Original Article

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Role of Multiplanar Reconstruction Imaging and Three-dimensional Computed Tomography Imaging in Diagnosing Cranial and Facial Fractures

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Abstract

Introduction: Skull fractures can occur in road traffic accidents, assaults, sports, and any other injuries. Fractures to the skull can occur in any region of the skull. The role of plain radiographs in assessing facial traumas has declined over the years. The use of multiplanar reconstruction (MPR) and three-dimensional (3D) recon images of multiple detector computed tomography (MDCT) in the musculoskeletal system is of tremendous advantage in traumatic injuries when the results of plain radiography fail to answer the doubts of the surgeons regarding satisfactory alignment of complex fractures.

Objective: To assess the accuracy of MDCT with MPR and 3D reconstruction sequences in imaging cranial and facial fractures.

Materials and Methods: A total of 100 patients fulfilling the criteria were included in the study, the average age taken was from 22 to 44 with appropriate brain and facial protocols with bone and soft tissue reconstruction. Inclusion criteria: Traumatic cranial and facial fractures. Exclusion criteria: Pregnant and lactating women. Nontraumatic.

Results: The results of the present study revealed that compared to the four types of fractures, simple undisplaced was found to be the most frequently occurring one, wherein MPR technique was found to be more detective for fractures compared to MRP and 3D, MPR, axial and 3D, MPR and axial.

Conclusions: Thus, this study has high lightened the usefulness of MPR technique as an imaging tool in enabling accurate localization of free bone fragments and assessing the degree of their displacement, thus helping reduce recurrent exposures.

Key words: Cranial, Fractures, Reconstruction

INTRODUCTION

The various injuries that are caused by ferocity lead to the head and facial regions being most commonly affected. Involvement of these regions may lead to life-threatening situations, which include profuse blood loss, soft tissue swelling, lacerations, and pain.[1] Skull fractures (also known as cranial fractures) can occur in road traffic accidents, assaults, sports, and any other injuries. Fractures to the skull can occur in any region on the skull. All brain injuries including traumatic brain injury, subdural hematoma, epidural or extradural hematoma or traumatic intracerebral hematoma/contusion.[2,3] The role of plain radiographs in assessing facial traumas has declined over the years since X-rays are sensitive to cranial vault fractures but in sensitive to skull base fractures as it does not provide sufficient information regarding the anatomic details.[4,5] The role of magnetic resonance imaging (MRI) in trauma is to assess soft tissue injuries since it has good soft tissue contrast, and it also aids in assessing patients with neurological

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Table 1: Parameters

kVp	mAs	Slice thickness	Increment	Fov	Scan length	DLP mGy*cm	CTDI vol mGy*cm
100-120	300-350	5 mm	2.5 mm	18-22	250-300 mm	1095	45.0

DLP: Dose-length product, Fov: Field of view, CTDI: Computed tomography dose index

deficits but is not useful as compared to computed tomography (CT) in the evaluation of bony pathologies. The use of multiplanar reconstruction (MPR) and three-dimensional (3D) recon images of multiple detector computed tomography (MDCT) in the musculoskeletal system is of tremendous advantage in traumatic injuries when the results of plain radiography fail to answer the doubts of the surgeons regarding satisfactory alignment of complex fractures. Small structures that are not well seen with conventional CT imaging can be clearly depicted using MPR and 3D overlapping reconstruction at small intervals. Reformatted images also provide complementary information about various conditions including congenital malformation, vascular anomalies, and trauma involving the cranial and facial bones. The added advantage of MDCT is 3D technology which is very helpful in assessing large comminuted, displaced, and complex fractures involving multiple planes hence providing a road map for surgeons to initiate appropriate management.[6-8] These data obtained improve communications between the interpreting radiologist and the referring clinician and between the referring clinician and patients, since multiplanar and 3D reformations, give a real-time view of exam data in any plane with the ability to screen-capture the images for the permanent digital archive. MPR and 3D images are usually generated from the original two-dimensional data, and all reformatted images are obtained with the help of a neuroradiology fellow or a post processing technologist. During CT examinations, radiation exposure should be minimized for sensitive organs as prescribed by "ICRP" therefore, the radiologic technologists and radiologists must recognize the risks of patient doses during CT examinations and suggest appropriate protocols to reduce the doses.[9,10]

