January, 2012

Diagnosis of Facial Asymmetry Using Conventional PA Cephalometric Analysis and a Maxillofacial 3-Demensional CT Analysis: A Comparative Study

Abstract

The advent of computed tomography has greatly reduced magnification errors from geometric distortions that are common in conventional radiographs. Recently introduced 3-dimensional (3D) software enables 3D reconstruction and quantitative measurement of the maxillofacial complex. 3D images are also useful in understanding asymmetrical structures. This article compares 3D and 2D images as well as right and left side of the face of an individual which helps to diagnose the facial asymmetry.

Introduction

As the demand for improved facial esthetics increases, more patients complain of the development or the progression of facial asymmetry, particularly mandibular asymmetry, during or after orthodontic treatment. Patients who undergo orthognathic surgery for sagittal relationship problems, such as maxillary protrusion or mandibular prognathism, also tend to become aware of facial asymmetry after the surgical procedure. Because a misdiagnosis of facial asymmetry can result in the wrong treatment for a patient, accurate evaluations of facial asymmetry are crucial in orthodontic practice.

In most cases, the presence and degree of facial asymmetry can be diagnosed by using posteroanterior (PA) cephalometry.[1, 2 and 3] However, a PA cephalometric radiograph does not provide sufficient information for identifying the causes of asymmetry or determining a suitable

Scanned by CamScanner

treatment plan. Chin deviation is a common form of facial asymmetry. It usually develops from a right and left side difference in ramus length, but there are also other possible causes, such as a difference of body length in the mandible. Distinguishing a problem-causing structure is extremely important in treatment planning, but PA cephalometry does not always provide accurate information, even with the aid of lateral and submentovertex projections. Conventional radiographic images can be misleading in interpreting the cause of the deviation because complex 3-dimensional (3D) structures are projected onto flat 2-dimensional (2D) surfaces, creating possible distortion of the images and subsequent magnification errors.[4 and 5] The development of computed tomography (CT), however, has greatly reduced the possibility of these errors and improved our ability to understand the 3D nature of facial structures.[6] In addition, recently introduced 3D CT software enables 3D reconstruction and accurate measurement of the maxillofacial complex.[7 and 8] Exact measurement is the key element in evaluating asymmetry: 3D images can provide accurate and detailed information for the diagnosis and treatment planning of facial asymmetry by means of quantitative measurement and comparison between the right and left sides of the structures.

CT scans are currently widely used to acquire 3D information on craniofacial complexes.[9] The development of CT and computer technology allows easy access to maxillofacial 3D images.

In spite of its usefulness, however, clinicians and patients have been hesitant to use conventional CT because of the long procedure in a cramped space and the high level of radiation. The introduction of the spiral CT resolved these concerns. Creating a simultaneous patient translation through the continuous rotation of the source detector assembly, spiral CT, with its spiral sampling locus, acquires raw projection data in a relatively short time.[10,11]

Hence this study was designed to compare the differences in the diagnosis of facial asymmetry, using two different methods, three dimensional image (3D-CT) analysis with the conventional (Postero-Anterior ceph, Lateral ceph and Submentovertex) radiographic analysis.

Methodology

The sample consisted of ten patients selected from the outpatients to the Department of Orthodontics and Dentofacial Orthopedics, Rajarajeswari Dental College and Hospital, Bangalore. The patients were selected based on the following inclusion and exclusion criteria.

Inclusion criteria:

1. Patients within the age group of 18 to 25 years.

2. Patients with the full complement of permanent teeth (excluding third molars).

Exclusion criteria:

1. Patients who have undergone Orthodontic/ Orthopedic/ Orthognathic surgical

treatment.

1. Patients with history of trauma.
2. Patients with obvious/ gross facial asymmetry.

Standard radiographs of the selected patients were obtained in the *postero-anterior, lateral* and *submentovertex* views using Rotograph Plus – panceph machine (Fig 1). Three dimensional *computed tomographic* digital images were also obtained from the patients using Xvision GX, Toshiba (Fig 2).

Scanned by CamScanner

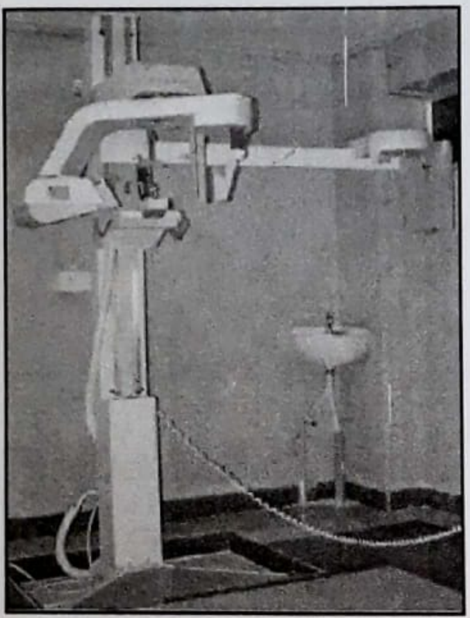


Fig. 1: Rotagraph plus Panceph machine on which the PA ceph, lateral ceph and submentovertex view radiographs were taken.

