ROLE OF CT IN THE EVALUATION OF SAFE TRAJECTORY FOR THE PLACEMENT OF TRANSARTICULAR FACET SCREWS IN SUBAXIAL CERVICAL SPINE

DISSERTATION SUBMITTED TO

THE TAMILNADU DR.M.G.R MEDICAL UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF

MASTER OF CHIRURGIE - BRANCH II

NEUROSURGERY – 5 YEARS

AUGUST 2013

MADURAI MEDICAL COLLEGE, MADURAI

THE TAMILNADU DR.M.G.R. MEDICAL UNIVERSITY

CHENNAI TAMILNADU

CERTIFICATE

This is to certify that this dissertation entitled submitted by **Dr.N.Arunkumar** to the faculty of Neurosurgery, The Tamil Nadu Dr. M.G.R. Medical University, Chennai, in partial fulfilment of the requirement in the award of degree of **MASTER OF CHIRURGIE IN NEURO SURGERY**, **Branch – II**, for the **August 2013** examination is a bonafide research work carried out by him under our direct supervision and guidance.

DEAN
Madurai Medical College
Madurai

Prof.N.Muthukumar,M.Ch.
Professor and Head of Department
Department of Neurosurgery
Madurai Medical College
Madurai,Tamilnadu

DECLARATION

I, **Dr.N.Arunkumar** solemnly declare that the dissertation titled **"ROLE OF CT IN THE EVALUATION OF SAFE TRAJECTORY FOR THE PLACEMENT OF TRANSARTICULAR FACET SCREWS IN SUBAXIAL CERVICAL SPINE"** has been prepared by me under supervision of Professor and HOD, Department of Neurosurgery, Madurai Medical College and Government Rajaji Hospital, Madurai between 2010 and 2013.

This is submitted to The Tamil Nadu Dr. M.G.R. Medical University, Chennai, in partial fulfillment of the requirement for the award of **MASTER OF CHIRURGIE, M.Ch., NEUROSURGERY,** degree examination to be held in **AUGUST 2013.**

Place : Madurai

Date : **DR.N.ARUNKUMAR**

ACKNOWLEDGEMENT

I thank with gratitude The Dean, Government Rajaji Hospital, Madurai Medical College, Madurai for permitting me to utilize the clinical materials of this hospital.

At the very outset I express my sincere gratitude to **Prof.N.Muthukumar**, Professor and Head of the Department of Neurosurgery, Government Rajaji Hospital, Madurai for his great kindness, inspiration and valuable suggestion throughout the period of my dissertation.

I am extremely grateful to **Prof.M.Sundararajan** and **Prof.R.Veerapandian** for their academic assistance and consistent encouragement. I am indebted to the sincere compliments and enthusiasm rendered by all my assistant professors, Department of Neurosurgery.

My immense thanks to **Prof.N.Sundari** Professor and Head of the Department of Radiology, for kindly permitting me to use their resources. I hereby record my sincere gratitude to all the staff of the Department of Radiology, Government Rajaji Hospital, Madurai.

I thank my colleagues, family, friends and well wishers for their unequivocal support they gave me during this process.

I owe my prayers to The Lord, who gave me the inner strength to complete this work.

CONTENTS

INTRODUCTION

Various techniques have been developed for the fixation of the subaxial cervical spine. Few decades earlier, older methods such as inter spinous wiring and facet to spinous wiring were in use, but intact posterior elements and prolonged external immobilisation were inevitable for these techniques.

In addition many biomechanical studies proved that they may not provide the sufficient stabilization and immobilisation of the sub axial cervical spine.

To overcome these, novel techniques have evolved; they are lateral mass screws fixation and pedicle screws fixation.

Various lateral mass screw techniques have been developed by Roy-Camille, Magerl, Seemann and others. They are biomechanically superior to older wiring techniques, but with increased chance of injury to the vertebral artery and to the nerve roots.

Pedicle screws fixation which provides three column stability requires great skill for inserting the screws and there is a high risk benefit ratio.

Congenital anomaly, previous surgery or abnormal morphological characters of the cervical spine may limit the use of both pedicle and lateral mass screw fixation.

Transarticular facet screws fixation technique has been used as an alternative technique to achieve posterior cervical spine stability. Transarticular facet screws were used by Magerl and Seeman for fixing the atlanto axial joint which was biomechanically superior to any other technique and achieved excellent stabilisation. But it is a technically demanding procedure because of increased risk of injury to the vertebral artery and the complex anatomy of the atlanto axial joint.

In 1972, Roy Camille was the first to describe the use of transarticular screws for the subaxial cervical spine for fixation of the facets in case of lateral mass fractures.

Klekamp et al proved that the biomechanical strength of transarticular facetal screws were superior to lateral mass screws because it provides greater pull out strength due to four cortical layer purchase, when compared to the lateral mass screw fixation where only two layer of cortical purchase is achieved.

Despite these advantages, transarticular facet screws are not routinely used by neurosurgeons. This is due to unfamiliarity about the trajectory for placing the screws.

Many techniques have been evolved for placement of the transarticular facet screws in a safe trajectory in the sub axial cervical spine such as Takayasu, Dalcanto, Klekamp, Miyanji etc. Each technique has its own merits and demerits.

To the best of my knowledge, only a few studies are available regarding the placement of transarticular facets screws in a safe trajectory; that too, these studies are found in foreign literature. This study is an attempt to analyze the role of CT in the evaluation of a safe trajectory for the placement of transarticular facet screws in the subaxial cervical spine in patients who were under treatment in MADURAI MEDICAL COLLEGE & GOVERNMENT RAJAJI HOSPITAL, MADURAI.

AIMS & OBJECTIVES

- To determine the length and angle of safe trajectory for placing transarticular facet screws at each sub axial cervical spine level using CT cervical spine in our population.
- To define the insertion point for transarticular facet screws.

REVIEW OF LITERATURE

The posterior cervical spine instrumentation was first described by Berthold Earnest Hadra in 1891. He used silver wire around the spinous processes of the cervical spine to achieve stabilisation. Hadra treated spine fractures, deformities of spine such as scoliosis, kyphosis and Pott's spine with this technique[13.]

In1911, Hibbs described the fusion of the cervical spine. Hibbs' method of solid bony arthrodesis brought about a revolution in the field of spine surgery. [14]

Over the past decade, increased knowledge about the spinal column has resulted in the development of newer techniques for various instrumentation.

The main aim of posterior cervical instrumentation is to provide adequate stability, to achieve excellent fusion and early mobilization of the patient.

Now, various techniques of posterior cervical instrumentation have evolved which impart better stability to the sub axial cervical spine.[1]

Posterior cervical spine instrumentation may be warranted in several conditions

Such as

- ❖ Traumatic fractures
- ❖ Degenerative cervical spine disease such as OPLL, cervical spondylotic myelopathy
- ❖ Inflammatory conditions such as rheumatoid arthritis, ankylosis spondylosis
- ❖ Congenital malformations of the spine
- ❖ Neoplasms
- ❖ Infections such as Pott's spine and other osteomyelitis of spine [1]

The main indication for posterior cervical spine instrumentation is cervical spine instability. Injury or destruction to bony structures such as vertebral body, disc, laminae, spinous process, lateral masses and other ligaments may produce instability.

Techniques of posterior cervical instrumentations are

- ➢ Inter spinous Wiring
    - ❖ Rogers technique
    - ❖ Bohlman triple wiring technique
    - ❖ Dewar technique
    - ❖ Robinsons technique

- Sub laminar wiring

- Hooks and clamp system
    - Cervical laminar hooks
    - Interlaminar or Halifax clamp system
- Screws fixation technique
    - Lateral mass screws and plates fixation
    - Lateral mass screws and rod fixation
    - Cervical transpedicular screws fixation technique.[1]

Interspinous wiring technique was first described by Roger in 1941 by treating cervical spine fractures with the help of wiring. Bohlman triple wiring technique (inter spinous wiring along with two additional wires to hold the graft), Dewar technique (tension band inter spinous wiring), Robinson's technique (facet wiring) and sub laminar wiring which were in practice earlier, were simple but these older methods didn't provide adequate stabilisation and rigid immobilisation for longer periods. Osteoporotic bone is not well suited for this technique.

Interlaminar clamps and hooks:

Halifax inter laminar clamp was first used by Tucker for atlantoaxial joint in 1975.It is also used for the sub axial cervical spine. Posterior elements are to be intact for this procedure. However it is not useful for multilevel fusion. It can also cause injury to spinal cord by its secondary effect of canal narrowing. It has two clamps –rostral clamp (threaded) applied over upper laminae and caudal clamp (none threaded) applied over caudal laminae .[1]

Next to wiring techniques, newer techniques were developed to overcome these obstacles. They were lateral mass screws fixation (LMSF) and pedicle screw fixation (PSF) techniques .[1]

In 1964, lateral mass screw fixation was first described by Roy-Camille and since then numerous refinements have been made.

Various techniques used for lateral mass are

- Roy Camille
- Magerl
- Jeannert
- An and Gordon

Each technique has a different entry point and a different trajectory for the placing the lateral mass screw (LMS). Initially lateral mass screws plate system was developed, which had predetermined holes in the plates. It was difficult in placing the screws along with the plates in conditions such as spinal anomalies, trauma, and severe degenerative changes where normal anatomy would be altered. When screws are not in line with the plates, it is necessary to skip that level. Giving distraction can lead to foraminal stenosis which may lead to radiculopathy. To avoid these difficulties lateral mass screws with rods were developed.

Usually polyaxial screws of diameter ranging from 3.5 to 4 mm and length of screws used are 16 mm.[1] Usually C3 to C6 lateral mass fixation can be done easily but it is difficult to place the lateral mass in C7 because of the thin and oblique lateral mass.

