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A Proposed Diagnostic Algorithm Regarding the Prospective Role of Ultrasonography in Detection of Facial Fractures and Its Justified Application to Maxillofacial Trauma- A Descriptive Study

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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, cost factor, unavailability in rural health care set up, etc. This compelled researchers to seek modalities that circumvent these aspects. Ultrasonography is a quick, inexpensive, non-ionizing radiographic tool which offers advantages over conventional use of CT/plain film radiographs. We aimed to explore the prospective role of Ultrasonography in detection of facial fractures and identify its validity as a radiographic modality in maxillofacial trauma by adhering to a diagnostic algorithm based on the ATLS protocol. We observed that Ultrasonography was able to detect fractures with significant ease and the added advantage of being non-ionizing. However, severe form of trauma where signs of concomitant head injury are present, it remains imperative that a CT scan be the diagnostic modality of choice. We concluded that the prospective role of Ultrasonography in maxillofacial trauma lies not in replacing the existing 'gold standard'; but to augment skills in emergency department as the primary screening tool in favor of plain films, in children and pregnant patients, in patients with isolated injuries and in resource poor settings.

Keywords: Maxillofacial trauma; Imaging; Ultrasonography; Computerized tomograms; plain film radiographs

1. 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.

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 [1]

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.

Ultrasounds were introduced into the field of medical practice by Dr Donald during World War II as a rapid, dynamic, non-invasive and inexpensive radiographic technique with its chief application being the evaluation of pathologies or study of solid organs in the visceroperitoneum. However, rapid development in engineering, biophysics and technology have facilitated advancement in the computing hardware of ultrasonography, making them applicable not only to soft tissues but also to the musculoskeletal system [2] 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. [3]

Numerous articles exist in the literature which compares its diagnostic value with CT scan and majority has reported positive findings. However, in spite of its almost universal efficacy, USG has few limitations, which need to be underlined such as difficulty to distinguish from a suture or a foramen, heavy dependence on the need for an adjacent anatomical landmark, the requirement of a printed film and detailed reporting. Therefore it is important not to be overzealous and embrace the evidence supporting the use and probably the substitution of ultrasonography for CT in maxillofacial trauma, just because it is patient oriented, but also to appraise the sources of the evidence.

Our study proposes a diagnostic algorithm with focus on the various indications and contraindications of this upcoming popular radiographic modality and a discussion on how it can be tailor made to suit the need of the hour on a patient to patient basis.

2. PATIENTS AND METHODS

A prospective study was carried out on 40 patients who reported to our emergency department with head injury and suspected facial fractures. Each patient was examined clinically as per the ATLS protocol. Referrals to the Department of Radiodiagnosis and Imaging for radiographic evaluation were made after obtaining written informed consent to participate in the study. Patients were subjected to scanning by CT and/or USG as per our diagnostic algorithm.