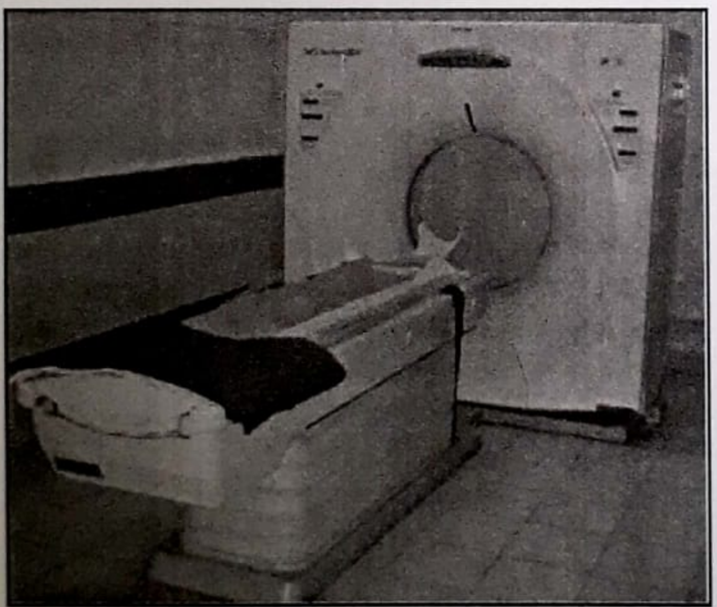


Fig.2: X vision GX machine on which the spiral 3D computed tomographic images were taken.

All the radiographs were taken using a Panceph machine (250 Kvp, 25 ma) using a 8.5" x 10" sized radiographic film CT scans of the same 10 subjects were obtained by using a spiral CT scanner with a mode with **2.5** mm thickness, slice pitch 3, and a scanning time of **0.8** seconds. The acquired 2D CT digital image data were then input onto a personal computer.

Scanned by CamScanner

Conventional Computed Axial Tomography (CAT) [12,13]

The technique of X-ray CT was invented by Godfrey Hounsfield in 1972. The basic principle behind CT is that the two-dimensional internal structure of an object can be reconstructed from a series of one-dimensional "projections" of the object acquired at different angles.

Disadvantage of conventional CT

In the conventional CT systems, if multiple slices are required to cover a larger volume of the body, then the patient table has to be moved in discrete steps through the plane of the X-ray source and detector. A single slice is acquired at each discrete table position, with an inevitable time delay between obtaining each image. This process is both time-inefficient and can result in spatial misregistrations between slices if the patient moves.

Spiral/ Helical Computed Tomography [13,14]

In the early 1990s a technique called spiral, or helical, CT was developed to overcome these problems by acquiring data as the table position is moved continuously through the scanner. The trajectory of the X-ray beam through the patient traces out a spiral, or helix: hence the name. Typical spiral CT scanners have dual-focal-spot X-ray tubes with three kVp settings possible.

3D landmarks used in the study were (Fig 3 and 4) (Table I):

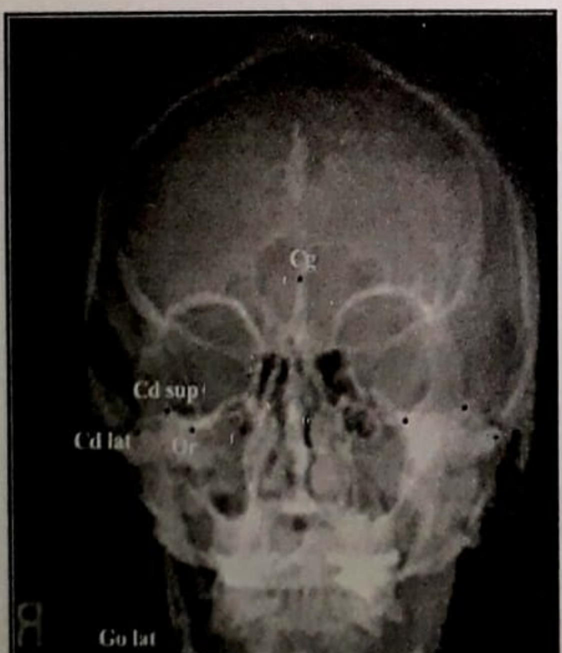


Fig.3: Landmarks used for assessment of facial asymmetry in the PA ceph.