Jeannert and Magerl described a technique of insertion that maximizes the length of the screw while directing it away from the nerve root and vertebral artery.

Some authors have suggested that bicortical purchase may be dangerous because of the proximity of the nerve root and vertebral artery.[1]

The technique of transpedicular screw placement in the subaxial traumatic instability spine was first described by Abumi and colleagues in 1994.

Stabilization and resistance to screw pullout were equivalent to lateral mass screws technique which was proved by many biomechanical studies in animal and cadaveric spines. Trans pedicular screws can be applied to C3-C6. The entry point for pedicle screws is just lateral to midpoint of the lateral mass and just caudal to the articular line with a trajectory of 25 degree - 45 degree medially in the axial plane and parallel to the superior end plate of the vertebra in the sagittal plane.

Trans pedicular screws are usually applied for C7 pedicle rather than C3-C6 because the lateral mass of C7 is small and thin, the diameter of the pedicle is larger and the vertebral artery is away from the site of screw entry.[12]Insertion is thought to be technically more difficult and associated with more potential risks to neurovascular structures than the insertion of lateral mass screws.

Despite it's biomechanical strength, certain conditions such as trauma, tumour, congenital anomalies which alter the normal morphology of the spine, may limit the usage of these pedicle screws and lateral mass screws. It is also difficult to place lateral mass screws and pedicle screws where the normal bony anatomic landmarks have been significantly altered by previous surgery and superimposed degenerative processes.

Transarticular facet screws (TAFS) is one of the alternative techniques for posterior subaxial cervical spine fixation. Transarticular facet screws (TAFS) fixation techniques developed by Magerl and Seeman for the atlanto-axial joint have shown excellent results and are biomechanically superior to others.[5]

In 1972, Roy Camille and Sailliant were the first to use the TAFS for the sub axial cervical spine for fixing the facets in cases of lateral mass fractures [6]. They used the same entry point which they used for lateral mass with a different trajectory.

Transfacet screws have been used for fixation of the lumbar spine. Many biomechanical studies have proved that it provides excellent stabilization of the spine particularly in extension and fusion rates of 94%.[31]

Volk man et al also proved that the trans laminar facets screw fixation provided excellent stabilisation and motion stiffness in extension. [35]

In 2000 Klekamp et al and Ugbo et al conducted a study in ten fresh cadaveric spines. After exposing the lateral mass of sub axial cervical spine from C2 to C7, lateral mass screws were inserted with entry point of one mm medial to centre point of lateral mass and with trajectory of 20 degree cranial and 25 degree lateral position. With the same entry point transarticular screws were inserted with a trajectory of 40 degree sagittal angle to the facet joint surface and 20 degree of lateral angle. After inserting the screws a device was fit around the screws and was used to pull out each screw .It was proved that 360 N mean to load failure was needed to pullout the lateral mass screws but the mean load to failure for transfacet screws was 470 N. The pullout strength values for transfacet screws were significantly greater when compared to lateral mass screws.

Jones et al who proved by his study that the mean to load failure for lateral mass screws is 349 N.[3]

Heller et al also proved in his study the mean to load failure of LMS is around 356 N. [32-34] Mean to load failure value of lateral mass screws proved by Klekamp is well correlated and it is consistent with the literature.

Transarticular facet screw has greater pull out strength than the lateral mass screw because the former has four cortical layer purchases when compared to the lateral mass screw which has only two layer cortical purchase[3]. Screw with four layer of cortical purchase means the posterior aspect of lateral mass, subchondral bone of both articular process and the anterior aspect of the caudal lateral mass.

Anatomy of cervical facet joints:

Facet joints are diarthroidal joints formed by the articulation of the inferior articular facet of the superior vertebrae and the superior articular facet of the inferior vertebrae. Otherwise they are known as apophyseal or Zygapophyseal joints. Facet joints are synovial joints of the spine .They are covered by a connective tissue capsule lined by synovial membrane which secretes synovial fluid which nourishes the joint. The joints are lined by hyaline cartilage which is thicker in the centre of the joint and thinner in the periphery of the joint which also helps in the movement of the joints smoothly.[30]

Orientation of cervical facets joints:

Pal et al, in his study proved that the orientation of cervical facet joints varies. Facets face postero- superiorly in most of third and fourth cervical vertebrae, facets in sixth and seventh cervical vertebrae face postero- laterally. So transition of orientation of facet joints occurs probably at C5. These findings are quite contradictory to the study by Panjabi et al where most of the cervical facet joints are strictly of coronal orientation and transition of orientation of facet joints occurs at the cervico thoracic junction. But the above findings were consistent with the study by Tulsi et al.[29, 40]

The superior articular facets face backwards and upwards and inferior articular facets face anteriorly and forwards. The articular surface of the superior articular facet is flat and the articular surface of the inferior articular facet is concave and forms an arch to hold the joint. Due to this orientation, rotational and lateral bending movements of the spine are possible.

According to pal et al, around 20-25% weight was carried by the facet joint when axial compressive load was applied .Weight carried by the facet joints in the cervical region is transmitted to the vertebral body at the thoracic region. [29, 30]

Pal et al conducted another study where he measured the sagittal and axial angle of inclination of the superior articular facet at each level.[29]

The sagittal angle of inclination of the superior articular facets is gradually increased from 69 degree to 94 degree on the right side and from 71 degree to 99.35 degree on the left side. [29]

Level	Sagittal angle of inclination (0°) Mean ± S.D	
	Right side	Left side
C3	68.59 ± 6.9	70.5 ± 6.9
C4	80.46 ± 9.67	81.9 ± 10.11
C5	90.9 ± 11.01	90.9 ± 11.11
C6	95.78 ± 10.52	94.94 ± 10.06
C7	93.53 ± 7.11	99.35 ± 5.61

The axial angle of inclination of superior articular facet also gradually progresses from 45 degree to 65 degree on the right side and 47 degree to 64 degree on the left side .[29]

Level	Axial angle of inclination (0°) Mean ±S.D	
	Right side	Left side
C3	44.79 ± 9.47	46.79 ±7.59
C4	49.99 ± 8.01	51.00 ±7.70
C5	51.07 ± 6.71	53.63 ±7.09
C6	55.83 ± 8.02	56.39 ± 8.79
C7	65.30 ±7.40	64.09 ± 6.41

Important biomechanical functions of the cervical facet joints are

- They help in transmitting 20-25 % body weight
- Prevent joint distraction
- Provide resistance to shear
- Prevent anterior-posterior, lateral vertebral translation
- Finally they also provide torsion stress.[30]

In 2005 Dalcanto et al conducted a study for comparison of transfacet screw fixation with lateral mass screw fixation in 13 cadaveric spines exposed from C2-C7. Both lateral mass and trans facet screws were placed. cervical range of movements were tested in flexion, extension, lateral bending ,torsion under the load of two NM. He proved that the lateral mass screw fixation (LMSF) and TAFS fixation at two levels were equivalent and found that both fixation system had reduced range of motion along with increased stiffness in flexion ,extension, torsion and lateral flexion.[11]

Sung Kim et al conducted a study where he compared anterior cervical discectomy with facet screw fixation, transpedicular screw fixation, and anterior cervical discectomy with posterior wiring technique. He proved that anterior cervical discectomy with facet screw fixation is biomechanically superior than the other two.[36]

Uygur et al in his study had done transarticular screw fixation for traumatic spine injury with bilateral locked facet. After reduction of the locked facet and decompression of the cervical spine, transarticular screw fixation gave excellent result.[37]

In 2011, Liu et al had undertaken a cadaveric study where they chose an entry point, which was one mm medial to the centre point of the lateral mass similar to that of Klekamp technique with the exit point at the junction of the transverse process and the facet joint. They used 3.5 mm cortical screws with thirty mm length. Transarticular facet screws were inserted under direct vision to avoid damage to the nerve roots. CT of the cervical spine was taken with two mm thickness. A total of 162 screws were inserted from C2-C3 to C5- C6 .From the CT scan images ,the medio lateral angle and sagittal angle were measured .They were 16.9° ± 4.3° and 37.1° ± 4.9° respectively. The average bony purchase was 18.4 ± 1.7mm.In this study, the length of the screws used at C2-C3 was longer than those used at C5-C6.[39]

Miyanji et al also proved by biomechanical study that transfacet screws and lateral mass screws provide similar stabilization of the cervical spine in all ranges of motion .[26]

Yu poo lee et al in 2010 conducted another study where he proved that multiple anterior cervical discectomy was associated with increased pseudoarthrosis and in order to prevent that, posterior cervical fusion is necessary[10]. Though posterior cervical fusion by lateral mass screw fixation is a safe method to achieve excellent stabilization, it needs open midline approach, which requires extensive dissection and prolonged retraction of paraspinal muscles .[19-22]Damage to the para spinal muscles occurs due to detachment of the muscles from the spinous processes and laminae and also prolonged retraction by self retaining retractors[23-25]. Histological studies of muscles taken from open midline approach showed muscle ischemia and necrosis which is seen in compartment syndrome. Apart from this, open midline approach carries high morbidity, high infection rate, post-operative pain, injury to the cervical musculature and blood loss.[15-18] To avoid morbidity, minimally invasive technique is being used in posterior cervical instrumentation.

Minimal invasive surgery (MIS) has now become a popular one.

Advantages of MIS are

- Quicker recovery
- Low infection rate
- Small skin incision
- Decreased intra operative blood loss
- Lesser morbidity
- Minimal post operative pain .[15-18]

Disadvantage of MIS are

- Minimal exposure of normal anatomy
- Lesser degree of orientation .[15-18]

In spite of the advantages of minimally invasive surgery, till now there is no specific minimally invasive method of posterior instrumentation for the sub axial cervical spine.

