't allow for the fractured site, although picked up, to be related to any adjacent anatomical landmark. In the absence of a report, the printed film alone will not be of much use. Clinical correlation is a must for a proper application.

We identify USG as presently being in its budding stage, in its application to the musculoskeletal system, and a possible paradigm shift is likely to thrust it into higher places with research and technical advancements occurring rapidly, and as radiologists gain proper training and experience in its potential application to the maxillofacial trauma setting. It will be important in the coming future to explore and extend its validity in the diagnosis of undisplaced fractures and the use of smaller transducer probes to identify the specifications of the optimal probe size required that will aid in the easy diagnosis of non-displaced fractures as well.

ETHICAL APPROVAL

Approved by the Institutional Ethical committee

REFERENCES