Scanned by CamScanner

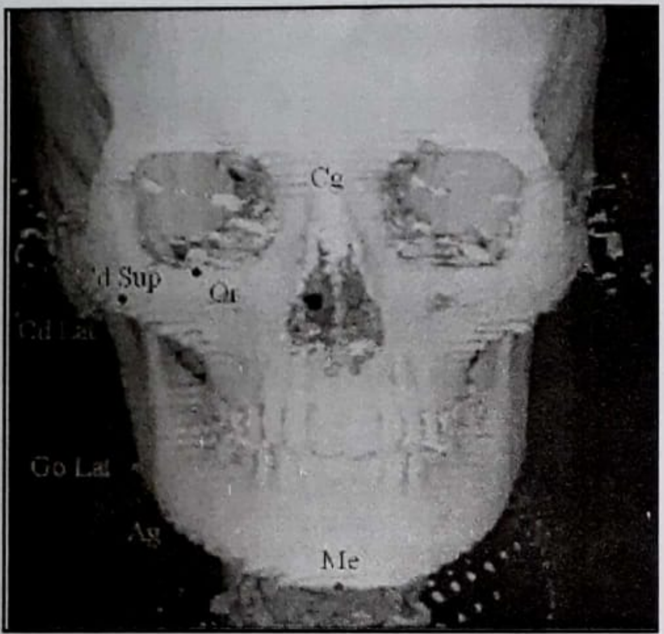


Fig.4: Landmarks used for the assessment of facial asymmetry in the 3D CT image.

	Landmark	Abbreviation	Description
1.	*Crista galli*	**Cg**	Most superior point of crista galli of ethmoid bone.
2.	*Opisthion*	**Op**	Most posterior point on posterior margin of foramen magnum.
3.	*Porion*	**Po**	Highest point on roof of external auditory meatus
4.	*Orbitale*	**Or**	Deepest point on infraorbital margin
5.	*Condylion superius*	**Cd sup**	Most superior point of condyle head
6.	*Condylion lateralis*	**Cd lat**	Most lateral point of condyle head
7.	*Condylion posterius*	**Cd post**	Most posterior point of condyle head
8.	*Gonion lateralis*	**Go lat**	Most lateral point of gonion area
9.	*Gonion posterius*	**Go post**	Most posterior point of gonion area
10.	*Gonion inferius*	**Go inf**	Most inferior point of gonion area
11.	*Antegonion*	**Ag**	Deepest point of antegonial notch of mandible
12.	*Menton*	**Me**	Most inferior point on mandibular symphysis.

Scanned by CamScanner

Table I: Parameters used to assess the facial asymmetry.

The parameters used to assess facial asymmetry were:[14]

1.Maxillary Height: First molar to FH (Po-Or-Po) – distance between the FH plane and the occlusal fossa of the maxillary first molar (in mm, Fig 5).

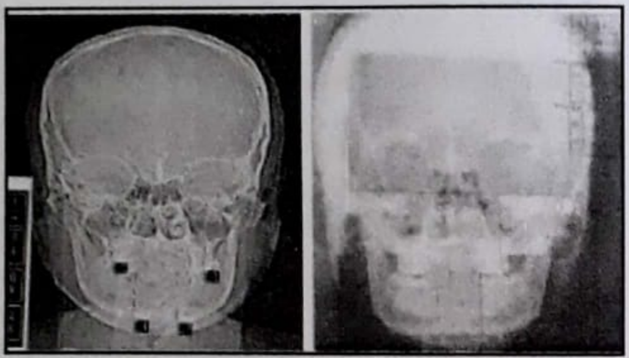


Fig 5: Measurement of maxillary height in CT and PA ceph.

2.Mandibular Height: Canine to mandibular plane (Ag-Me-Ag), distance from the canine cuspal tip perpendicular to the mandibular plane (in mm, Fig 6).

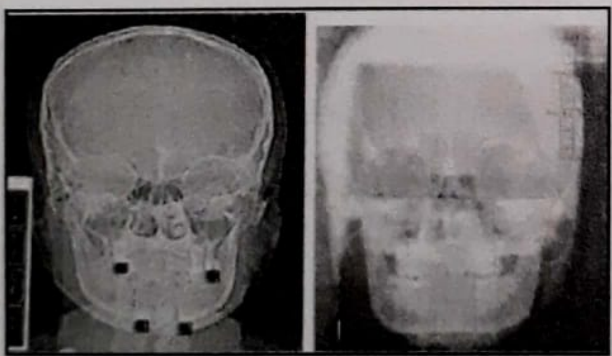


Fig. 6: Measurement of mandibular height in CT and PA ceph.

3.Ramus Length: Condylion superior – Gonion inferior – distance between the highest point of the condyle and the lowest point of the gonion area(in mm, Fig 7).

Scanned by CamScanner

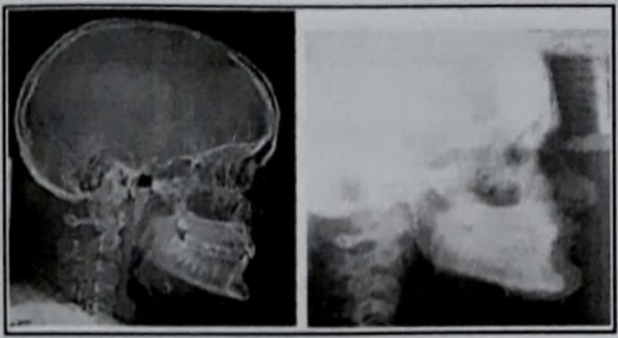


Fig. 7: Measurement of ramal length in CT and lateral ceph.