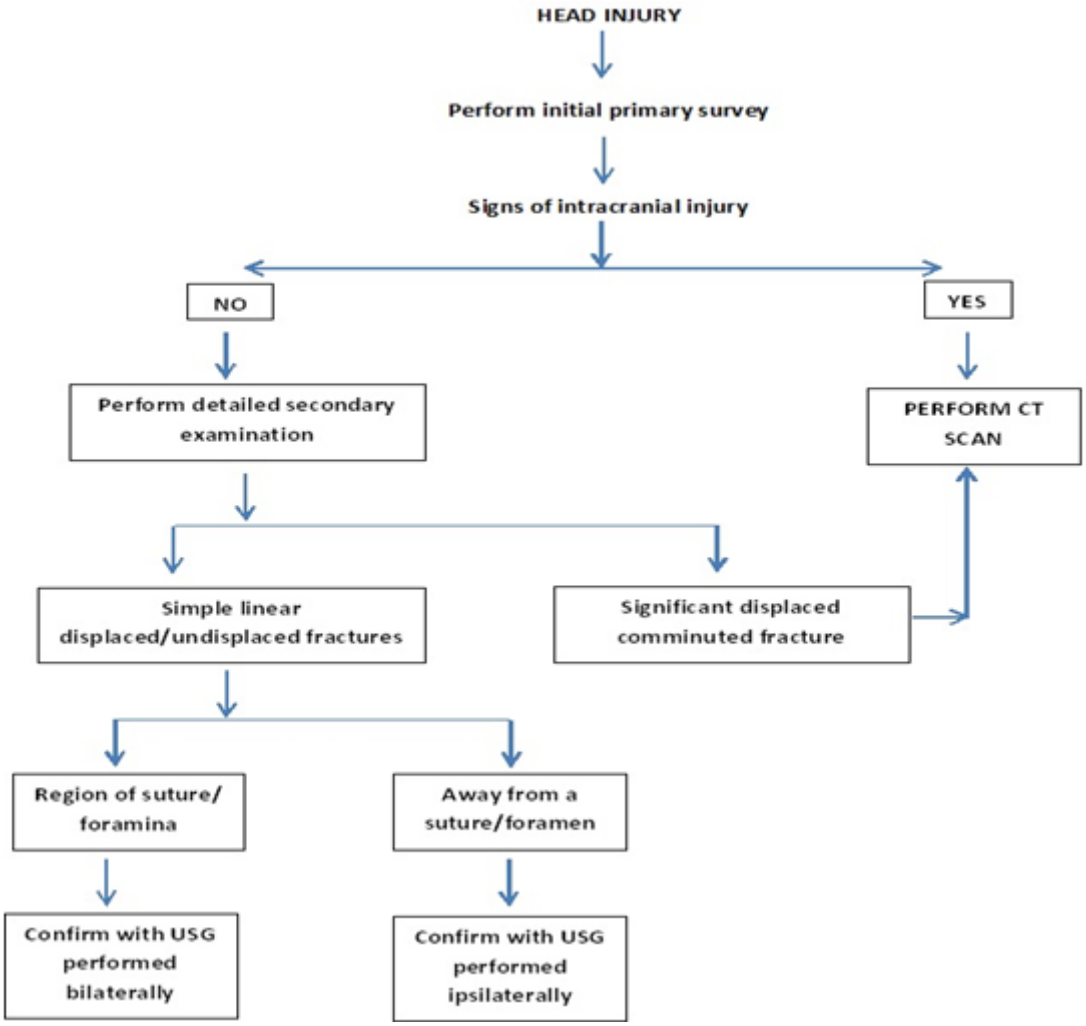
- CT scanning unit was **GE Hi speed DXI** single slice scanner and 16 slice **MDCT GE Brivo385 unit.**

- 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 any existing CT findings.

The radiologist was asked to report on the presence or absence of a fracture and to comment on the pattern of the sustained injury. A printed film of the anatomical region with a detailed report regarding the location of the fracture was made available to the operating surgeon to aid in intraoperative localization.

To minimize error in diagnosis, the radiologist studied the anatomical area in the affected and non-affected site bilaterally especially where there is presence of a known suture or a foramen.

Table 1: Diagnostic algorithm for evaluation of maxillofacial fractures using Ultrasonography



3. RESULTS

- There were 32 males and 8 females aged from 9-62 years of age
- Most common cause for trauma was RTA followed by falls from height, interpersonal violence and sports related injuries.

Ultrasonographic evaluation

- USG was able to identify the fracture in all the patients.
- USG scan was considerably cheaper than a regular CT scan.
- The report was given immediately with the printed film with bilateral imaging and detailed localization of the site of fracture with reference to an adjacent anatomical landmark.

CT evaluation

- Thorough clinical examination was performed at the initial primary survey as per ATLS protocol. In the presence of any signs of an intracranial injury, a prompt CT scan was performed.
- In the complicated, significantly displaced comminuted type of fractures, CT was able to identify all the fractures in all the patients and certain fractures required reformatted coronal and sagittal images.

- Some patients reported with a referral from a rural primary health care set where a plain film radiograph was made as a screening tool. The identification of the fracture sites on such films was often difficult to interpret as it relied heavily on the technician skill and the inherent drawbacks in the projection geometry. Fractures of the angle of the mandible could be visualized well on the OPG but degree of displacement and pattern of displacement could not be gauged from the 2-dimensional aspect that the radiograph provided.

