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ORIGINAL ARTICLE

Diagnosis of Mandibular Asymmetry Using Conventional PA Cephalometric Analysis and A Maxillofacial 3-Dimensional CT Analysis

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Abstract

Background: 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 mandible of an individual which helps to diagnose the asymmetry of mandible.

Material and Methods: The sample consisted of ten patients within the age group of 18 to 25 years. Three dimensional *computed tomographic* digital images as well as *postero-anterior, lateral* and *submentovertex* view radiographs were obtained.

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 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 was found to be statistically significant (***p=0.05***).

Conclusion: Although most patients with mandibluar 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 asymmetry of mandible, 3D imaging analysis will enable us to comprehend its cause more accurately.

Keywords: mandibular asymmetry, three dimensional CT, cephalometric analysis

INTRODUCTION

As the demand for improved facial esthetics increases, more patients complain of the development or the progression of facial asymmetry, particularly asymmetry of mandible, during or after orthodontic treatment. Because a misdiagnosis of asymmetry of mandible can result in the wrong treatment for a patient, accurate evaluations of mandibular asymmetry are crucial in orthodontic practice.

In most cases, the presence and degree of mandibular 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 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 mandibular asymmetry: 3D images can provide accurate and detailed information for the diagnosis and treatment planning of mandibular asymmetry by means of quantitative measurement and comparison between the right and left sides of the structures.

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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 mandibular 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.
2. Patients with history of trauma.
3. 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).

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

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

1. **Mandibular Height:** Canine to mandibular plane (Ag-Me-Ag), distance from the canine cuspal tip perpendicular to the mandibular plane (in mm, Fig 5).
2. **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 6).
3. **Mandibular Body Length:** Menton – Gonion posterior, distance between menton and the most posterior point of the gonion area (in mm, Fig 7).
4. **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 8).
5. **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 9).

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 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 (**$p=0.05$**).

DISCUSSION

In most cases, the presence and degree of mandibular 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 mandibular 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 mandibular asymmetries are discussed 2 headings.

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

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. Prevalence of mandibular asymmetry

The maximum asymmetry was seen in the Mandibular body length and the least in the Mandibular height.

In the conventional radiographs, the right side measurements were greater compared to the left side of the face in 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.

CONCLUSION

Both 3D and 2D images are useful to better understand asymmetrical structures. Although most patients with mandibular asymmetry are well diagnosed by using cephalometric radiographs, some occasions require 3D imaging analysis to obtain

Fig-3 Landmarks used for Assessment of facial asymmetry in the Postero-Anterior Ceph

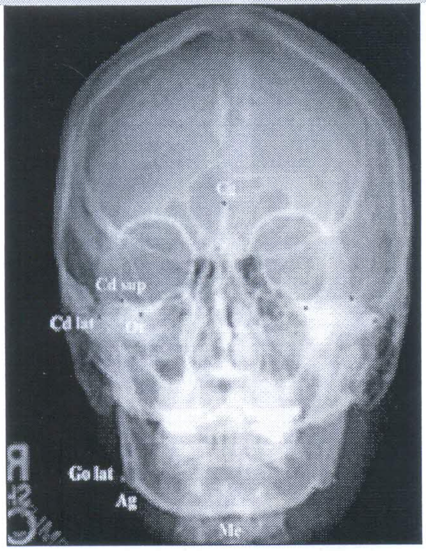
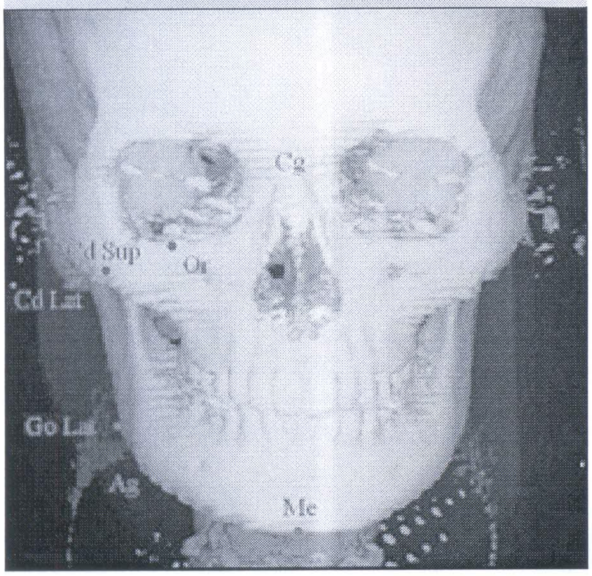
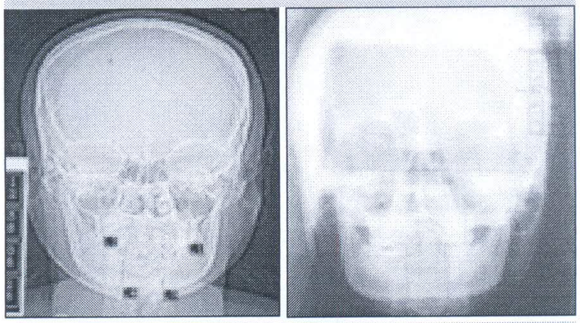