4.Mandibular Body Length: Menton – Gonion posterior, distance between menton and the most posterior point of the gonion area (in mm, Fig 8).

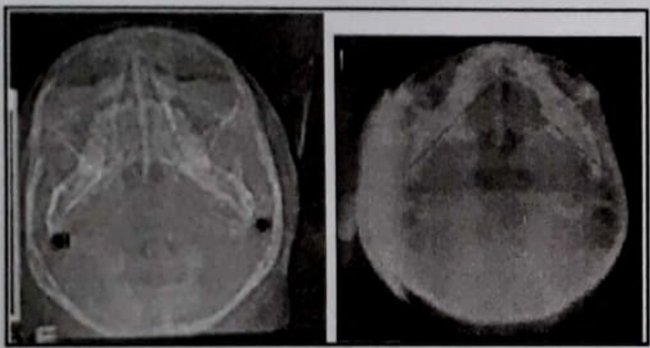
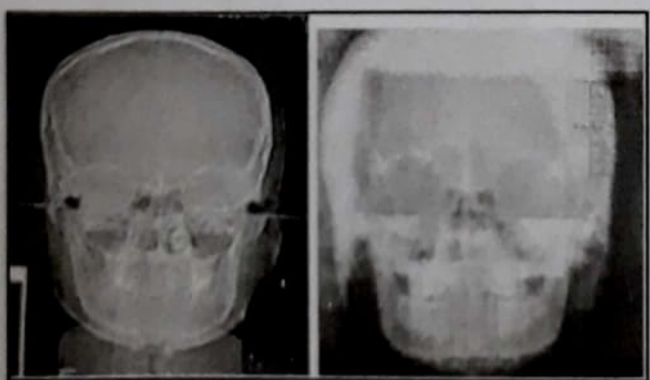


Fig. 8: Measurement of mandibular body in CT and submental vertex ceph.

5.Frontal Ramal Inclination: Condylion lateral – Gonion lateral to midsagittal reference plane (Op-Cg-ANS) – angle formed by the FH plane and the posterior border of the ramus (in degrees, Fig 9).



Scanned by CamScanner

Fig. 9: Measurement of frontal ramal inclination in CT and PA ceph.

6.Lateral Ramal Inclination: Condylion posterior – Gonion posterior to FH (Po-Or- Po), angle formed by the FH plane and the posterior border of the ramus (in degrees, Fig 10).

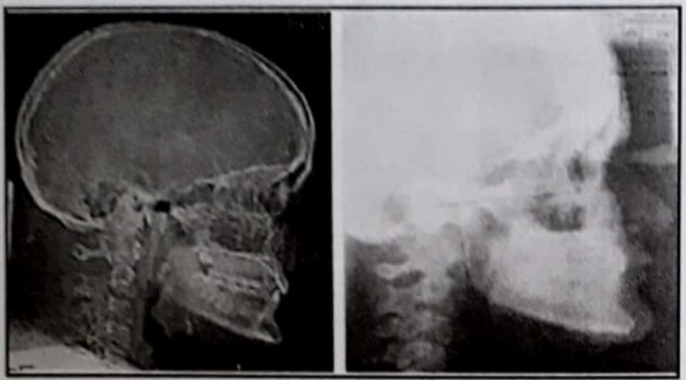
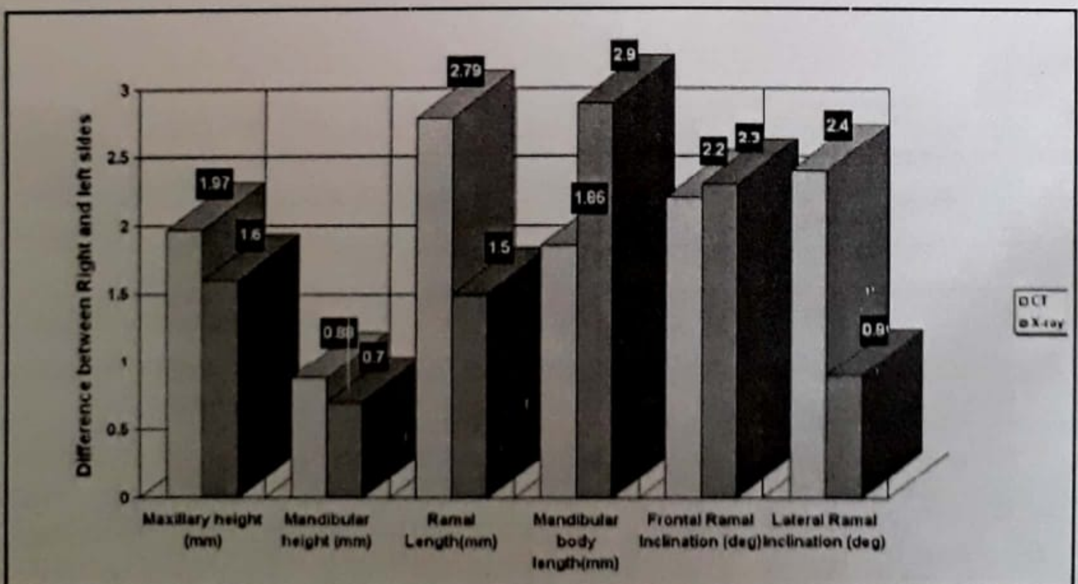