TAFS can be placed safely by the percutaneous method when compared to the lateral mass screws so that we can minimise the soft tissue injury, decrease intra operative blood loss and decrease post operative pain.

Ahmed et al in 2012, in his study used minimally invasive technique for percutaneous placement of TAFS with help of the cortical screws used for orthopaedic indications. He also stated that rods and plates needed in lateral mass technique can be avoided by using TAFS.[38] With recent inventions such as navigation and image guidance, it is very easy to place the trans facet screw in the sub axial cervical spine.

Transarticular screw fixation techniques are not being popularly used by neurosurgeons due to unfamiliarity with the trajectory. To overcome these obstacles recently various techniques have been developed for passing the transarticular facet screws similar to that of lateral mass screws.

Various techniques for placing the TAFS in safe trajectory are

- Takayasu technique
- Dalcanto technique
- Klekamp technique
- Miyanji technique

All these techniques vary in their entry point and trajectory for placing the screws.

TAKAYASU technique[2]_

Entry point is between the superior and the median third of vertical midline and trajectory passes 60 degree to 80 degree caudal with zero degree lateral.

DALCANTO technique[7]_

Entry point is two mm distal and one mm to centre point of lateral mass and trajectory passes 20 degree to forty degree caudal and twenty degree lateral.

KLEKAMP technique[3] –

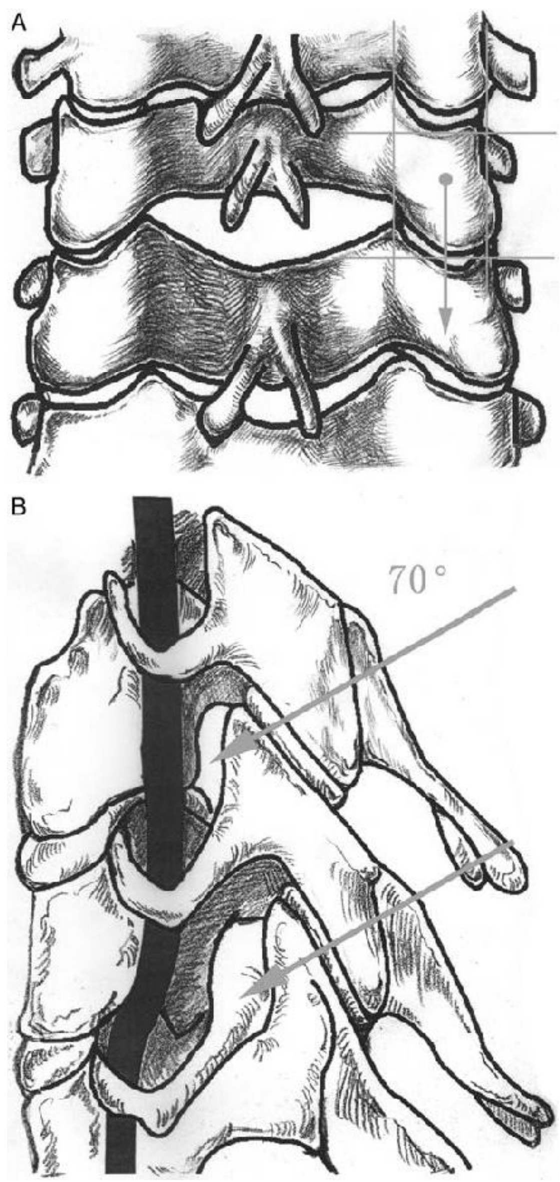
Entry point is two mm caudal and one mm medial to the centre point of lateral mass and trajectory passes forty degree caudal and twenty degree lateral.

MIYANJI technique[26]-

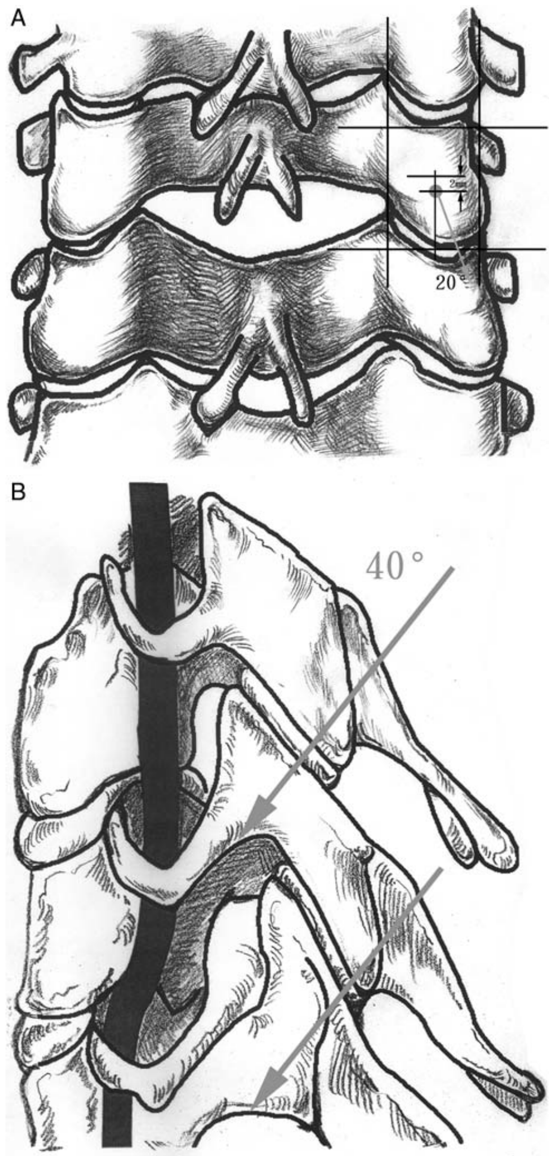
Entry point is the centre point of lateral mass and trajectory passes perpendicular to the facet joint and five degree lateral.

Of these techniques most commonly used ones are Takayasu and Dalcanto.

TAKAYASU technique [2]– Entry point is between the superior and the median third of vertical midline and trajectory passes sixty degree to eighty degree caudal with zero degree lateral



Dal Canto technique [7]– Entry point is two mm distal to midpoint of lateral mass and trajectory passes twenty degree to forty degree caudal and 20 degree lateral



Most common complications encountered during the implantation of transarticular facet screws are

- Facet fractures
- Injury to the vertebral artery
- Injury to the cervical nerve roots
- Screws that failed to pass through the facets .[4]

According to Liujun Zhao et al, [4,8] he compared the Takayasu technique and Dalcanto technique in eight cadaveric spines. Totally 64 screws were implanted, 32 screws by Takayasu technique and 32 screws by Dalcanto technique. All the screws were inserted under fluoroscopic guidance. Tip of the screws used were four mm just anterior to the lateral mass. Lengths of the screws were measured by sliding caliper by the radiologist.

Analyzing the result of this study, complications such as lateral mass fracture / facet splitting was mostly seen in Dalcanto technique. There were ten facets fracture (31.3 percentages) noted. Of these there was complete breakage in eight facets and partial breakage noted in two facets. In particular inferior border fracture accounts for 21.9% and lateral border fracture for 9.4%. No facet fracture was noted in Takayasu technique. No superior facet splitting was noted in both techniques. This difference in facet fracture in both the techniques is due to the entry point and trajectory used to pass the screws. In Dalcanto technique, insertion point is two mm caudal to the centre point of lateral mass and with oblique trajectory when compared to Takayasu technique.[8] Another technique described by Miyanji, where the entry point is the centre of lateral mass and trajectory is nearly perpendicular to the facet joint with 5 degree lateral angle similar to that of Takayasu technique, resulted in no facet fracture.[26]

Injury to the vertebral artery :

Vertebral artery injury seems to be associated with Takayasu technique nearly at six sites, and is commonly seen at C5 –C6 level and C6-C7 level. No incidence of vertebral artery injury was noted in Dalcanto technique.

Injury to the anterior cervical roots :

Spinal nerve root divides into a large anterior root and a small posterior root. Injury to the anterior cervical roots is commonly seen in Takayasu technique and nearly seven roots were involved in this study.

Injury to the vertebral artery and the cervical nerve rootS is commonly seen in Takayasu technique because of straight trajectory. In this study tip of the screw reaches four mm beyond the ventral cortex of the lateral mass which is responsible for injury of the vertebral artery and nerve roots .[8]

Xu et al also proved that by using Dalcanto technique with oblique trajectory, the exit point is between the anterior border of lateral mass and posterior tubercle of transverse process so that there is lesser incidence of vertebral artery injury and cervical nerve roots injury .[27]

Screws that failed to pass through the facet :

Only one screw failed to pass through the facet in Takayasu technique due to faulty implantation technique but no screws failed to pass through in Dalcanto technique.

COMPLICATIONS OF TAFS :

Complications	Takayasu %	Dalcanto %
Facet fracture	0	31.9
Vertebral artery injury	18	0
Injury to cervical nerve rootS	21	0
Screws failed to pass through facet	2	0

In 2003 MASAKAZU TAKAYASU et al, clinically conducted a study in 25 patients with age range from 15 to 84 years, in whom a total of 81 screws were inserted under fluoroscopic guidance. No incidence of injury to the vertebral artery and cervical nerve roots was noted. He used 1 mm pitch so that there was no chance of injury to the vertebral artery and nerve roots. He also used the transarticular screws for anchoring purposes in osteoporotic bone. On regular follow up ranging five months to two years, there was no screw loosening or screw back out confirmed by radiology and fusion was achieved in all cases.[2]

Takayasu also stated the advantages of transarticular screws. They are

a) In certain conditions such as trauma and cervical spondylotic myelopathy changes when there is a need for posterior decompression procedures such as laminectomy and laminoplasty, it is difficult to place the lateral mass screw due to alteration of mediolateral trajectory. So TAFS can be placed safely in these situations.

b) It can be used as an anchoring screw for posterior cervical spine fixation and also for facet fixation.