MATERIALS AND METHODS

A total of 100 patients with clinical history and examination findings of cranial and facial fractures from Chettinad Hospital and Research Institute who were referred for CT imaging to the Department of Radiology were included in the study. The study was initiated after the approval of Institutional Human Ethics Committee. Informed consent was obtained from the participating conscious subjects/subjects attenders, before the study related procedure. 100 patients fulfilling the criteria were included in the study; the average age taken was from 22 to 44. Patients were scanned in a Philips Ingenuity Core 128 Slice CT Machine with appropriate brain and facial protocols with bone and soft tissue reconstruction. During the study, proper instructions were given to the patient and protective measures, such as lead aprons, were used to cover the patient's body and to minimize the radiation dose to the patient. Throughout the procedure vitals were monitored. Fractures that were assessed include hairline, simple undisplaced, communited, and simple displaced. The images obtained were subjected to radiological analysis and interpretation (Table 1).

Selection Criteria

Inclusion criteria: Traumatic cranial and facial fractures.

Exclusion criteria: Pregnant and lactating women. Nontraumatic.

RESULTS

The results of the present study revealed that compared to the four types of fractures, simple undisplaced was found to be the most frequently occurring one, wherein MPR technique was found to be more detective for fractures compared to (Figures 1-4 and Graphs 1-3):

1. MRP and 3D
2. MPR, axial, and 3D
3. MPR and axial.

Statically analysis was carried out using formula and software *t*-test.

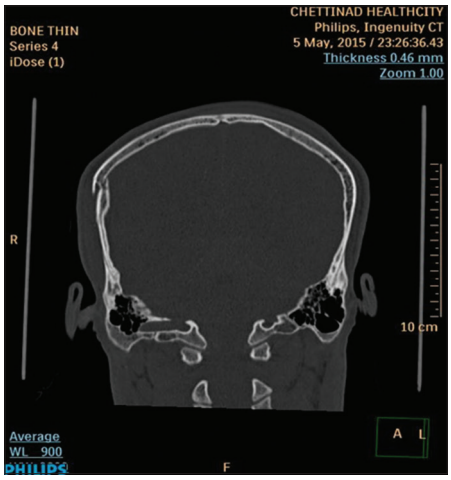


Figure 1: Minimally displaced fracture in right parietal and right temporal bones , well depicted in coronal reformatted CT image