Fig. 10: Measurement of lateral ramal inclination in CT and lateral ceph.

Results

Comparison of the differences between the right and left sides in both three dimensional CT images and conventional radiographic images showed that there was no statistical significance for the differences in Maxillary height (***p=0.69***), Mandibular height (***p=0.69***), Ramal Length (***p=0.33***), Mandibular body length (***p=0.30***) and Frontal Ramal Inclination (***p=0.92***). But the difference in the Lateral Ramal Inclination between right and left sides in three dimensional CT images and conventional radiographic images (**Graph I**) was found to be statistically significant (***p=0.05***).



Scanned by CamScanner

Graph I : Comparison of the difference in the various parameters between right and left sides in 3D CT and conventional radiographic measurements.

Discussion

In most cases, the presence and degree of facial asymmetry can be diagnosed by using posteroanterior (PA) cephalometry.[2] But PA cephalometry does not always provide accurate information, even with the aid of lateral and submentovertex projections. Conventional radiographic images can be misleading in interpreting the cause of the deviation because complex three dimensional structures are projected onto flat two dimensional surfaces, creating possible distortion of the images and subsequent magnification errors.[15,16] The development of computed tomography (CT), however, has greatly reduced the possibility of these errors and improved our ability to understand the 3D nature of facial structures.[17] In addition, recently introduced 3D CT software enables 3D reconstruction and accurate measurement of the maxillofacial complex.[18,19] 3D images can provide accurate and detailed information for the diagnosis and treatment planning of facial asymmetry by means of quantitative measurement and comparison between the right and left sides of the structures. The rotating function and the computer-aided 3D measure function enable precise analysis, clear visualization and quantification of the right and left difference of the structure. The present study was conducted to compare three dimensional CT scan with conventional radiographic techniques in diagnosing and quantifying facial asymmetries are discussed 3 headings.

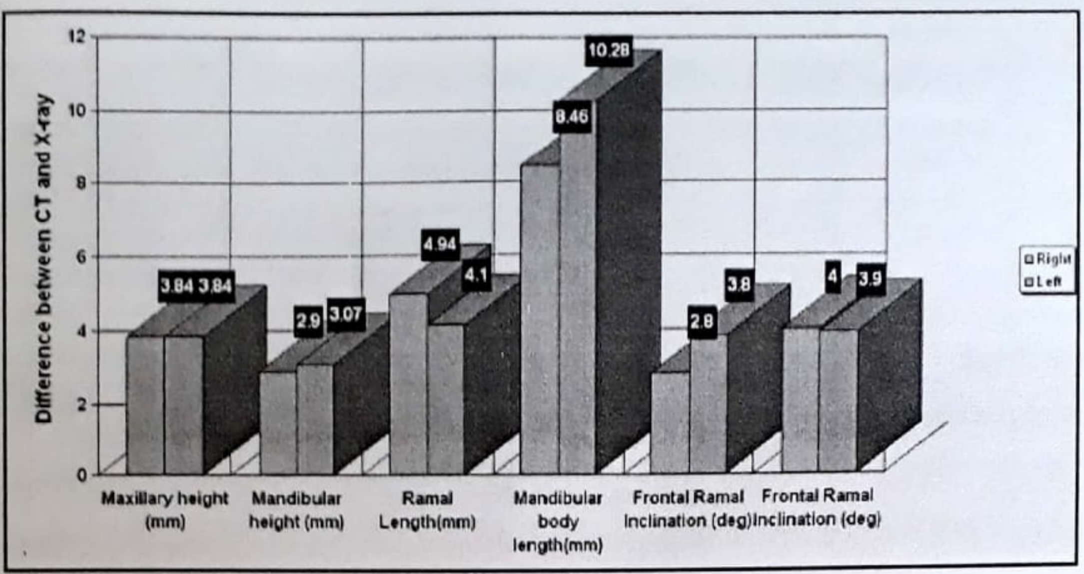
1. Comparison of the three dimensional CT image analysis with the conventional PA cephalometric analysis in diagnosing facial asymmetries.

