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Diagnostic validity of ultrasonogaraphy in zygomatic arch fractures: A clinical study

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Abstract

Objective: The Objective of the present study was to investigate the uses of ultrasonography in the diagnosis of zygomatic arch fractures and to identify the acoustic pattern between ultrasound image and true morphology of zygomatic arch.
Method: Once the patient was positioned, the acoustic coupler was applied to the patients control side i.e., the normal zygomatic arch and a similar scanning was carried out on the fractured side using a linear array transducer utilizing a frequency of 11 MHz. The areas of interest were scanned under both transverse and longitudinal sections, findings were entered into the proforma and then the printouts of the ultrasound pictures were printed using Sony type 1 (normal) high quality printing paper using a B&W Thermal Printer UP-895CE Sony.
Results: All the 16 patients were subjected to ultrasonography and in all 16 cases fracture of the zygomatic arch was confirmed, implying there is 100% accuracy.
Conclusion: Ultrasound offers a safe, inexpensive, accurate adjunct to conventional radiography of the facial bones and is well tolerated by recently injured patients. Ultrasound may also be considered as an alternative to repeating plain X-ray films to answer any doubts about the configuration or displacements of fractures, as ultrasound is noninvasive and overcomes the disadvantages of radiography.

This study emphasizes the need of the hour in diagnostic imaging and its possible role in intraoperative reduction of zygomatic arch fractures. The present study was also able to distinguish the patterns of zygomatic arch fractures as given by Hönig Merten.

Keywords: Diagnostic ultrasound, Real time imaging, Zygomatic arch fracture

Introduction

It is important to perform an early diagnostic test to plan appropriate management of facial fractures. A unique aspect of facial injuries is that the restoration of appearance may be the chief indication for the treatment.(1) Ultrasound is simply sound waves, like audible sound. The audible sound frequencies are below 15 000 to 20 000 Hz, while diagnostic ultrasound is in the range of 1 - 12 Mhz.(2) Ultrasonography has been proved very useful in screening maxillofacial trauma.(3)

As expertise in the facial area improves it is obvious that the oral diagnostician may find the use of ultrasound an excellent screening tool, especially in the evaluation of multiple trauma patients. The severity of injuries in the face may vary from minor fractures to complex fractures involving orbital-zygomatico-malar complexes. Profound efficiency of ultrasonography as a diagnostic aid in the oral and maxillofacial region has been studied in the past.(4,5) Ultrasonographic examination of the traumatized eye is useful in assessing the presence of intraocular or retrobulbar hemorrhage, retinal detachment, orbital “blow-out” fractures, and intraocular foreign bodies.(6)

Ultrasound is a painless and non-invasive method of bio imaging that is constantly evolving to suit the needs of the medical field as we approach a new millennium. Ultrasound is also relatively inexpensive and widely available with little side effects. It also provides “real time” imaging that makes it well suited for guiding Instruments in medical procedures. Rapid and accurate assessment of maxillofacial injury still remains a true challenge.

This study proposes that injuries like zygomatic arch fracture may be adequately detected and documented by non-invasive and cost effective high-resolution sonography or ultrasound.

Objectives of the study

1. To investigate the uses of ultrasonography in the diagnosis of zygomatic arch fractures.
2. To identify the acoustic pattern between ultrasound image and true morphology of zygomatic arch fracture.

The study was conducted at Department of Oral Medicine and Radiology, M.R. Ambedkar dental college and hospital, Bangalore and Hospital for Orthopaedics, Sports Medicine, and Arthritis & Trauma Bangalore (HOSMAT). The study consisted of 16 patients of suspected zygomatic arch fracture. The subjects were taken from regular outpatient Department of Oral Medicine and Radiology, M.R. Ambedkar Dental College and Hospital, Bangalore and causality of HOSMAT hospital (Hospital for Orthopaedics, Sports Medicine, Arthritis & Trauma) Bangalore.

Criteria for selection of subjects:

1. No age and sex bar.
2. Patient with suspected zygomatic arch fractures (unilateral) within 48-72 hrs of sustaining injury were included in the study. (Table 1)