Fig -4 Landmarks used for Assessment of facial asymmetry in the 3D CT image

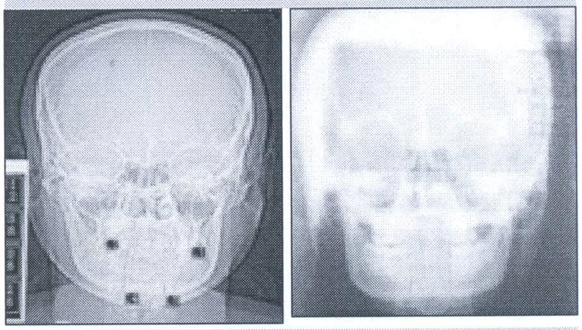


1. Cg - Crista galli
2. Or - Orbitale
3. Cd sup - Condylion superius
4. Cd lat - Condylion lateralis
5. Go lat - Gonion lateralis
6. Ag - Antegonion
7. Me - Menton

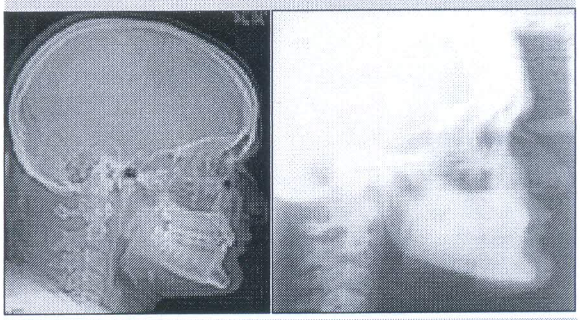
(a) (b)
Fig 5: Measurement of Maxillary height in CT (a) and PA Ceph (b)



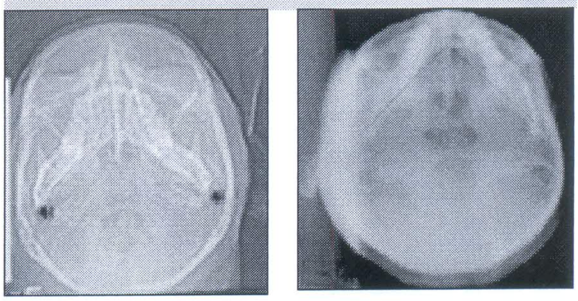
(a) (b)
Fig 6: Measurement of Mandibular height in CT (a) and PA Ceph (b)



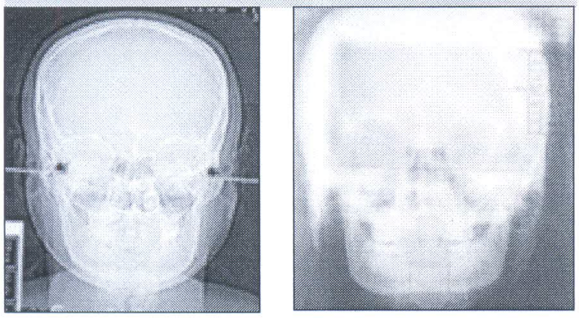
(a) (b)
Fig 7: Measurement of Ramal Length body in CT (a) and PA Ceph (b)



(a) (b)
Fig 8: Measurement of Mandibular in CT (a) and PA Ceph (b) body in CT (a) and PA Ceph (b)



(a) (b)
Fig 9: Measurement of Frontal Ramal Inclination in CT (a) and PA Ceph (b)



(a) (b)
Fig 10:Measurement of Lateral Ramal Inclination in CT (a) and PA Ceph (b)