Comparison of the differences between the right and left sides in both three dimensional CT images and conventional radiographic images (Table II) (Graph II) showed that there was maximum difference in the Lateral ramal inclination (**1.5^0**) followed by Ramal length (**1.29 mm**) and Mandibular body length (**1.04 mm**).). But except for the difference in the Lateral ramal inclination, all the above differences were statistically not significant.

Variables	CT	X-ray	P value
Maxillary height (mm)	1.97±1.67	1.60±1.17	0.619
Mandibular height (mm)	0.88±0.74	0.70±0.67	0.532
Ramal Length(mm)	2.79±2.65	1.50±1.96	0.326
Mandibular body length(mm)	1.86±2.16	2.90±2.07	0.302
Frontal Ramal Inclination (deg)	2.20±2.04	2.30±2.21	0.922
Lateral Ramal Inclination (deg)	2.40±2.01	0.90±1.28	0.05+

Table II: Comparison of the difference in various parameters between right and left sides in 3D CT and conventional radiographic measurements. (+ indicates P value < 0.05)

Scanned by CamScanner



Graph II: Comparison of difference of measurement between 3D CT and conventional radiograph for the difference of left and right sides.

The present study revealed that values derived from three dimensional CT are more accurate than conventional radiographic techniques in diagnosing facial asymmetry. Moreover 3DCT has the added advantages of ease of manipulation and better quantification and three dimensional view of the structures.

2. Reliability of three dimensional CT image analysis in assessing facial asymmetries.

Numerous studies have investigated the reliability of various techniques of diagnosing facial asymmetry: anthropometry[7], photographs[20,21,22,23], conventional two dimensional radiographs, stereophotogrammetry[24,25,26] and three dimensional (3D) CT[27,28,29,30,31,32,33,34].

In the present study comparison of the initial values with the repeated readings (inter examiner measurements) for the various parameters showed a high correlation for all the parameters on both right and left side in the three dimensional CT image measurements (Table III). This indicates a high reliability of the measurements done on three dimensional CT images for assessing facial asymmetry. These findings are in accordance with *Hwang et al*[14], *Katsumata et al*[28], *Maeda et al*[32], *Oosterkamp et al*[33] and *Yáñez-Vico et al*[34], who demonstrated that the 3D-CT imaging technique was a practical and reliable method of evaluating the morphology of facial asymmetry. They also added that 3DCT had greatly reduced magnification errors from geometric distortions that are common in conventional radiographs. A 3-dimensional software also enables 3D reconstruction and quantitative measurement of the maxillofacial complex.

Scanned by CamScanner

Variables	CT		X-ray	
	Right	Left	Right	Left
Maxillary height (mm)	0.996**	0.995**	0.994**	0.981**
Mandibular height (mm)	0.997**	0.991**	1.000**	0.958**
Ramal Length(mm)	0.999**	0.929*	1.000**	0.847+
Mandibular body length(mm)	1.000**	1.000**	0.957**	0.943**
Frontal Ramal Inclination (deg)	1.000**	0.902*	1.000**	0.983**
Lateral Ramal Inclination (deg)	1.000**	0.913*	1.000**	0.988**
Results are r value, * indicates good correlation, ** indicates high correlation, + indicates moderate correlation				

Table III: Correlaton with the inter-examiner values showing the reliability of 3D CT images measurements.

The present study found that measurements done on three dimensional CT images are reliable and repeatable.

3. Prevalence of facial asymmetry

The maximum asymmetry was seen in the Mandibular body length and the least in the Mandibular height. In both 3DCT and X-ray, maxillary height showed moderate asymmetry.

These findings are in concurrence with that of *Peck et al*[6] showed that the orbital region exhibited the least asymmetry (0.87 mm) and the mandibular region the most (3.54 mm) with the zygomatic region exhibiting a moderate asymmetry of 2.25 mm. They found that more the structures were away from the cranium, greater was the asymmetry. These findings are also in agreement with that of *Maeda et al* [32] who found that asymmetry was observed most frequently in the mandibular body region and only about 6.1% of the patients examined demonstrated a mild degree of maxillary asymmetry

In the conventional radiographs, the right side measurements were greater compared to the left side of the face in Maxillary height, Mandibular height, Ramal length and Frontal ramal inclination. Only the Mandibular body length and Lateral ramal inclination showed predominance on the right side of the face in conventional radiographs. These findings are in accordance with those of *Shah et al*[1], *Peck et al*[6] and *Farkas et al*[7], who also reported that normal, pleasing facial features, with normal occlusion showed a statistically significant difference between their right and left sides, with the right side being slightly larger than the left.

The present study found that the facial asymmetry was more as one progresses caudally from the cranium, with the mandibular components exhibiting the most asymmetry. The right and the left sides showed equal predominance in their asymmetry.