DISADVANTAGES :

a) When we are using the transfacet screws as anchoring, one more level of fixation of cervical spine is needed.

b) It is difficult to place the transfacet screws at C2-C3 level due to interference of occipital bone prominence.[2]

MATERIALS AND METHODS

Totally 31 patients were included in my study, who underwent high resolution CT of the cervical spine for evaluation of neck pain, either due to trauma or degenerative process. The study was conducted in the Department of Neurosurgery and the Department of Radiology during the period of 2011 -2012.

INCLUSION CRITERIA:

- Age greater than 18 years with informed consent to participate in the study,
- CT cervical spine done for evaluation of neck pain .
- CT Cervical spine done as a pre-operative evaluation for patients with cervical spine pathology.

EXCLUSION CRITERIA:

- Patient's refusal to participate in the study
- Patients with severe spondylotic changes
- Patients with inflammatory changes
- Patients with cervical spine fractures

- Patients with cervical spine dislocations
- Pregnant patients

Transarticular facet screws (TAFS) insertion is one of the alternative techniques for the stabilisation of the subaxial cervical spine. However, the usage of transarticular facet screws in the subaxial cervical spine is not a quotidian one and the main reason for this is the strangeness with the trajectory. In this study my principal aim is to define the insertion point, angle of safe trajectory and the length of the screw in the subaxial cervical spine.

High resolution CT cervical spine with one mm cuts along with **dicom viewer osirix** on an **Apple macintosh computer** for the reconstruction of cervical spine was used and evaluated for safe placement of transarticular screw in the subaxial cervical spine (C2–3, C3–4, C4–5, C5–6, and C6–7) facet joints.

The entry point used was 3 mm above in a vertical midline to the centre point of lateral mass, which is similar to Takayasu technique. Exit point used in my study was ventral aspect of caudal lateral mass. From that entry point which has been defined, the sagittal angulations were set to traverse the facet joint plane near perpendicularly.

DEFINTION OF THE SAGITTAL ANGLE*:*

The **sagittal angle** was defined as the sagittal projection of the facet joint surface.

DEFINTION OF THE SCREW LENGTH:

Screw or **Trajectory length** was defined as the distance from entry point to exit point and is measured in the sagittal plane.

With these parameters, ideal insertion angles and screw lengths were identified.

The information collected regarding all the cases were registered in the master chart. Data analysis was done with computer using EPIDEMIOLOGICAL INFORMATION PACKAGE (EPI 2002).

Using this software minimum, maximum, range, median, mean and standard deviation, Mean difference, standard error difference, 95% confidence interval, p –value by student t -test were calculated at each level of the sub axial cervical spine on both sides for all patients.

RESULTS

This study was conducted at the Department of Neurosurgery & Department of Radiology of GOVERNMENT RAJAJI HOSPITAL & MADURAI MEDICAL COLLEGE, MADURAI, during the period of 2011-2012.

In my study, the entry point used was 3 mm above in a vertical midline to the centre point of lateral mass. Exit point was the ventral aspect of caudal lateral mass.

Length of the screws was defined as distance from entry point to exit point. This was measured at each level (C2-C3, C3-C4, C4-C5, and C5-C6) on both sides for 31 patients.

Sagittal angle -The **sagittal angle** was measured as the sagittal projection of the facet joint surface as it passes through the posterior aspect of lateral mass, subchondral bone of both articular processes and ventral aspect of the caudal lateral mass at each level (C2-C3,C3-C4,C4-C5,C5-C6) on both sides for 31 patients .

In this study, minimum, maximum, range, median, mean and standard deviation, mean difference, standard error difference, 95% confidence interval, p –value by student t -test were calculated at each level of the sub axial cervical spine on both sides for all patients.

SEX DISTRIBUTION:

In my study, out of a total of 31 patients, 22 were males and 9 were females.

In my study, I compared the length of the screws and sagittal angle at each sub axial spine level between both the sexes. M: F ratio was 2.5:1.

	Frequency	Percent
Male	22	71
Female	9	29
Total	31	100

AGE DISTRIBUTION:

In this study, the lowest age was 21 years and highest age was 65 years . The mean age was 36.87 with a standard deviation of 11.65. (Mean age was 37$\pm$ 12 years).

Age	Number of patients	Range	Minimum	Maximum	Mean	Standard deviation
	31	44	21	65	36.87	11.65

Among males, minimum age was 21 years and maximum age was 65 years.

Among females, minimum age was 31 years and maximum age was 50 years.

The length of the screws was measured from CT for placing transarticular facet screws on the right side facet joints in males. The measured screw length gradually increased from C2-C3 level (13.46 ± 2.21 mm) to C6-7 level (16.14 ± 1.75 mm).

But the mean value of screw length at C3-C4 is slightly lower than C2-C3.

The median value of screw length also increased from 13.2 mm to 16.35 mm .

Measured Screw length(mm) in the right facet joint in males						
Level	Minimum	Maximum	Range	Median	Mean	Standard Deviation
C2-C3	10.6	19.6	9.0	13.2	13.46	2.21
C3-C4	9.5	16.4	6.9	13.3	13.07	1.82
C4-C5	11.6	17.2	5.6	13.4	13.66	1.56
C5-C6	12	18	6	14	14.14	1.78
C6-C7	12	20	8	16.35	16.14	1.75

The length of the screws was measured from CT for placing transarticular facet screws on the right side facet joints in females. The measured screw length gradually increased from C2-C3 level (13.23 ± 1.66 mm) to C6-7 level (15.51 ± 1.76 mm).

The median value of screw length also increased from 13.1mm to 15.70 mm.

Measured Screw length (mm) in the right facet joints in females						
Level	Minimum	Maximum	Range	Median	Mean	Standard Deviation
C2-C3	10.5	15.6	5.1	13.1	13.23	1.66
C3-C4	11.7	17.5	5.8	14.4	14.07	1.77
C4-C5	12	18.6	6.6	13.6	14.52	2.45
C5-C6	10	17	6	14.60	14.52	2.12
C6-C7	12	18	5	15.70	15.51	1.76

The length of the screws was measured from CT for placing transarticular facet screws on the left side facet joints in males. The measured screw length gradually increased from C2-C3 level (13.67 ± 1.46 mm) to C6-7 level (17.10 ± 2.72 mm).

But the mean value of screw length at C6-C7 was higher on the left than on the right side.

The median value of screw length also increased from 13.85 mm to 17.25mm.

Measured Screw length (mm) in the left facet joints in males						
Level	Minimum	Maximum	Range	Median	Mean	Standard Deviation
C2-C3	10.2	16.5	6.3	13.85	13.67	1.46
C3-C4	10.1	16.1	6.0	13.65	13.71	1.56
C4-C5	10.8	15.9	5.1	13.55	13.57	1.43
C5-C6	11.3	18.7	7.4	14.55	14.73	1.87
C6-C7	11.2	23.4	12.2	17.25	17.10	2.72

The length of the screws was measured from CT for placing transarticular facet screws on the left side facet joints in females. The measured screw length gradually increased from C2-C3 level (13.78 ± 2.24 mm) to C6-7 level (17.91±3.17mm).

The median value of screw length also increased from 13 mm to 19.8 mm.

Measured Screw length (mm) in the left facet joints in females						
Level	Minimum	Maximum	Range	Median	Mean	Standard Deviation
C2-C3	11.2	17.3	6.1	13	13.78	2.24
C3-C4	12.2	16.1	3.9	14.6	14.55	1.40
C4-C5	12.3	16.9	4.6	14.2	14.22	1.39
C5-C6	11.3	16.3	5	14.8	14.22	1.75
C6-C7	10.7	20.2	9.5	19.8	17.91	3.17

Comparison of the measured screw length -right side facet joints of male with right side facets of the female and left side facet joints of the male with left side facets joints of female.

Group Statistics					
Cervical spine levels	Sex	No. of patients	Mean	Std. Deviation	Std. Error Mean
C2-C3 right facet	M	22	13.464	2.2122	.4716
	F	9	13.233	1.6628	.5543
C2-C3 left facet	M	22	13.677	1.4629	.3119
	F	9	13.789	2.2430	.7477
C3- C4 right facet	M	22	13.073	1.8208	.3882
	F	9	14.078	1.7747	.5916
C3- C4 left facet	M	22	13.714	1.5646	.3336
	F	9	14.556	1.4001	.4667
C4-C5 right facet	M	22	13.664	1.5640	.3335
	F	9	14.522	2.4596	.8199
C4-C5 left facet	M	22	13.573	1.4343	.3058
	F	9	14.222	1.3980	.4660
C5-C6 right facet	M	22	14.14	1.782	.380
	F	9	14.52	2.123	.708
C5-C6 left facet	M	22	14.736	1.8748	.3997
	F	9	14.222	1.7591	.5864
C6- C7right facet	M	22	16.14	1.735	.370
	F	9	15.51	1.761	.587
C6-C7 left facet	M	22	17.105	2.7265	.5813
	F	9	17.911	3.1703	1.0568

Cervical spine levels	t-test for Equality of Means					
	t	P -value	Mean Difference	Std. Error Difference	95% Confidence Interval	
					Lower	Upper
C2-C3 right facet	.280	**.781**	.2303	.8211	-1.4491	1.9097
C2-C3 left facet	-.165	**.870**	-.1116	.6782	-1.4986	1.2754
C3-C4 right facet	-1.405	**.171**	-1.0051	.7155	-2.4684	.4583
C3-C4 left facet	-1.399	**.172**	-.8419	.6018	-2.0728	.3890
C4-C5 right facet	-1.170	**.252**	-.8586	.7339	-2.3596	.6424
C4-C5 left facet	-1.152	**.259**	-.6495	.5636	-1.8022	.5032
C5- C6 right facet	-.518	**.608**	-.386	.745	-1.909	1.137
C5-C6 left facet	.705	**.487**	.5141	.7295	-.9778	2.0061
C6-C7 right facet	.907	**.372**	.625	.689	-.785	2.035
C6-C7 left facet	-.714	**.481**	-.8066	1.1300	-3.1177	1.5046

Comparing measured screw length of the right side facet joints of male with right facet joints of female and left side facet joints of male with left side facet joints of female there is no significant differences in values statistically.