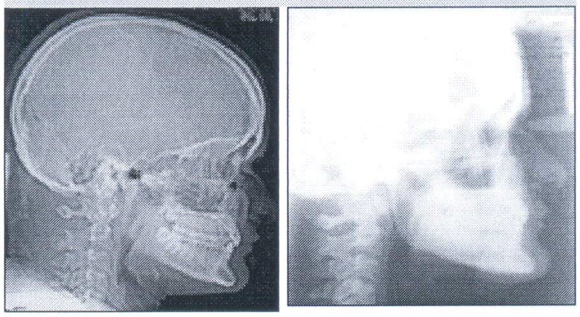


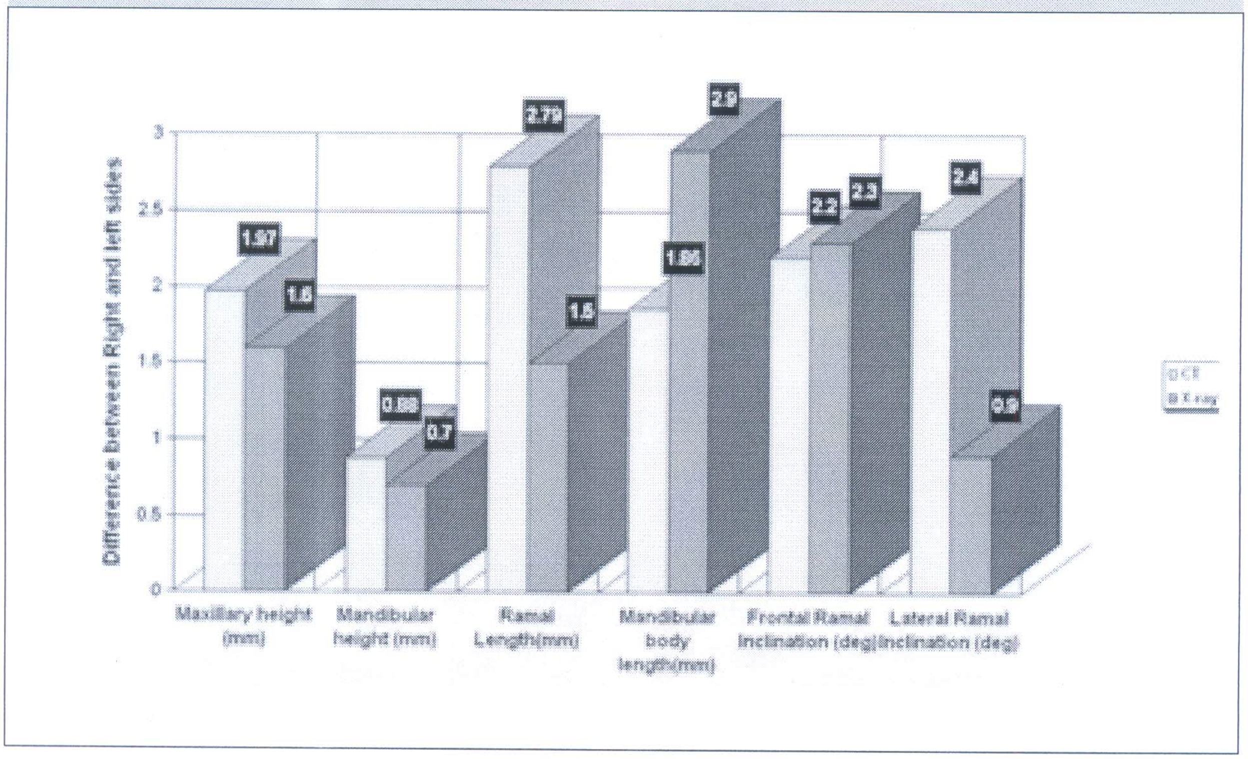
Table I: Parameters used to assess the facial asymmetry

	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 offoramen 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.