No.	Patients	Age/Sex	Chief Complaint	Mouth opening (inter-incisal)	Facial asymmetry	Clinical assessment of fracture (Step deformity)	Circumorbital ecchymosis & Subconjunctival haemorrage	Ophthalmic examination	Provisional Diagnosis
1.	Patient 1	30/M	Pain & swelling	1.2 cms	Left side	Not elicited	Present-left eye	Normal visual acquity	Left Zygomatic complex fracture
2.	Patient 2	20/M	Pain & swelling	2.8 cms	Left side	Not elicited	Present- left eye	Normal visual acquity	Left Zygomatic complex fracture
3.	Patient 3	31/M	Pain & swelling	2.3 cms	Left side	Not elicited	Present- left eye	Normal visual acquity	Left Zygomatic complex fracture
4.	Patient 4	33/M	Pain & swelling	2 cms	Left side	Not elicited	Present- left eye	Normal visual acquity	Left Zygomatic complex fracture
5.	Patient 5	50/M	Pain & swelling	1.7 cms	Left side	Not elicited	Present- left eye	Normal visual acquity	Left Zygomatic complex fracture
6.	Patient 6	29/M	Pain & swelling	2 cms	Left side	Not elicited	Present- left eye	Normal visual acquity	Left Zygomatic complex fracture
7.	Patient 7	27/M	Pain & swelling	2.5 cms	Left side	Not elicited	Present- left eye	Normal visual acquity	Left Zygomatic complex fracture
8.	Patient 8	27/M	Pain & swelling	2 cms	Right side	Not elicited	Present-right eye	Normal visual acquity	Right Zygomatic complex fracture
9.	Patient 9	38/F	Pain & swelling	1.8 cms	Bilateral	Not elicited	Present-right eye	Normal visual acquity	Lefort -I
10.	Patient 10	28/M	Pain & swelling	1.6 cms	Left side	Not elicited	Present-left eye	Normal visual acquity	Left Zygomatic complex fracture
11.	Patient 11	24/M	Pain & swelling	2 cms	Right side	Not elicited	Present- right eye	Normal visual acquity	Right Zygomatic complex fracture
12.	Patient 12	32/M	Pain & swelling	2.1 cms	Right side	Not elicited	Present- right eye	Normal visual acquity	Right Zygomatic complex fracture
13.	Patient 13	28/M	Pain & swelling	2.5 cms	Right side	Not elicited	Present- right eye	Normal visual acquity	Right Zygomatic complex fracture
14.	Patient 14	28/M	Pain & swelling	2.1 cms	Right side	Not elicited	Present- right eye	Normal visual acquity	Right Zygomatic complex fracture
15.	Patient 15	38/M	Pain & swelling	2 cms	Right side	Not elicited	Present- right eye	Normal visual acquity	Right Zygomatic complex fracture
16.	Patient 16	40/M	Pain & swelling	1.6 cms	Left side	Not elicited	Present- left eye	Normal visual acquity	Left Zygomatic complex fracture

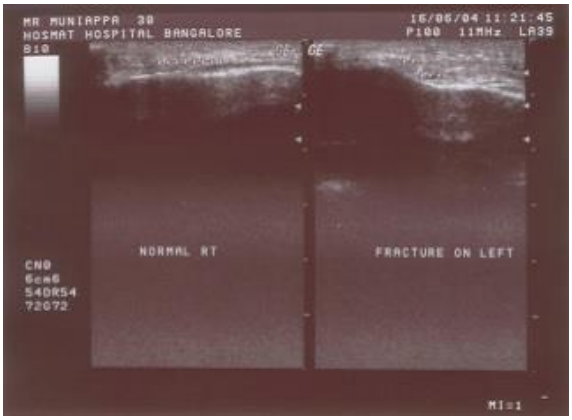
Selection criteria for controls

1. Normal contra lateral zygomatic arch served as control.

For clinical diagnosis and examination of the patient, a well-illuminated dental chair, mouth mirror, straight probe, disposable gloves, disposable mouth mask, and sterile kidney tray were used.

The ultrasonographic equipment consisted of the LOGIQ 400 PRO Series, which incorporates GE Ultrasound's Breakthrough technologies to precisely focus the ultrasound beam. DICOM compliance for seamless networking is an added advantage. The LOGIQ 400 PRO's high-precision, programmable Digital Beamformer immediately digitizes the signal, which preserves image quality and ensures uniform lateral, axial and temporal resolution from near-field to far-field. Dynamic receive focusing continuously compensates for the temporal differences of the returned signals to further enhance image quality. The result: Homogeneous lateral and axial resolution from the body surface to all depths. Automatic Tissue Optimization (ATO) automatically adjusts the imaging parameters to display the optimal image quality for the actual tissue being imaged for every patient, every exam, and every operator. ATO is not a series of presets. Instead, the system's Adaptive Processing uses actual image data to perform an instantaneous analysis of the anatomy of interest, and then applies the optimum parameters. The result: An extremely easy-to-use capability that provides a level of consistency among operators and increased diagnostic confidence.