The sagittal angle was measured from CT for placing transarticular facet screws on the right side facet joints in males.The measured sagittal angle gradually increased from C2-C3 level (77.75°±9.63°) to C6-C7 level (104.26° ± 8.84°)

The median value of the sagittal angle also increased from 77.75° to 99.75°.

Measured sagittal angle (^{0}) in the right facet joints in males						
Level	Minimum	Maximum	Range	Median	Mean	Standard Deviation
C2-C3	62.4	94.7	32.3	77.75	79.34	9.63
C3-C4	65.7	98.9	33.2	83.85	82.80	9.40
C4-C5	73.3	108.4	35.1	88.35	89.99	11.41
C5-C6	71.1	114.5	43.4	92.05	92.32	14.55
C6-C7	88.2	123.1	34.9	99.75	104.26	8.84

The sagittal angle was measured from CT for placing transarticular facet screws on the right side facet joints in females. The measured sagittal angle gradually increased from C2-C3 level (78.45°± 13.64°) to C6-7 level (97.86° ±11.04°).

The median value of sagittal angle also increased from 79.5° to 97.80°.

Measured sagittal angle (^{0}) in the right facet joints in females						
Level	Minimum	Maximum	Range	Median	Mean	Standard Deviation
C2-C3	61.5	106.4	44.9	79.5	78.45	13.64
C3-C4	71.3	104.7	33.4	89.90	85.65	11.26
C4-C5	66.3	118.2	51.9	90.10	87.25	15.06
C5-C6	63.9	112.2	48.3	91.30	87.77	14.76
C6-C7	78.8	110.2	31.4	97.80	97.86	11.04

The sagittal angle was measured from CT for placing transarticular facet screws on the left side facet joints in males. The measured sagittal angle gradually increased from C2-C3 level (81.33° ± 9.15°) to C6-C7 level (101.99°± 8.99°)

The median value of the sagittal angle also increased from 81.95° to 99.8°.

Measured sagittal angle (^{0}) in the left facet joints in males						
Level	Minimum	Maximum	Range	Median	Mean	Standard Deviation
C2-C3	66.9	101.1	34.2	81.95	81.33	9.15
C3-C4	65.3	99.3	34	87	86.71	8.32
C4-C5	73.2	102.8	29.6	89.65	89.45	8.46
C5-C6	65.4	107.6	42.2	94.4	91.89	11.05
C6-C7	90.3	121.1	30.8	99.8	101.99	8.99

The sagittal angle was measured from CT for placing transarticular facet screws on the left side facet joints in females. The measured sagittal angle gradually increased from C2-C3 level (81.80°± 9.43°) to C6-7 level (93.57° ± 9.26°)

The median value of sagittal angle also increased from 87.90° to 94.30°.

Measured sagittal angle (^{0}) in the left facet joints in females						
Level	Minimum	Maximum	Range	Median	Mean	Standard Deviation
C2-C3	68.9	92.6	23.7	87.90	81.80	9.43
C3-C4	69.4	91.8	22.4	78.20	80.25	7.85
C4-C5	68.3	104.3	36	79.20	83.84	11.38
C5-C6	69.2	108.2	39	84.50	87.3	14.79
C6-C7	82.3	104.7	22.4	94.30	93.57	9.26

Comparison of the measured sagittal angle- right side facet joints of male with right side facets of the female and left side facet joints of the male with left side facets joints of female.

Group Statistics					
Cervical spine levels	sex	No. of patients	Mean	Std. Deviation	Std. Error Mean
C2-C3 right facet	M	22	79.341	9.6383	2.0549
	F	9	78.456	13.6454	4.5485
C2-C3 left facet	M	22	81.336	9.1525	1.9513
	F	9	81.800	9.4372	3.1457
C3-C4 right facet	M	22	82.800	9.4049	2.0051
	F	9	85.656	11.2686	3.7562
C3-C4 left facet	M	22	86.714	8.3298	1.7759
	F	9	80.256	7.8505	2.6168
C4-C5 right facet	M	22	89.991	11.4106	2.4327
	F	9	87.256	15.0653	5.0218
C4-C5 left facet	M	22	89.455	8.4657	1.8049
	F	9	83.844	11.3878	3.7959
C5-C6 right facet	M	22	92.327	14.5587	3.1039
	F	9	87.778	14.7626	4.9209
C5-C6 left facet	M	22	91.891	11.0532	2.3565
	F	9	87.300	14.7906	4.9302
C6- C7 right facet	M	22	100.345	8.8494	1.8867
	F	9	97.867	11.0402	3.6801
C6-C7 left facet	M	22	101.991	8.9926	1.9172
	F	9	93.578	9.2693	3.0898

Cervical spine levels	t-test for Equality of Means					
	t	P - value	Mean Difference	Std. Error Difference	95% Confidence Interval	
					Lower	Upper
C2-C3 right facet	.205	**.839**	.8854	4.3098	-7.9291	9.6998
C2-C3 left facet	-.127	**.900**	-.4636	3.6529	-7.9347	7.0074
C3-C4 right facet	-.725	**.474**	-2.8560	3.9386	-10.9114	5.1994
C3-C4 left facet	1.990	**.056**	6.4581	3.2447	-.1782	13.0943
c4_c5right facet	.552	**.585**	2.7354	4.9562	-7.4013	12.8720
C4-C5 left facet	1.514	**.141**	5.6101	3.7049	-1.9673	13.1875
C5-C6 right facet	.787	**.438**	4.5495	5.7830	-7.2781	16.3771
C5-C6 left facet	.951	**.349**	4.5909	4.8270	-5.2814	14.4632
C6-C7 right facet	.659	**.515**	2.4788	3.7607	-5.2127	10.1703
C6-C7 left facet	2.344	**.535**	8.4131	3.5888	1.0733	15.7530

Comparing sagittal angle of the right side facet joints of male with right facet joints of female and left side facet joints of male with left side facet joints of female there is no significant differences in values statistically.

The screw length was measured from CT for placing transarticular facet screws on the right side facet joints in all patients. The measured screw length gradually increased from C2-C3 level (13.3±2.04 mm) to C6-7 level (15.95 ± 1.73mm)

The median value of the measured screw length also increased from 13.2 mm to 16.2 mm.

Measured screw length (mm) for the right facet joints in all patients						
Level	Minimum	Maximum	Range	Median	Mean	Standard Deviation
C2-C3	10.5	19.6	9.1	13.2	13.3	2.04
C3-C4	9.5	17.5	8.0	13.4	13.36	1.83
C4-C5	11.6	18.6	7	13.6	13.91	1.86
C5-C6	10	18	8	14	14.25	1.85
C6-C7	12	20	8	16.2	15.95	1.73

The screw length was measured from CT for placing transarticular facet screws on the left side facet joints in all patients. The measured screw length gradually increased from C2-C3 level (13.37 ± 2.04 mm) to C6-7 level (17.33 ± 2.84 mm).

The median value of the measured screw length also increased from 13.8 mm to 17.5 mm.

Measured screw length (mm) for the left facet joints in all patients						
Level	Minimum	Maximum	Range	Median	Mean	Standard Deviation
C2-C3	10.2	17.3	7.1	13.8	13.37	2.04
C3-C4	10.1	16.1	6.0	14	13.95	1.54
C4-C5	10.8	16.9	6.1	13.7	13.76	1.43
C5-C6	11.3	18.7	7.4	14.6	14.58	1.82
C6-C7	10.7	23.4	12.7	17.5	17.33	2.84

The sagittal angle was measured from CT for placing transarticular facet screws on the right side facet joints in all patients.The measured sagittal angle gradually increased from C2-C3 level (79.08° ±10.71°) to C6-C7 level (99.62° ± 9.41°)

The median value of the sagittal angle also increased from 78.2° to 99.3°.

Measured sagittal angle (^{0}) for the right facet joints in all patients						
Level	Minimum	Maximum	Range	Median	Mean	Standard Deviation
C2-C3	61.5	106.4	44.9	78.2	79.08	10.71
C3-C4	65.7	104.7	39	84.6	83.62	9.87
C4-C5	66.3	118.2	51.9	88.8	89.19	12.37
C5-C6	63.9	114.5	50.6	91.3	91.00	14.52
C6-C7	78.8	123.1	44.3	99.3	99.62	9.41

The sagittal angle was measured from CT for placing transarticular facet screws on the right side facet joints in all patients. The measured sagittal angle gradually increased from C2-C3 level (81.47° ± 9.07°) to C6-C7 (99.54° ± 9.72°).

The median value of the sagittal angle also increased from 82.1° to 98.5°.

