Original Article

Use of ultrasound as a screening tool in the maxillofacial fractures

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Abstract

Aim of this study was to find out the efficiency of ultrasound in screening maxillofacial fractures, comparing the result with gold standard Computed Tomography. Fifty patients were assessed which included 10 subjects as controls. Linear probe with a frequency of 5 to 10 MHz was used. Ultrasound showed a sensitivity of 95% in locating fracture lines. Exceptions were undisplaced high condylar fracture and pure blowout fracture.
Key Word: Ultrasonography, Computed tomography, Hyperechoic, Hypoechoic.

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INTRODUCTION

Imaging of ultrasonography has gained importance in human medicine due to its notable features like non-invasive, non-ionizing, rapid and painless techniques [1]. Due to its remarkable features ultrasound has been widely used by different medical specialties for diagnosis and therapeutic procedures[2]. In diagnostic procedure, high frequency ultrasound waves are transmitted into the body and propagated through tissues and by a transducer it is returned back as echoes and displayed on screen[3]. Generally the ultrasound frequency used in medical purposes are 3-15MHz, otherwise high levels of ultrasound waves damage the tissues and teratogenic effects occur due to excess heat and acoustic cavitation[4]. Normally the ultrasound waves travel at an average velocity of 1540 m/s for body tissues[5] .Also the variations in the speed of sound occur due to distribution of heterogeneous soft tissues or local temperature differences within the tissues.

With the emerging innovation in software and biomedical engineering facilitated the technological stepping stone of ultrasonography which made it applicable to pass the ultrasound waves to the bony lesions of head and neck apart from the soft tissues used. Hence the use of ultrasound in assessing the maxillofacial fractures is an emerging concept yet to be established. The traditional diagnostic tools used for maxillofacial injuries are conventional techniques like plain radiography and computed tomography. With the high cost of computed tomography machine and operator expenses, hence it is not available at primary health care centres[6]. Though ultrasound facilities are cheap and easily available, it can be used at primary health care. It is less dependent on patient cooperation and technical sensitivity of patient positioning is minimal.

The aim of this study is to evaluate the reliability of ultrasonography as screening tool in maxillofacial fractures by comparing with CT scan. Ultrasound being an inexpensive, non-invasive and readily available imaging technique, it can be used as a primary investigative Imaging tool. If ultrasound can be used as a screening tool in patients with suspected facial fractures, visualization of fracture lines can clear the dilemma of presence of fracture. The confirmation of fracture with the help of USG can avoid repeated conventional X rays, so that only an indicated investigation is required.

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MATERIALS AND METHODS

Patients reporting to the Department of Accident and Emergency/Emergency medicine and trauma care, Sri Ramachandra Medical Centre Chennai, suspected with maxillofacial fractures following road traffic accident , assault, slip and fall or any other mode of trauma to maxillofacial region during the year 2012-2014 were included in this study.

Inclusion Criteria: Mild, moderate or severe maxillofacial injuries. All age groups. Both males and females.

Exclusion Criteria: Patients with any surgical or medical emergency.

Methodology: Forty patients (36 Males, 4 Females) who presented with clinically diagnosed injuries to the maxillofacial region were included in the study. Computed Tomography of the facial skeleton with a 3-dimensional reconstruction was taken and examined, to establish a diagnosis[7]. The patients were subjected to an ultrasound examination of the affected regions carried out by the same radiologist using *GE* VOLUSON ultrasound machine. Ten subjects who had no maxillofacial injuries were taken as controls.

The probe is cleaned with Bacillol 25% and wrapped with a plastic cover. Jelly / Coupling agent is applied on the probe which is the transmitting medium. Ultrasonography of the facial region was done using a linear probe in a standardized pattern on both sides of the face, beginning from the frontal region, nasal bone, orbit, zygoma, maxilla, mandible (condyle, ramus, angle, body, parasymphysis, and symphysis) in that order. Care was taken to ensure that no pressure was exerted, with minimum mobilization of the patient during the procedure. Absolute care was taken to perform the scan with total precautions to prevent any infection due to the scan, as some of the patients had skin injuries.