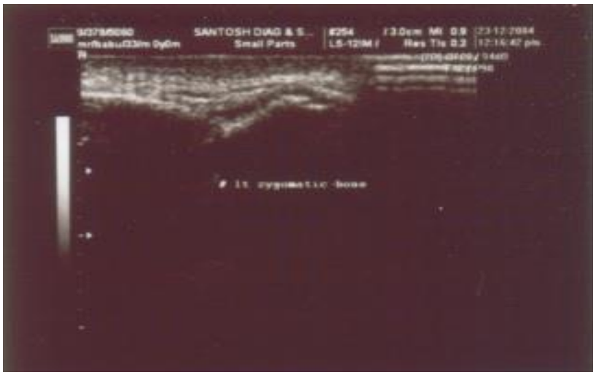
Printer used was a B&W Thermal Printer UP-895CE Sony for the final image output. Printing resolution: 325 dpi High quality images with glossy near photographic prints and newly developed printing paper, UP-110HG. Fast printing was done at approx. 3.9 seconds per screen (standard mode) Zoom function.



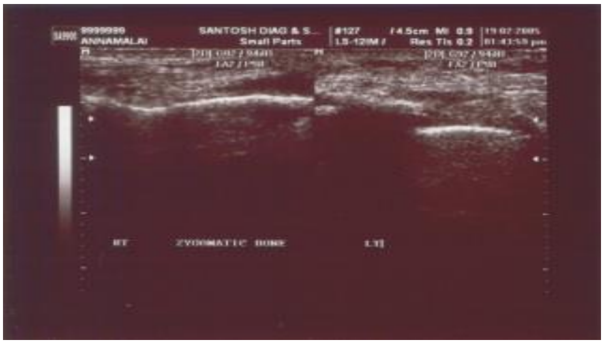
Case 1

Case 2

Case 3



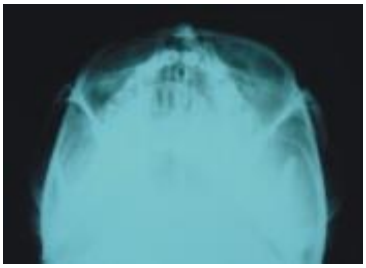
Case 4



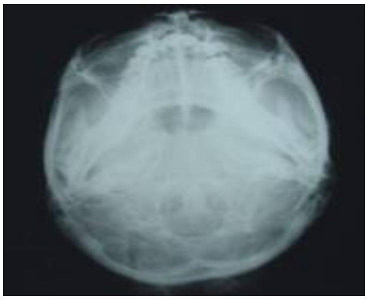
Case 5

Method

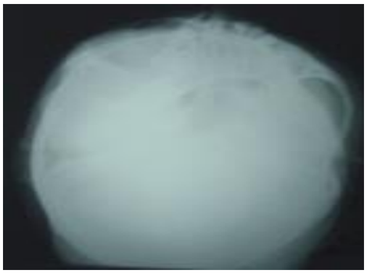
Once the patients were selected, their consent was taken. They were made to sit comfortably on the dental chair, the examination was carried out under artificial illumination, and the details of the patient were entered into a specially designed proforma, which is attached. The diagnosis was confirmed by radiographic or CT examination. Then the patients were taken for sonographic examination to HOSMAT hospital Bangalore. All sonographic examinations were performed in a darkened room and performed by single examiner. The patients were positioned in a comfortable position. The patients were positioned such that their heads were in level with the examiners knees. The examiner always sat on the right side of the patient where the ultrasound apparatus was also placed. Once the patient was positioned, the acoustic coupler was applied to the patients control side i.e., the normal zygomatic arch and then the same scanning was repeated on the fractured side, using a linear array transducer utilizing a frequency of 11 MHz. The areas of interest were scanned under both transverse and longitudinal sections, findings were entered into the proforma, then the printouts of the ultrasound pictures were printed using Sony type 1 (normal) high quality printing paper using a B&W Thermal Printer UP-895CE Sony. The sonographic printouts were stored according to the manufacturers guidelines.



Radiograph 1



Radiograph 2



Radiograph 3

Radiograph 4

Radiograph 5

Discussion

Ultrasonography has gained wide acceptance as a valuable diagnostic aid in the evaluation of head and neck lesions.(7) But the present day high resolution ultrasongraphy can be practicably applied has a diagnostic aid for fractures of the zygomatic arch with substantial displacement of the fragments.(8)

This study was taken up to determine the efficacy of ultrasonography in the diagnosis of zygomatic arch fractures. Sixteen cases of suspected zygomatic arch fractures were chosen for this study. In order to determine the exact location of the fracture of the zygomatic arch, a submentovertex radiograph or a C.T. scan was done as a preliminary mode of investigation.