Measured sagittal angle (^{0}) for the left facet joints in all patients						
Level	Minimum	Maximum	Range	Median	Mean	Standard Deviation
C2-C3	66.9	101.1	34.2	82.1	81.47	9.07
C3-C4	65.3	99.3	34	83.7	84.83	8.59
C4-C5	68.3	104.3	36	89.2	87.82	9.56
C5-C6	65.4	108.2	42.8	91.3	90.55	12.17
C6-C7	82.3	121.1	38.8	98.5	99.54	9.72

DISCUSSION

In this study, thirty one patients were included who underwent high resolution CT of the cervical spine for evaluation of neck pain, either due to trauma or degenerative process. Also patients who were evaluated pre operatively for surgical procedures were also included in the study. High resolution CT cervical spine was taken from the period 2011 to 2012.The findings obtained from this study are very useful for placing the transarticular screws in the sub axial cervical spine.

Transarticular factes screws fixation is an alternative technique for stabilising the middle and lower cervical spine which provides immediate and excellent stabilization. Bio mechanically it is superior to lateral mass screw fixation because of greater pull out strength due to four cortical layer purchase.

Transarticular facet screws can be placed safely and the entry point used was 3mm above in a vertical midline to the centre point of the lateral mass. The exit point was the ventral aspect of the caudal lateral mass.

The study by GREGORY.F.HOST ET AL is the one which systematically evaluated the safe trajectory for placing the TAFS using high resolution CT cervical spine. Here I am comparing the findings of my study with the study of GREGORY.F.HOST et al.

In their study they did not compare the screw length and sagittal angle between both the sexes. But in my study, I have compared the screw length and sagittal angle values for right facet joint of male with right facet joint of female and left facet joint of male with left facet joint of female .There were no significant differences between the two groups.

The mean length of the screws for the right and the left facet joints in males and females measured from CT cervical spine gradually increased from C2-C3 level to C6-C7 level .The results were consistent when compared to the values of the study by Geoffrey F.Host et al.

Screw level	Mean screw length (mm) measured from CT cervical spine of males and females (Mean ± S.D)				
	This Study				Gregory F.host et al
	Rt facet joint- males	Rt facet joint- females	Left facet joint- males	Left facet joint- females	
C2-C3	13.46 ± 2.21	13.23 ±1.66	13.67±_1.46	13.78 ±2.24	15± 2.1
C3-C4	13.07 ±1.82	14.07 ± 1.77	13.71± 1.56	14.55 ±1.40	14 ± 1 .4
C4-C5	13.66 ±1.56	14.52 ± 2.45	13.57± 1.43	14.22 ±1.39	15 ± 1 .5
C5-C6	14.14 ± 1.78	14.52 ±2.12	14.7 ± 1.87	14.22 ±1.75	16 ± 2.6
C6-C7	16.14 ±1.75	15.51 ± 1.76	17.10 ± 2.72	17.91 ± 3.17	23 ± 4 .1

The mean sagittal angle of the screws for the right and the left facet joint in males and females measured from the CT cervical spine, gradually increased from C2-C3 level to C6-C7 level .The results were consistent when comparing the values of the study by Geoffrey F.host et al.

Screw level	This Mean sagittal angle (°) measured from CT cervical spine of male and female sex (Mean ± S.D)				
	This Study				Gregory F.host et al
	Rt facet joint- males	Rt facet joint- females	Left facet joint- males	Left facet joint- females	
C2-C3	79.34 ± 9.63	81.33 ± 9.15	81.33 ± 9.15	81.80 ± 9.43	77 ±10.2
C3-C4	82.80 ± 9.40	86.71 ± 8.32	86.71 ±8.32	80.25 ±7.85	77± 10.7
C4-C5	89.99 ±11.41	89.45 ± 8.46	89.45 ± 8.46	83.84 ±11.38	80 ±11.2
C5-C6	92.32 ±14.55	91.89 ±11.05	91.89 ±11.05	87.3 ± 14.79	81 ± 8.1
C6-C7	104.26 ±8.84	101.99± 8.99	101.99± 8.99	93.57 ± 9.26	100 ±10

The mean length of the screws for the right and the left facet joints in all patients measured from CT cervical spine values gradually increased from C2-C3 level to C6-C7 level .The results were consistent when compared to the values of the study by Geoffrey F.Host et al.

Screw level	Mean screw length (mm) measured from CT cervical spine of all patients (Mean ± S.D)		
	This Study		Gregory F.host et al
	Rt facet joints of all patients	Left facet joints of all patients	
C2-C3	13.3 ± 2.04	13.37 ± 2.04	15 ± 2.1
C3-C4	13.36 ± 1.84	13.95 ±1.54	14 ± 1 .4
C4-C5	13.91 ± 1.86	13.76 ±1.43	15 ±1 .5
C5-C6	14.25 ± 1.85	14.58 ± 1.82	16 ± 2.6
C6-C7	15.95 ± 1.73	17.33 ± 2.84	23 ± 4 .1

The mean sagittal angle of the screws of the right and the left facet joints in all patients measured from CT cervical spine gradually increased from C2-C3 level to C6-C7 level.The results were consistent when compared to the values of the study by Geoffrey F.Host et al.

Screw level	Mean sagittal angle (^{0}) measured from CT cervical spine of all patients (Mean ± S.D)		
	This Study		Gregory F.host et al
	Rt facet joint of all patients	Left facet joint of all patient	
C2-C3	79.08 ± 10.71	81.47 ± 9.07	77 ± 10.2
C3-C4	83.62 ± 9.87	84.83 ± 8.59	77 ± 10.7
C4-C5	89.19 ± 12.37	87.82 ± 9.56	80 ±11.2
C5-C6	91.00 ±14.52	90.55 ± 12.17	81 ± 8.1
C6-C7	99.62 ± 9.41	99.54 ± 9.72	100 ± 10

Drawbacks of this study:

1. Sample of my study which included both young and old population ranges from 21 years to 65 years with mean age of 37 years, but transarticular facet screws are mostly used for older population with the combination of anterior cervical procedure or facet fixation after decompressive laminectomy. Degenerative changes in the older population which may interfere with the identification of the entry point or angulation may impede the placement of screws.
2. This study is only a virtual assessment for placing the screws in safe trajectory and trajectory simulation was not tested by using these measurements.
3. CT CERVICAL SPINE is taken in supine position with the neck in neutral or slightly extended position. But surgical procedures are done in prone with military tuck in position, which make clearance of the occipital and cervical region. So angulations may slightly vary but this can be avoided under the guidance of c –arm fluoroscopy.

CONCLUSION

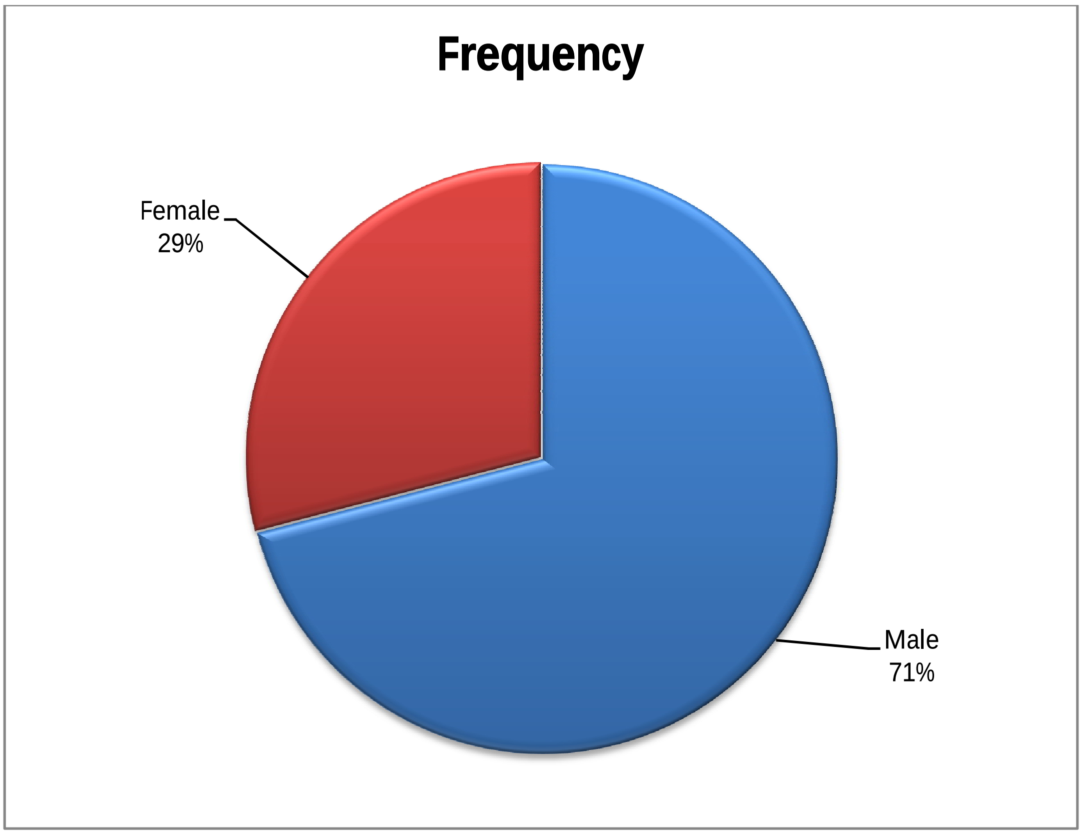
This study provides the entry point , screw length and trajectory angle for the sub axial cervical spine (C2-C3,C3-C4,C4-C5,C5-C6,C6-C7) ,which were evaluated from high resolution CT .This is very useful for placing transarticular facet screws in the safe trajectory in sub axial cervical spine for most of the cases.