Scanned by CamScanner

Conclusion

Both 3D and 2D images are useful to better understand asymmetrical structures. Although most patients with facial asymmetry are well diagnosed by using cephalometric radiographs, some occasions require 3D imaging analysis to obtain more accurate information. By observing and accurately gauging the factors that contribute to facial asymmetry, 3D imaging analysis will enable us to comprehend its cause more accurately.

The present study found that the facial asymmetry was more as one progresses caudally from the cranium, with the mandibular components exhibiting the most asymmetry. The right and the left sides showed equal predominance in their asymmetry.

Bibilography

1. *Shah SM, Joshi MR.* An assessment of asymmetry in the normal craniofacial complex. *Angle Orthod.* 1978;48:141–148.
2. *Letzer G.M, Kronman J.H.* A posteroanterior cephalometric evaluation of craniofacial asymmetry. *Angle Orthod* 1967;37:205-211.
3. *Cook J.T.* Asymmetry of the craniofacial skeleton. *Br.J.Orthod.* 1980;7:33-38.
4. *Lu K.H.* Harmonic analysis of the human face. *Biometrics.* 1965;21:491-505.
5. *Bishara S.E, Burkey P.S, Kharouf J.G.* Dental and facial asymmetries: A review. *Angle Orthod* 1994;64(2):89-98.
6. *Peck S, Peck L, Kataja M.* Skeletal asymmetry in esthetically pleasing faces. *Angle Orthod.* 1990;61:43–48.
7. *Farkas LG, Cheung G.* Facial asymmetry in healthy North American Caucasians. An anthropometrical study. *Angle Orthod.* 1981; 51:70–77.
8. *Severt TR, Proffit WR.* The prevalence of facial asymmetry in the dentofacial deformities population at the University of North Carolina. *Int J Adult Orthodon Orthognath Surg.* 1997;12:171–176.
9. *Fuhrmann RA, Schnappauf A, Diedrich PR.* Three-dimensional imaging of craniomaxillofacial structures with a standard personal computer. *Dentomaxillofac Radiol* 1995;24:260-3.
10. *Vannier MW, Marsh JL, Warren JO.* Three dimensional CT reconstruction images for craniofacial surgical planning and evaluation. *Radiology* 1984;150:179-84.
11. *Kalender WA, Seissler W, Klotz E, Vock P.* Spiral volumetric CT with single-breath-hold technique, continuous transport, and continuous scanner rotation. *Radiology* 1990;176:181-3.
12. *E. Seeram,* Computed Tomography: Physical Principles, Clinical Applications, and Quality Control, *Saunders,* Philadelphia (2001).
13. *W. A. Kalender,* Computed Tomography: Fundamentals, System Technology, Image Quality, Applications, *MCD*, Munich, Germany (2001).
14. *Hwang H.S, Hwang C.H, Lee K.H, Kang B.C.* Maxillofacial 3-dimensional image analysis for the diagnosis of facial asymmetry. *Am. J. Orthod.* 2006;130:779-85.
15. Bergersen EO. Enlargement and distortion in cephalometric radiography: compensation tables for linear measurements. Angle Orthod 1980;50:230-44.
16. *Ahlqvist J, Eliasson S, Welander U.* The cephalometric projection: part II. Principles of image distortion in cephalography. *Dentomaxillofac Radiol* 1983;12:101-8.
17. *Vannier MW, Marsh JL, Warren JO.* Three dimensional CT reconstruction images for craniofacial surgical planning and evaluation. *Radiology* 1984;150:179-84.
18. *Fuhrmann RA, Schnappauf A, Diedrich PR.* Three-dimensional imaging of craniomaxillofacial structures with a standard personal computer. *Dentomaxillofac Radiol* 1995;24:260-3.
19. *Vannier MW, Hildebolt CF, Conover G, Knapp RH, Yokoyama-Crothers N, Wang G.* Three-

Scanned by CamScanner

dimensional dental imaging by spiral CT. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1997;84:561-70.