RESULTS

In this study, 40 patients who were suspected to have facial bone fractures during physical examination were investigated using ultrasonography which were then compared with CT scans. Of these patients, 36 were males (90 %) and 4 were females (10%). Mean age of the patients was 32±8 years (range 20 to 52 years). The control group included 10 subjects, with normal sonoanatomical findings. The cases included in the study comprised of mandibular fractures (n=17), isolated zygoma fractures (n=8), Lefort fractures (n=7), residual deformity (n=1), soft tissue contusion (n=1), dentoalveolar fracture (n=1), panfacial fracture (n=1), isolated nasal bone fracture (n=1), pure blow out fracture (n=1) and naso orbito ethmoid fractures (n=2). These patients were diagnosed using USG and CT PNS with 3D reconstruction of facial bones. The findings demonstrated on the ultrasound were in concurrence with those noted in CT scanning in 95% of patients, ie 38 patients out of 40 showed positive results. Two cases that showed negative results were high condylar fracture and pure blow out / medial wall of orbit fracture In patients with mandibular fractures, bicortical discontinuity (buccal and lingual) was identified in cases of symphysis, parasymphysis and body of the mandible fractures. During the initial USG studies dentoalveolar segment and teeth were misdiagnosed as discontinuity, suggesting the possibility of fracture. However, correlation with the clinical examination and CT scan, helped to identify it as normal USG finding. Ultrasound could not identify high condyle fracture due to the shadowing of zygomatic arch and also due to the position of the condylar head which is encapsulated inside the glenoid fossa.

Nasal bone, frontal bone and zygomatic arch had 100% accuracy in the ultrasound diagnosis. The visualization of posterior wall of maxillary sinus was not possible with the help of linear probe in cases of midf ace fractures. However fracture of the posterior wall of the maxillary sinus were easily identified using a convex probe with low resolution (2 to 5 MHz). Fractures of medial wall and floor of the orbit could not be identified due to the poor sound wave penetration in cases of orbital fractures. Subcutaneous edema and hematoma collection were used as a guide to identify the location of fracture sites. The ultrasonographic examination detected the facial bone fractures with a sensitivity and accuracy of 95% as shown in Table 1. Since there was no negative result in the CT scan, the specificity of CT was not calculable. The positive predictive value was 100% .In no instance did ultrasound demonstrate pathologic finding that was not visualized on CT. Quantitation and localization of fractures as done with the ultrasound correlated well with the CT findings.

Table 1: USG*CT Cross tabulation

Cross Tab		CT		
		Positive	**Negative**	**Total**
USG	Positive	30	0	38
	Negative	2	0	2
Total		**40**	**0**	**40**

DISCUSSION

The patients were examined based on evidence of subjective and objective findings with the study of history, inspection, palpation, percussion, and auscultation. The clinician must select the relevant imaging modalities to confirm the diagnosis based on signs and symptoms that indicate the presence of fracture in the facial bone. Though there are conventional imaging techniques for assessing the fracture but each has its own drawbacks which make it difficult to interpret. Conventional radiography requires special patient positioning and repeated exposures which may be challenging in a trauma room. CT on the other hand is invasive, not easily accessible and high cost which makes it usage option limited. Ultrasound is a high frequency sound wave that is transmitted in to the human body by a transducer and the echoes from tissue surface are detected and displayed on a screen. Initially USG Was limited only to soft tissues. Hiroshi Yoshida *et al*[8] studied the clinical applications of USG on oral soft tissue lesions. He defined the margins, size and location of lesions, and their relationship to adjacent structures. After the inception of USG in soft tissue structures, it has been explored in field of diagnostic and therapeutic medicine. Since then the endeavour to introduce in the hard tissue like bone was in process. Use of ultrasound in the maxillofacial skeleton was first tried by Ord *et al* in 1981[9]. He evaluated patients with fracture of medial wall of the orbit using a 5 MHz probe. This study evaluated the efficiency of USG in screening maxillofacial fractures. It was found that ultrasound has 95% sensitivity in screening facial fractures. In this study, there were 17 mandibular fracture cases, of which USG could identify all the fractures except high condyle fracture. This was in agreement with the study done by R. E. Friedrich *et al*[10]. None of the previous studies have documented about the evidence to visualize bicortical displacement of fracture segments in USG. However, in this study, especially mandibular symphysis, parasymphysis and body showed bicortical disruption.