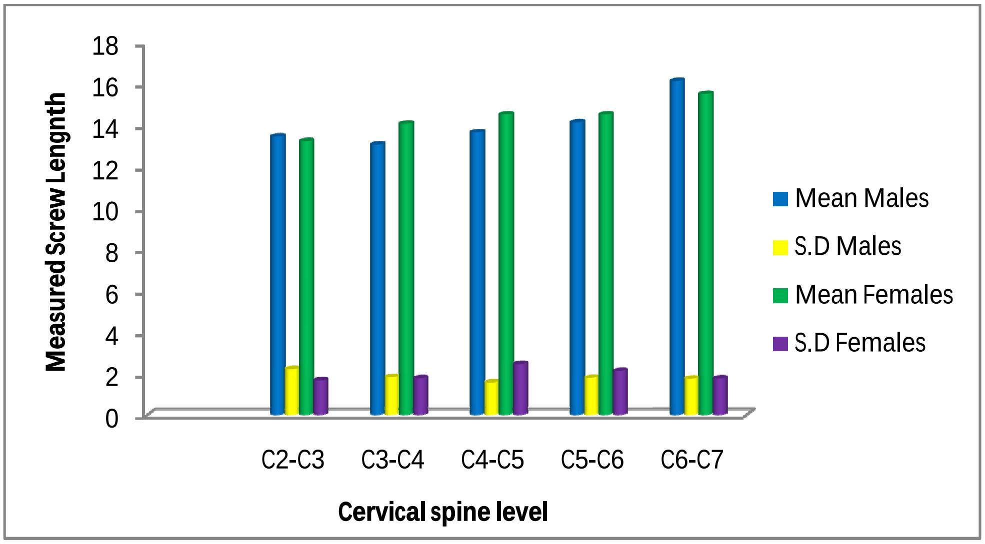
The information provided by the study may be helpful in placing the TAFS by free hand technique and also minimally invasive technique such as percutaneous placement of TAFS.

Cost wise the cortical screws are cheaper when compared to the lateral mass screws and pedicle screws. So it can be used as a routine procedure for posterior cervical instrumentation.

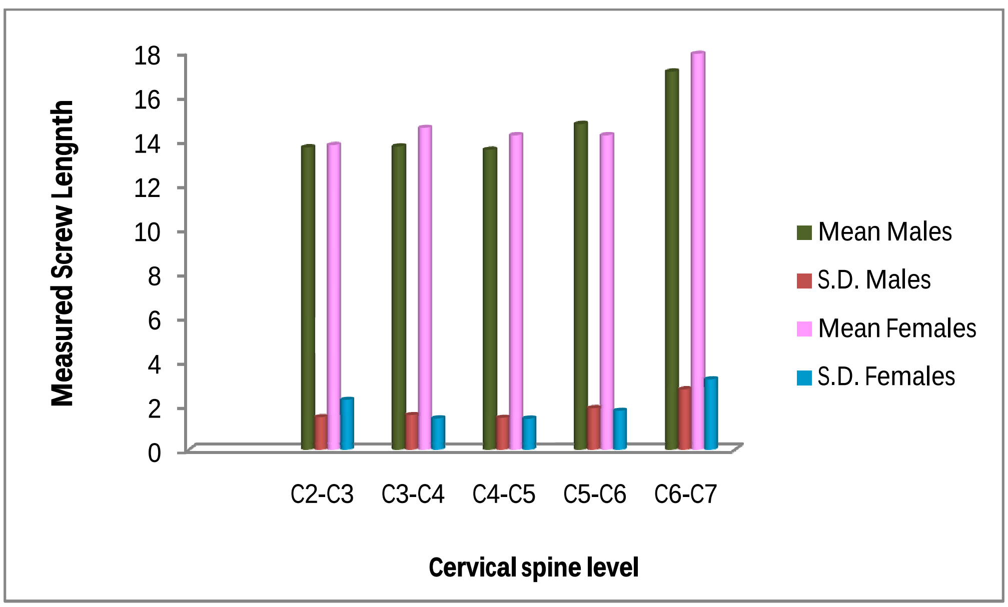
Finally, surgeons can use high resolution CT cervical spine pre operatively for measuring the screw length and sagittal angle so that they can confirm or modify it to reduce the incidence of vertebral artery injury and cervical nerve roots injury and also achieve excellent sub axial cervical spine stabilization by means of four cortical layer purchase.

SEX DISTRIBUTION:



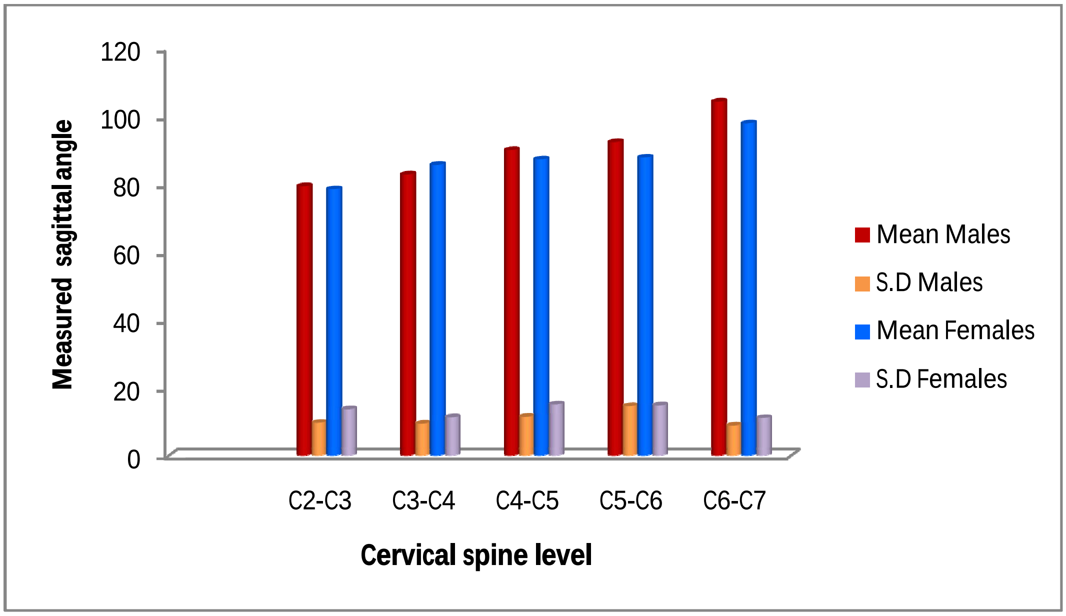


Measured Screw length of the right facet joints - comparison between males and females