The ultrasonography revealed the fractures in all 16 cases. (Table 2) These fractures were revealed depending on its size either as an interruption of the cortical reflection of echo or a dorsal band of echoes confined to the region of the fracture. The outcome of this study is consistent with results obtained in the similar studies conducted previously by various authors.(8,9,10,11,12,13)

Table 2

	Patient	Radiology / C.T. scan		Ultrasonography
	Age/Sex	Zygomatic arch fracture type/side		Fracture assessment
1	30/M	HM Class-II	Left	Loss of hyperechoic continuity of zygomatic arch
2	20/M	HM Class-II	Left	Loss of hyperechoic continuity of zygomatic arch
3	31/M	HM Class-II	Left	Loss of hyperechoic continuity of zygomatic arch
4	33/M	HM Class-I	Left	Loss of hyperechoic continuity of zygomatic arch
5	50/M	HM Class-II	Left	Loss of hyperechoic continuity of zygomatic arch
6	29/M	HM Class-II	Left	Loss of hyperechoic continuity of zygomatic arch
7	27/M	HM Class-I	Left	Loss of hyperechoic continuity of zygomatic arch
8	27/M	HM Class-II	Left	Loss of hyperechoic continuity of zygomatic arch
9	38/F	HM Class-I	Right	Loss of hyperechoic continuity of zygomatic arch
10	28/M	HM Class-II	Right	Loss of hyperechoic continuity of zygomatic arch
11	24/M	HM Class-II	Right	Loss of hyperechoic continuity of zygomatic arch
12	32/M	HM Class-II	Left	Loss of hyperechoic continuity of zygomatic arch
13	28/M	HM Class-I	Right	Loss of hyperechoic continuity of zygomatic arch
14	28/M	HM Class-II	Right	Loss of hyperechoic continuity of zygomatic arch
15	38/M	HM Class-II	Right	Loss of hyperechoic continuity of zygomatic arch
16	40/M	HM Class-I	Left	Loss of hyperechoic continuity of zygomatic arch

We were able to identify in this study the acoustic pattern between ultrasound image and true morphology of zygomatic arch fracture. This feature of ultrasound has not yet been reported. In this study we have followed the criteria given by Honig Merten (HM) for classification of zygomatic arch fractures. Among 16 cases of zygomatic arch fractures 13 cases were diagnosed with HM class-II and 3 cases with HM class-I. (Table 2)

A recent study by D. Gulicher, M. Krimmol and S.Reinert[8] demonstrated that transducers working with high frequencies up to 12 Mhz shortens the focus to superficial regions and were able to better visualize zygomatic arch fractures. Where as earlier studies by Akizuki et al used frequency as low as 5 Mhz, which resulted in inadequate visualization of superficial regions. In order to overcome such deficiency the same study recommended the use of water filled conductor to image more superficially located zygomatic arch fracture. In our study with a frequency of 11 Mhz, we were able to demonstrate the cortex of normal bone as smooth, echogenic reflective surface and fractured bone fragments as highly echogenic foci with an angulation. The gap between the fractured segments was clearly appreciated. The velocity of propagation of ultrasound and attenuation, were the two most important parameters observed in this study. These determine the frequency with which the tissues are imaged, which in turn set the fundamental limit on the axial and lateral resolution.

A comparative study between ultrasound and submentovertex radiograph done by Rajesh. P and Bhagwan Das Rai[15] showed that in only in 66% of the arch fractures were confirmed by radiograph as compared to 100% of the cases confirmed by ultrasonography.

A coronal C.T. is not possible in all cases particularly in severely injured patients and patients with neck fractures. Delay in extricating the patient from the machine is an emergency widely recognized and may prove fatal. The results in our study imply that ultrasound can be used as an alternative method in the investigation of zygomatic arch fractures without the disadvantage of radiation exposure.[12]

In the present study all 16 zygomatic arch fractures were clearly imaged by ultrasonography. The sensitivity and positive predictive value of fracture diagnosis were both 100%. This is consistent with earlier studies. Ultrasonography was performed as a bedside procedure and as an extension of clinical investigation for two of the patients who were severely injured which is another added advantage.

This shows that ultrasonography has been used conveniently regardless of severity of the case.

Conclusion

Ultrasound offers a safe, inexpensive, accurate adjunct to conventional radiography of the facial bones and is well tolerated by recently injured patients. Ultrasound may also be considered as an alternative to repeating plain X-ray films to answer any doubts about the configuration or displacements of fractures, as ultrasound is noninvasive and overcomes the disadvantages of radiography.

In closing, it is appropriate to note that this study emphasizes the need of the hour in diagnostic imaging and the role of possible future developments in maxillofacial diagnostic ultrasound. It also brings into focus the most likely avenues of biomedical ultrasound advances in intraoperative maxillofacial fracture like zygomatic arch fracture reduction.[16] As with any diagnostic imaging the dexterity and skill of the diagnostic sonologist is a detrimental factor.

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