Fig. 1: USG model Philips Envisor unit with Transducer probes

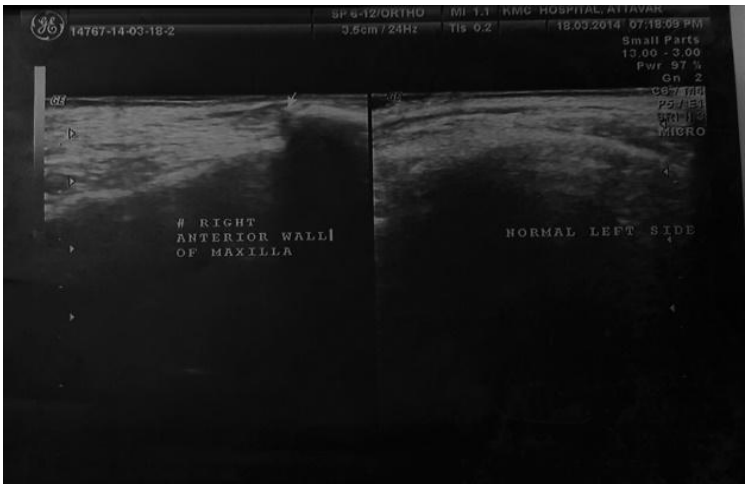


Fig. 2: Maxillary fracture

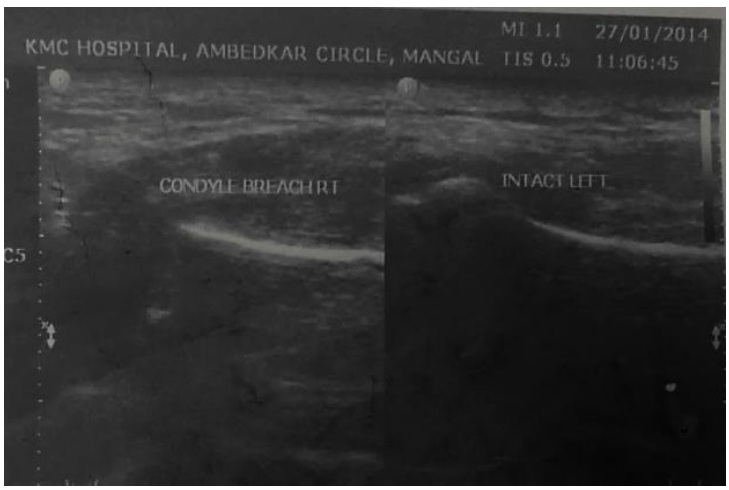


Fig. 3: Fractured condylar process of mandible

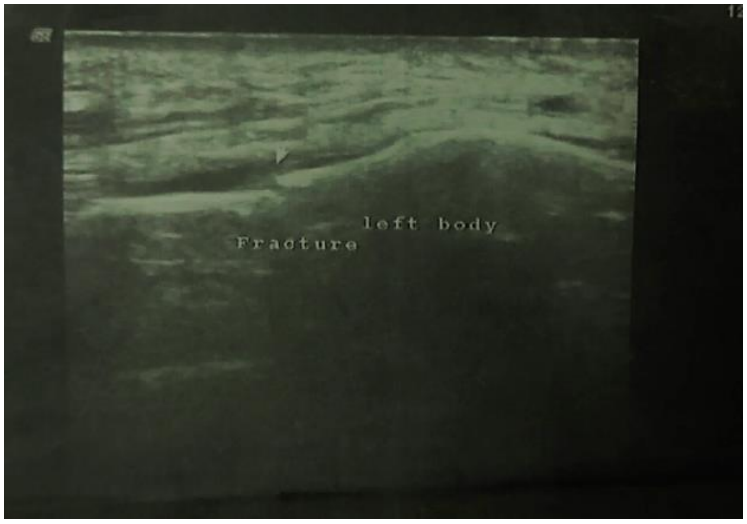


Fig. 4: Mandible fracture

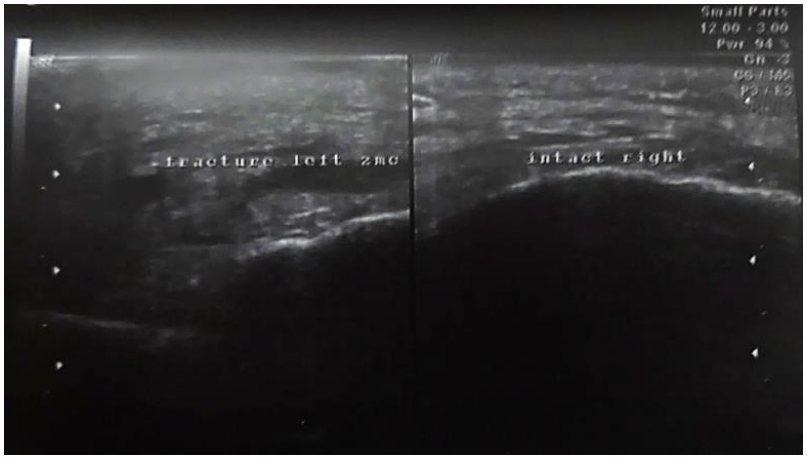


Fig. 5: Fracture of zygomatico-maxillary complex

Fig. 6: Mandible fracture

4. DISCUSSION

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, especially in pediatric age group, these forms of ionizing radiation should be reserved for when absolutely needed and strict adherence to radiation exposure reduction techniques should be used. [4]

The advantages of USG, as a diagnostic modality include its minimal technical sensitivity, ease of availability (even at rural health-care setting), little dependence on patient cooperation, cost factor and most importantly its non-ionizing nature. 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.

Its application in the study of musculoskeletal tissues 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 extensively at various times ever since its introduction into this setting. A systematic review of the diagnostic role of ultrasonography in maxillofacial fractures by Adeyemo and Akadiri[5] in 2011 noted that there is valid proof of its diagnostic efficacy which has been stated to be comparable to CT. However, specific guidelines and a clear cut protocol is lacking in the existing and ever increasing body of literature pertaining to its role in head and neck trauma.

The diagnostic algorithm in application of USG to detect facial fractures followed by our unit was simple to follow, clinically and morally relevant, adhered to radiation reduction protocol and may serve as an easy guide for other surgical units and resident trainees.

In pediatric children, who are especially uncooperative for appropriate positioning on the gantry of the CT machine, USG serves as an important tool in the armamentarium of the radiologist with minimal discomfort to the child while reducing radiation exposure and eliminating need for any form of sedation.

Intraoperative application of USG to assess accurate fracture reduction and fixation is as yet an unexplored territory and calls for necessary research. It bears the potential in itself to act as the counterpart of the popular use of C-arm used routinely in orthopedic surgery. Furthermore, although post-operative evaluation of fracture healing and revascularization has been studied extensively in orthopedic surgery and in healing of maxillofacial bones after distraction osteogenesis[5] and