20. *Edler R, Wertheim D, Greenhill D.* Clinical and computerized assessment of mandibular asymmetry. *Eur J Orthod.* 2001 Oct;23(5):485-94.
21. *Edler R, Wertheim D, Greenhill D.* Mandibular outline assessment in three groups of orthodontic patients. *Eur J Orthod.* 2002 Dec;24(6):605-14.
22. *Seiji Haraguchi, Yoshitaka Iguchi, Kenji Takada.* Asymmetry of the Face in Orthodontic Patients. *Angle Orthod* 2008;78(3):421-426.
23. *Lee MS, Chung DH, Lee JW, Cha KS.* Assessing soft-tissue characteristics of facial asymmetry with photographs. *Am J Orthod Dentofacial Orthop.* 2010 Jul;138(1):23-31.
24. *Ras F, Habets L.L.M.H, Van Ginkel F.C, Andersen B.P.* Method for quantifying facial asymmetry in three dimensions using stereophotogrammetry. *Angle Orthod* 1995;65(3):233-239.
25. *Shaner DJ, Peterson AE, Beattie OB, Bamforth JS.* Assessment of soft tissue facial asymmetry in medically normal and syndrome-affected individuals by analysis of landmarks and measurements. *Am J Med Genet.* 2000 Jul 17;93(2):143-54.
26. *Hood CA, Bock M, Hosey MT, Bowman A, Ayoub AF.* Facial asymmetry–3D assessment of infants with cleft lip & palate. *Int J Paediatr Dent.* 2003 Nov;13(6):404-10.
27. *Hwang H.S, Hwang C.H, Lee K.H, Kang B.C.* Maxillofacial 3-dimensional image analysis for the diagnosis of facial asymmetry. *Am. J. Orthod.* 2006;130:779-85.
28. *Bannister C, Lendrum J, Gillepsie J, Isherwood I.* Three-dimensional computed tomographic scans in the planning of procedures for reconstructive craniofacial surgery. *Neurol Res.* 1987 Dec;9(4):236-40.
29. *Kumiko Togashi, Hideki Kitaura, Koichi Yonetsu, Noriaki Yoshida, Takashi Nakamura.* Three-Dimensional Cephalometry Using Helical Computer Tomography: Measurement Error Caused by Head Inclination. *Angle Orthod* 2002;72:513–520.
30. *Katsumata A, Fujishita M, Maeda M, Ariji Y, Ariji E, Langlais RP.* 3D-CT evaluation of facial asymmetry. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2005 Feb;99(2):212-20.
31. *Akira Nakajima, Glenn T. Sameshima, Yoshinori Arai, Yoshito Homme, Noriyoshi Shimizu, Harry Dougherty Sr.* Two- and Three-dimensional Orthodontic Imaging Using Limited Cone Beam–Computed Tomography. *Angle Orthod* 2005;75:895–903.
32. *Maeda M, Katsumata A, Ariji Y, Muramatsu A, Yoshida K, Goto S, Kurita K, Ariji E.* 3D-CT evaluation of facial asymmetry in patients with maxillofacial deformities. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2006 Sep;102(3):382-90. Epub 2006 Apr 21.
33. *Oosterkamp BC, Damstra J, Jansma J.* Facial asymmetry: the benefits of cone beam computerized tomography. *Ned Tijdschr Tandheelkd.* 2010 May;117(5):269-73.
34. *Yáñez-Vico RM, Iglesias-Linares A, Torres-Lagares D, Gutiérrez-Pérez JL, Solano-Reina E.* Three-dimensional evaluation of craniofacial asymmetry: an analysis using computed tomography. *Clin Oral Investig.* 2010 Jul 15.

Dr.Dharmesh.H.S MDS, [1]

Dr.Rajkumar S Alle MDS, DNB [2]

Dr.Suma.T MDS [3]

Department of Orthodontics & Dentofacial Orthopaedics

Rajarajeshwari Dental College and Hospital

Bangalore.

Scanned by CamScanner

Correspondence address:-

Dr.Dharmesh. H.S,

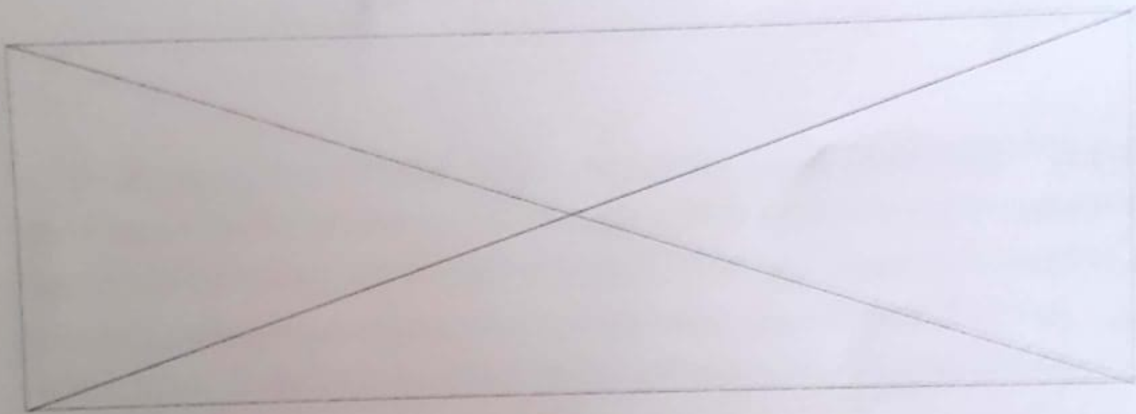
Geetha Multispeciality Dental Clinic

#5, 5th Main, Tata Silk Farm,

Basavangudi, Bangalore-560004

Ph.No. 98453-38403, 080-25928195

E-mail: drdharmi@gmail.com



Be the first to leave a comment.

Leave a Reply

Name (required) Email (required) Website (optional)

Type your comment here...

Add Comment

Search

Categories

- Appliances
- Business
- Development
- Diagnosis

Scanned by CamScanner