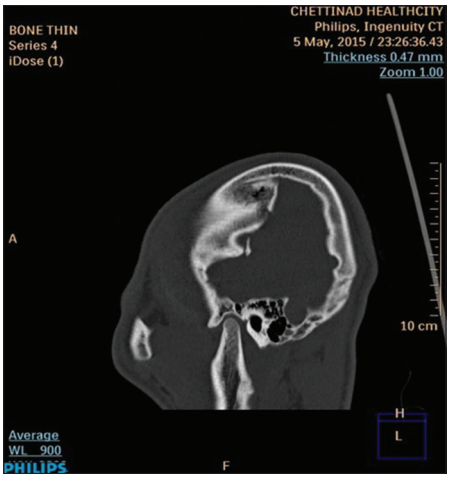


Figure 2: Sagittal reformatted CT image showing the fracture line

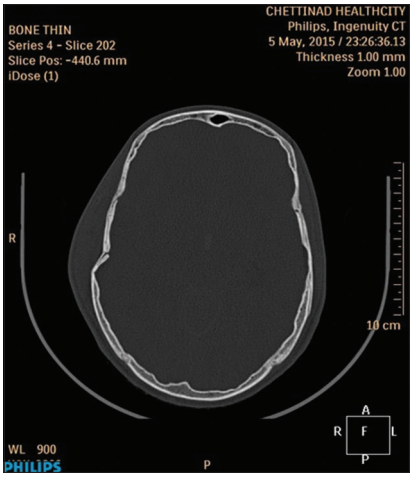


Figure 3: Axial CT image showing depressed fracture

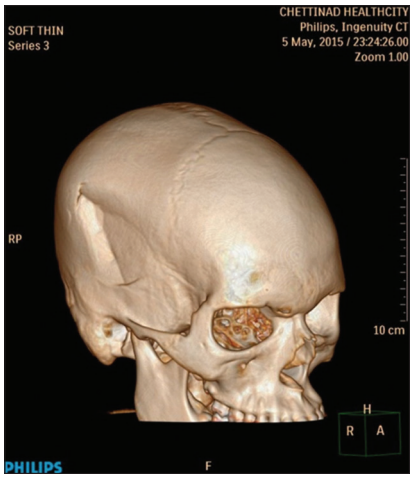
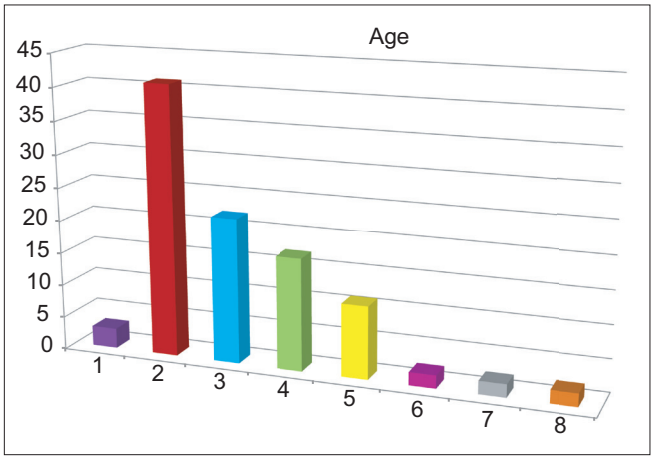
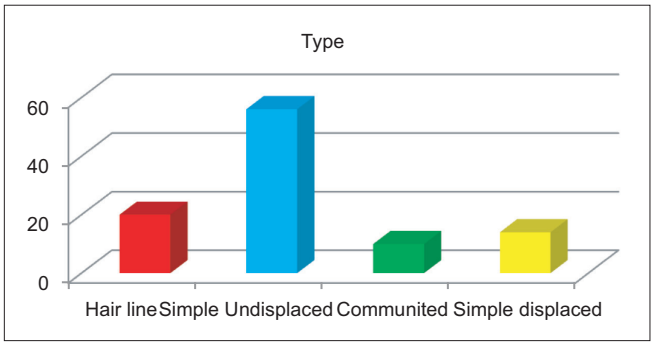


Figure 4: 3D CT image is very well demonstrating depressed fracture in right parietal and temporal bones and full extent of the fracture



Graph 1: The above bar graph shows that in my study fractures were seen to occur more commonly in the age groups pertaining to 20-40 years



Graph 2: The above bar graph shows that in my study simple undisplaced fractures were the most common ones sustained

DISCUSSION

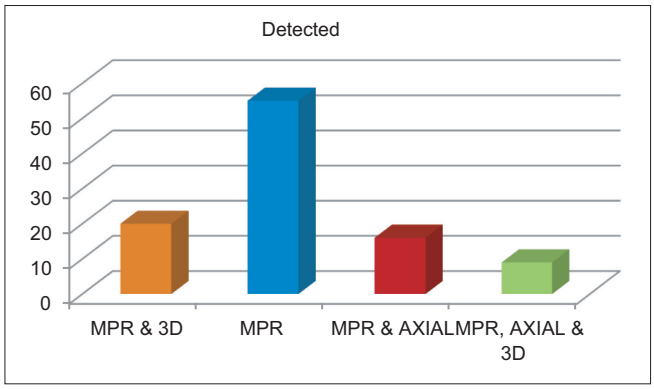
Plain Radiography

Plain radiography is the initial imaging modality in trauma patients but since it cannot provide adequate information regarding the internal and skull base anatomy its significance in assessing cranial and facial fractures trauma has declined, moreover in patients with multiple traumas especially involving cranial and facial injuries, there may be life-threatening consequences while positioning the patients, hence its role is limited.[11,12]

Depressed fracture noted in right parietal bone impinging on underlying brain parenchyma.