Figure 1

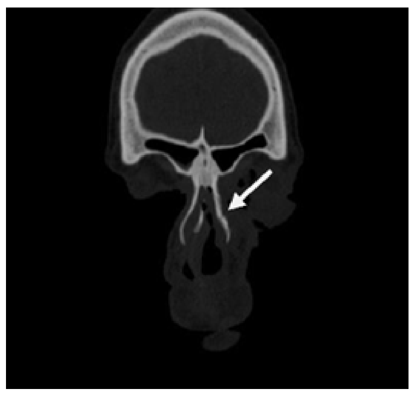

Figure 2

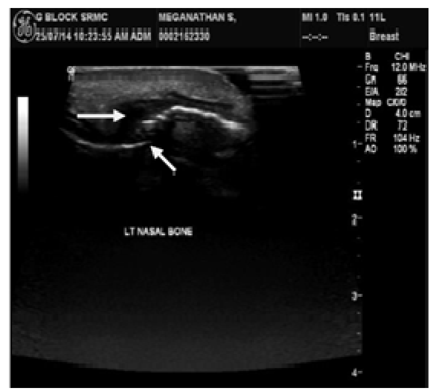

Figure 3

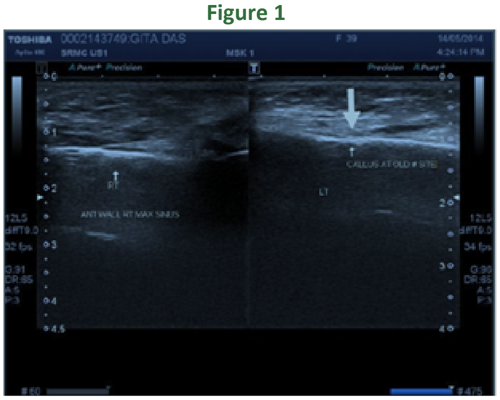

Figure 4

Figure 5

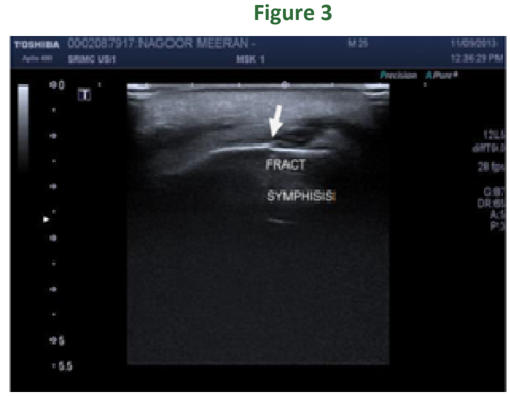

Figure 6

Legend

Figure 1: USG image showing the hyperechoic discontinuity of fracture left parasymphysis of mandible (arrow pointing the bicortical fracture segments).

Figure 2: CT coronal section showing left nasal bone fracture.

Figure 3: USG image showing hyper echoic discontinuity surrounded by hypoechogenicty in left nasal region suggestive of fracture with subcutaneous fluid collection.

Figure 4: USG image showing callus between two hyperechoic Lines of anterior wall of left maxilla suggestive of healed fracture.

Figure 5: CT coronal section showing undisplaced symphysis fracture.

Figure 6: USG image showing the hyperechoic discontinuity in symphysis region, suggestive of fracture (Undisplaced fragment is pointed).