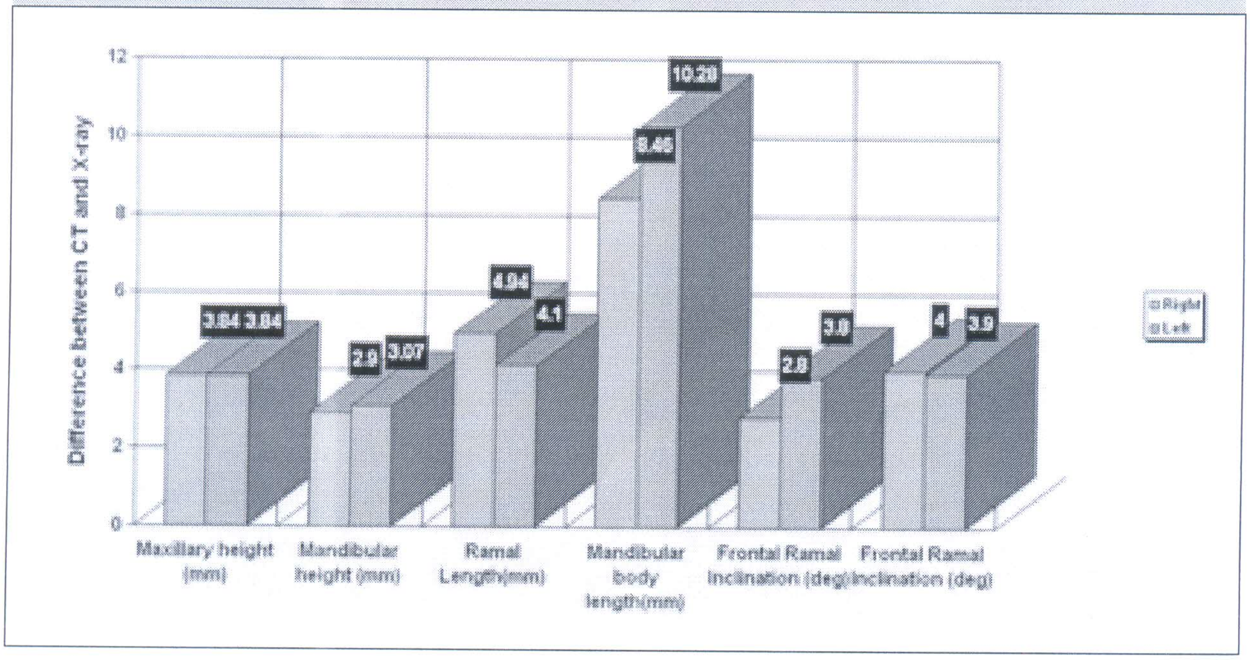
Table II: Comparison of the differences in various parameters between Right and left sides in 3D CT and conventional radiographic measurements (+ indicates P value ≤ 0.05)

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+

Graph-I: Comparison of the differences in the various parameters Between right and left sides in 3D CT and conventional Radiographic measurements



Graph-II: Comparison of difference of measurement between 3D CT and conventional radiograph for the difference of left And right side



more accurate information. By observing and accurately gauging the factors that contribute to mandibular asymmetry, 3D imaging analysis will enable us to comprehend its cause more accurately.

The present study found that the mandibular 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.

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Fig 1: Rotagraph plus Panceph Machine on which the PA ceph, Lateral ceph and Submentovertex view radiographs were taken.

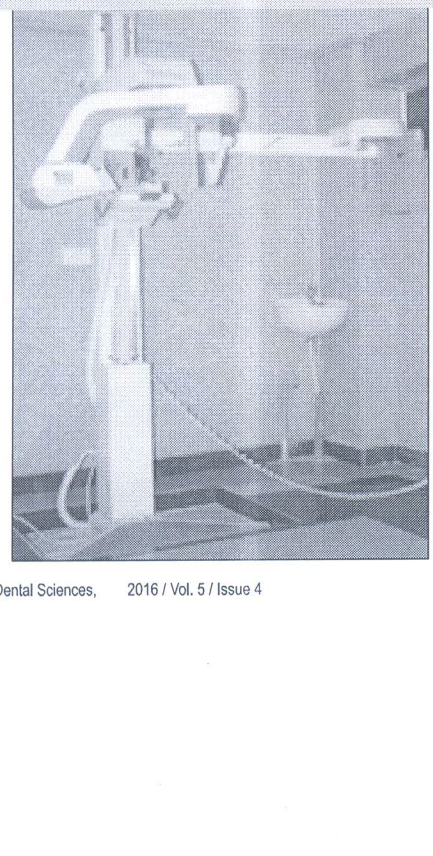

Fig 2: X vision GX machine on which the spiral 3D Computed tomographic images were taken