Segmental fracture noted in the inner table of right frontal sinus resulting in a large defect.

In the evaluation of fractures, MPR and 3D sequences are widely used for successful, identification of fracture sites. This is especially true for fractures of the cranial and facial region. This is because these structures are located and run in the transverse plane, but trauma images can produce false-positive images since adjacent regions easily overlap. Hence, this produces a false image thereby making diagnosis difficult. However, in a wider context, transverse



Graph 3: The above bar graph shows that in my study multiplanar reconstruction images were the most accurate means of detecting cranial and facial fractures

imaging is useful as a method of visualization of anatomical elements perpendicular to the examined plane.[13-16] A good example would be the evaluation of anterior and lateral walls of the maxillary sinus and orbital bones.

The highest sensitivity in diagnosing fractures of the maxilla, frontal, and nasal bone was revealed by MPR. It was noted that in imaging of thin and delicate bone structures (such as cribriform plate of the ethmoid bone) and orbital floor; and in some cases also the anterior wall of the maxillary sinus, 3D reconstructions were less useful than MPR. The use of 3D reconstructions in these areas often produces false-positive images suggestive of inexistent holes that are difficult or impossible to differentiate from fractures. Hence, 3D reconstructions cannot be used as the only imaging method in visualization of fractures.[17-20]

When comparing the results of imaging with the use of direct acquisition of raw data, with 3D reconstructions, it is also worth noticing their susceptibility to artifacts, i.e., the occurrence of false image elements that do not exist in real.[21,22] They may follow from the study protocol only. For example, if the slice is too thick during MPR, a "stair-step" artifact appears.

Hoeffner *et al.* conducted a study, in which it was proved that acquisition of MDCT, with slice thickness of 2.5 mm and slice distance of less than 1.5 mm, is enough to avoid "stair-step" artifacts in MPR reconstructions.

Furthermore, in the visualization of free, dislocated fracture fragments, MPR reconstructions turned out to be more successful in the assessment of post-traumatic lesions involving the orbits and maxillary sinuses.

3D reconstructions have also turned out to be of limited utility not only in the above-discussed group of symptoms but also in imaging of the ethmoid bones. However, it was successful in visualizing free bone chips within the condylar process, branches and body of the mandible, anterior wall of the frontal sinus, zygomatic arch, zygomatic bones, and nasal bones. It has also proved useful in imaging of "tripod fractures."[23,24]

The technique of 3D reconstruction also turned out to be useful also in the evaluation of fractures, with a high number and extent of dislocations of bone chips. Moreover, from among all applied techniques of presentation and reconstruction of CT images, the 3D option allows for a very precise reconstruction of post-traumatic anatomical relations in contrast to transverse and multiplanar imaging.[25]

CONCLUSIONS

Thus, this study has high lightened the usefulness of MPR technique as an imaging tool in enabling accurate localization of free bone fragments and assessing the degree of their displacement, thus helping reduce recurrent exposures.