Nasal bone, frontal bone and zygomatic arch fractures have 100% accuracy in the ultrasound diagnosis [9]. A Mohammadi *et al* compared ultrasound and conventional radiography in the diagnosis of nasal bone fractures[11]. Also sonography shows trauma of the cartilaginous part of the nose more accurately than conventional radiography. In 1990 Hiromichi Akizuki *et al* used USG intra operatively to evaluate zygomatic arch fracture reduction[12]. He had concluded that USG can be used as an ideal imaging tool to evaluate fracture reduction and can also avoid over correction (Figure 2 and 3).

Several authors have studied the use of USG in orbital fractures. It was in 1981 when Ord *et al* first used USG in the field of maxillofacial surgery. In a prospective blinded study conducted by Jenkins *et al* [13] the utility of USG in evaluating orbital floor fractures was compared with CT. It was concluded that USG can usefully be employed in the identification of patients with zygomatic fractures who have co-existent orbital floor fractures. Also, it was stated that USG alone cannot be conclusive in pure blowout fractures. This result is in agreement with the present study showing negative result of ultrasound in evaluating pure blow out fracture in one case.

W. L. Adeyemo *et al* reviewed the limitations of USG in diagnosing facial fractures. These included

a) Inability to delineate complex multiple facial fractures. In this study we were able to localize fractures even in patients with panfacial fractures.

b) Incapability to distinguish new fracture from old fractures. The present study, however differs from this. In a patient who reported for residual deformity correction after two years of trauma, USG showed the presence of callus formation between two fracture segments, suggesting that the fracture was healing[15] (Figure 4)

c) Misinterpretation of some anatomical areas as fractures. Dentoalveolar segment and teeth in this study was initially misdiagnosed as fracture. However, correlating the clinical examination and CT scan, it was identified to be normal USG finding.

d) Difficulty in detecting non-dislocated fractures[16]. This was not in concurrence with the present study. It was possible to diagnose even linear undisplaced fractures with USG (Figure 5 and 6)

e) Not able to investigate posterior orbital floor

f) Detailed bony imaging may be challenging in patients with acute

extensive facial edema and emphysema

g) Inability to identify intracapsular fracture of mandibular condyle, may be due to the overlapping of zygomatic arch.

In nutshell, ultrasound is safe, inexpensive, and an accurate adjunct to conventional radiography of the facial bones and it is well tolerated by injured patients. If ultrasound is performed as the first imaging modality in cases of suspected facial fractures by an experienced investigator, the visualization of fracture lines can avoid conventional imaging. This study showed 95% sensitivity in screening fractures of the facial skeleton using USG. It may also be useful when there is an unobtainability of CT scan in a primary health care set up or places where CT is not accessible.

CONCLUSION

In this study, ultrasound was able to detect the facial bone fractures with a sensitivity and accuracy of 95%. Quantitation and localization of fractures as assessed by the ultrasound correlated well with the CT findings. Thus high level of evidence is satisfactory to justify the use of ultrasonography as a screening tool in maxillofacial fractures. Ultrasound can be used as a primary imaging tool in an emergency department, especially in cases of mass trauma where subjecting all patients to CT scan is impractical. But the clinician must understand its limitations like difficulty / inability in identifying posterior orbital floor fractures and intracapsular mandibular condyle fractures. Also the fracture pattern cannot be visualized with the help of an ultrasound; hence treatment planning cannot be decided with it. To add further value we can incorporate its use in intra operative or postoperative cases of fractures treated conservatively like nasal bone reduction, subcondylar fracture etc. In future, it is a great opportunity if all maxillofacial surgeons can trained in USG imaging that can help in diagnosing facial fractures in an emergency set up. Also, the ultrasound probes can be designed and made compatible according to the facial skeleton which would make USG imaging easier and more reliable. If properly developed with innovative practices, the relative advantages of ultrasonography can surpass the use of CT which could be a stepping stone in maxillofacial imaging and trauma care

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