orthognathic surgery, the role of USG in prevention and management of non-union or malunion remains unsought. Avery et al in 2011[6] used transcutaneous ultrasonography in the management of non union of mandible. They say that during routine post operative investigation of the healing process after non-union of free flap osteotomy sites and complex fractures of the mandible, CT scans often distort significantly by artefacts due to the metallic hardware. However, initial callus could be easily seen during ultrasound scanning. Therefore information regarding intended safe removal of the external fixation device may be deduced by the use ultrasonography by knowing when sufficient bone union has occurred. They concluded by saying that transcutaneous ultrasound is a simple, safe, and readily available investigation that gives early objective evidence of bone healing and callus formation.

As of now, Ultrasonography is still in its budding stage and enjoying reasonable popularity as a pre-operative radiographic assessment tool both by the surgeons and radiologists. Although claims and attempts to compare the modality with CT scan seem to be overenthusiastic, with proper application and a justified usage, USG has the potential to completely eliminate the need for plain film radiographs and replace CT scans for simple undisplaced, uncomplicated fractures without an underlying intracranial injury. In the present study, we observed the versatility and efficacy of this radiographic tool and keeping in mind, both the advantages and shortcoming realized that the use of ultrasonography is beneficial to the patient because it is radiation free, non-invasive and can be helpful in uncooperative, restless patients such as the pediatric age group, or it can be used when ionizing radiation is contraindicated such as in pregnant patients

It is very likely that USG will expand the horizon of its application in musculoskeletal tissues of the body in general and the head and neck region in particular. From the technical point of view, the advances in hardware technology and biophysics are dynamic and unending. Undoubtedly, this will lead to scaling of greater heights in the manufacturing of the US scanning units and specifications of the probes. All the factors combined might witness this tool to eventually be considered a fore runner in the list of diagnostic modalities available for management of maxillofacial trauma.

Conflict of interest
None to declare

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None

Ethical approval
Approved by the Institutional Ethical committee

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