REFERENCES

1. Downing A, Cotterill S, Wilson R. The epidemiology of assault across the West Midlands. Emerg Med J 2003;20:434-7.
2. Anderson M, Hall S, Martin M. Foundations of Athletic Training: Prevention, Assessment and Management. 4th ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009. p. 192-221.
3. Bahr R, Maehlum S. Clinical Guide to Sports Injuries. Champaign, IL Human Kinetics; 2004.
4. Greene J. High School Baseball Player in Coma after Line Drive Hit. NBC Bay Area; 2010.
5. Ellis E 3rd, Moos KF, el-Attar A. Ten years of mandibular fractures: An analysis of 2,137 cases. Oral Surg Oral Med Oral Pathol 1985;59:120-9.
6. Haug RH, Prather J, Indresano AT. An epidemiologic survey of facial fractures and concomitant injuries. J Oral Maxillofac Surg 1990;48:926-32.
7. Turvey TA. Midfacial fractures: A retrospective analysis of 593 cases. J Oral Surg 1977;35:887-91.
8. Wiesenbaugh JM Jr. Diagnostic evaluation of zygomatic complex fractures. J Oral Surg 1970;28:204-8.
9. Fishman EK, Wyatt SH, Bluemke DA, Urban BA. Spiral CT of musculoskeletal pathology: Preliminary observations. Skeletal Radiol 1993;22:253-6.
10. Pretorius ES, Fishman EK. Volume-rendered three-dimensional spiral CT: Musculoskeletal applications. Radiographics 1999;19:1143-60.
11. 3-D Image post processing Educational Framework Sponsored by the American Society of Radiologic Technologists, 15000 Central Ave. SE.
12. Brenner DJ, Hall EJ. Computed tomography – An increasing source of radiation exposure. N Engl J Med 2007;357:2277-84.
13. Fazel R, Krumholz HM, Wang Y, Ross JS, Chen J, Ting HH, *et al.* Exposure to low-dose ionizing radiation from medical imaging procedures. N Engl J Med 2009;361:849-57.
14. Rizzo S, Kalra M, Schmidt B, Dalal T, Suess C, Flohr T, *et al.* Comparison of angular and combined automatic tube current modulation techniques with constant tube current CT of the abdomen and pelvis. AJR Am J Roentgenol 2006;186:673-9.
15. Kalra MK, Naz N, Rizzo SM, Blake MA. Computed tomography radiation dose optimization: Scanning protocols and clinical applications of automatic exposure control. Curr Probl Diagn Radiol 2005;34:171-81.

16. Fishman EK, Ney DR. Advanced computer applications in radiology: Clinical applications. Radiographics 1993;13:463-75.
17. Hoeffner EG, Quint DJ, Peterson B, Rosenthal E, Goodsitt M. Development of a protocol for coronal reconstruction of the maxillofacial region from axial helical CT data. Br J Radiol 2001;74:323-7.
18. Sanderov B, Viccellio P. Fractures of the medial orbital wall. Ann Emerg Med 1988;17:973-6.
19. Olszycki M, Kozakiewicz M, Arkuszewski P. Wtórne rekonstrukcje obrazowe TK i MR zmian pourazowych części twarzowej czaszki. Pol J Radiol 2004;69:94-9.
20. Rózylo-Kalinowska I. The influence of application of 3D CT reconstructions on classification of maxillofacial fractures. Ann Univ Mariae Curie Sklodowska Med 2002;57:549-55.
21. Bernhardt TM, Rapp-Bernhardt U, Fessel A, Ludwig K, Reichel G, Grote R. CT scanning of the paranasal sinuses: Axial helical CT with reconstruction in the coronal direction versus coronal helical CT. Br J Radiol 1998;71:846-51.
22. Abrahams JJ. Dental CT imagnig: A look at the jaw. Radiology 2001;219:334-45.
23. Daly BD, Russell JL, Davidson MJ, Lamb JT. Thin section computed tomography in the evaluation of naso-ethmoidal trauma. Clin Radiol 1990;41:272-5.
24. Pogorzelska-Stronczak B, Koszowski R, Lelek P. Zastosowanie TK z rekonstrukcją MRP i 3D w diagnostyce schorzeń części twarzowej czaszki. Przegl Lek 2002;59:4.
25. Rózylo-Kalinowska I, Rózylo TK. Diagnostic algorithm in high (cranial) maxillofacial fractures. Ann Univ Mariae Curie Sklodowska Med 2000;55:309-17.

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