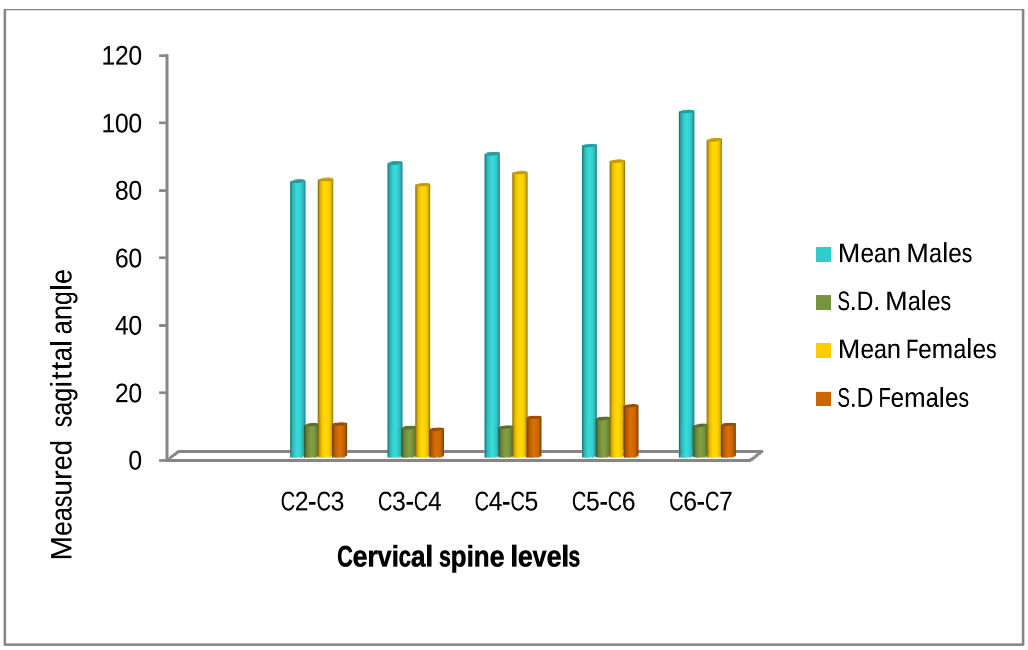


Measured Screw length of the left facet joints- comparison between males

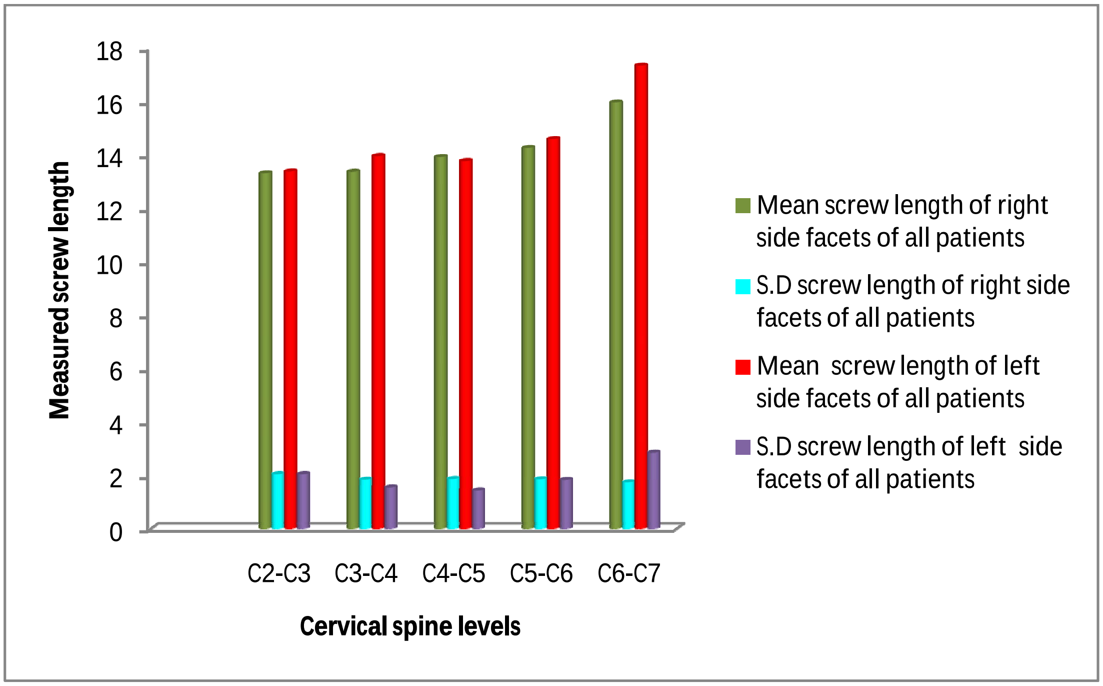
and females



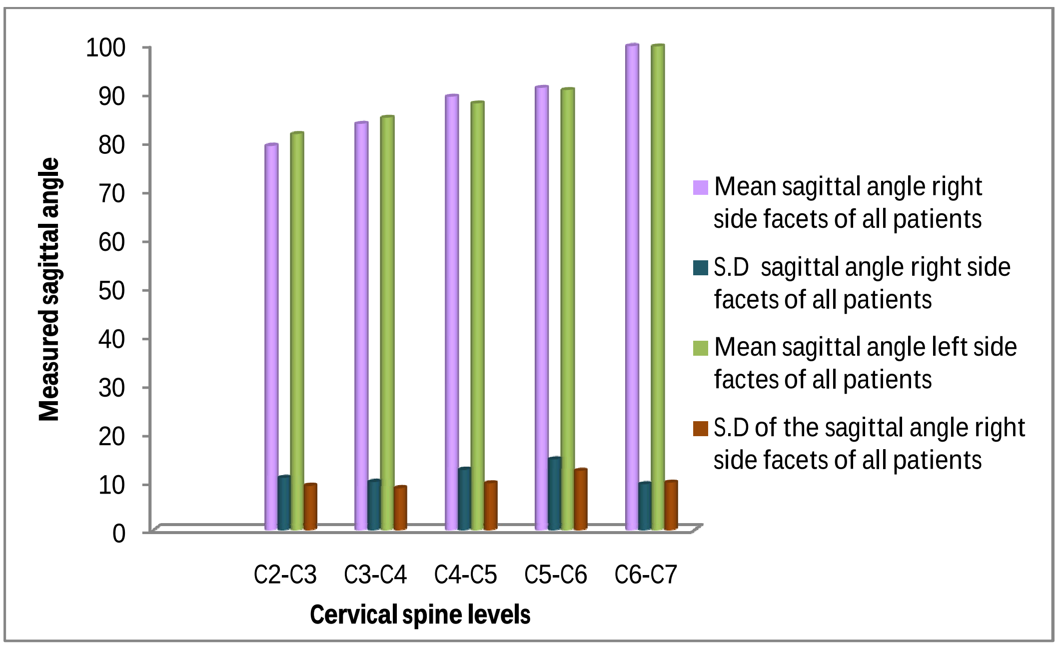
Measured sagittal angle of the right facet joints-comparison between males and females



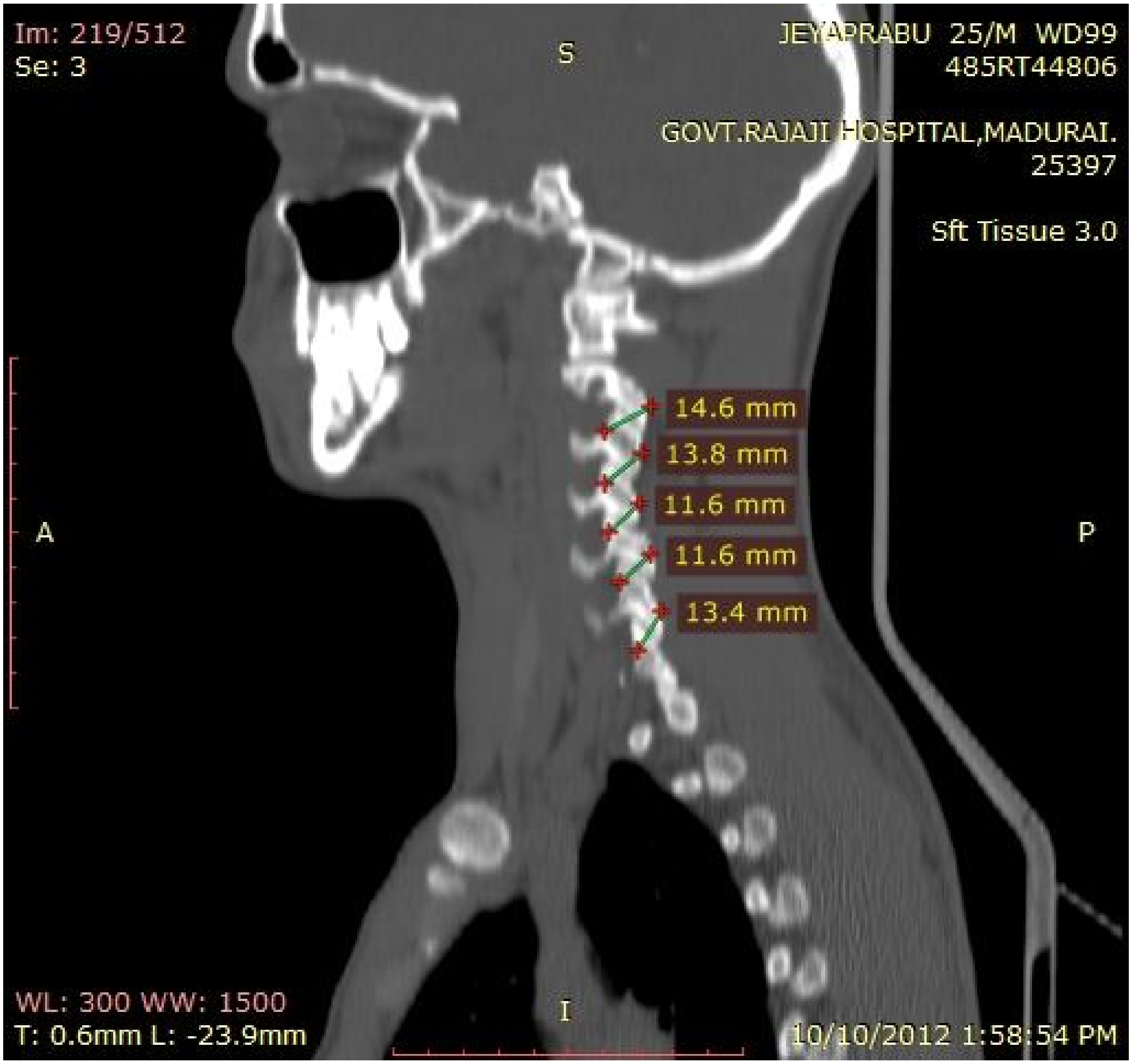
Measured Sagittal angle of the left facet joints - comparison between males and females



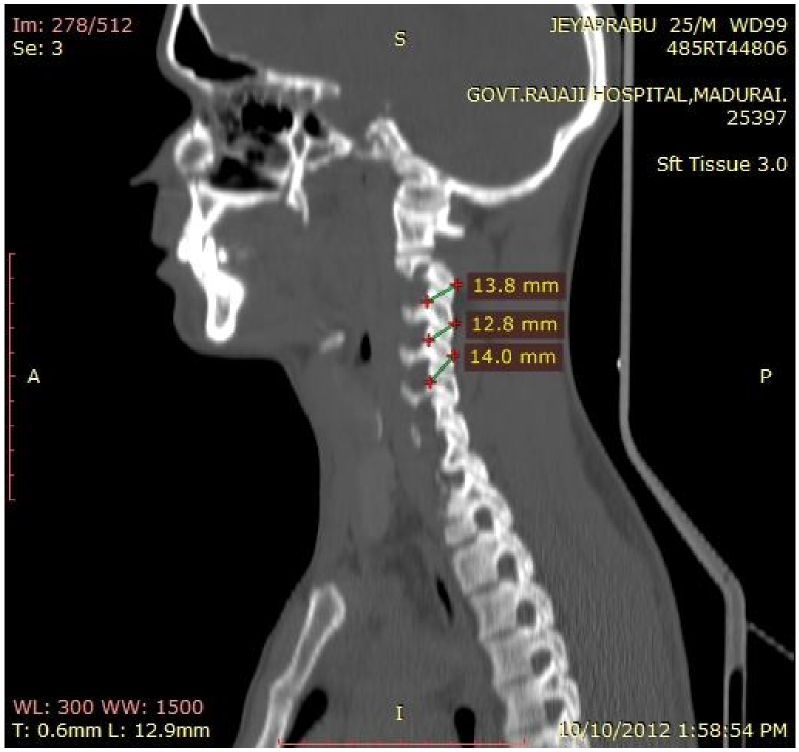
Measured Screw length of the right side & left side of the facet joints of all patients

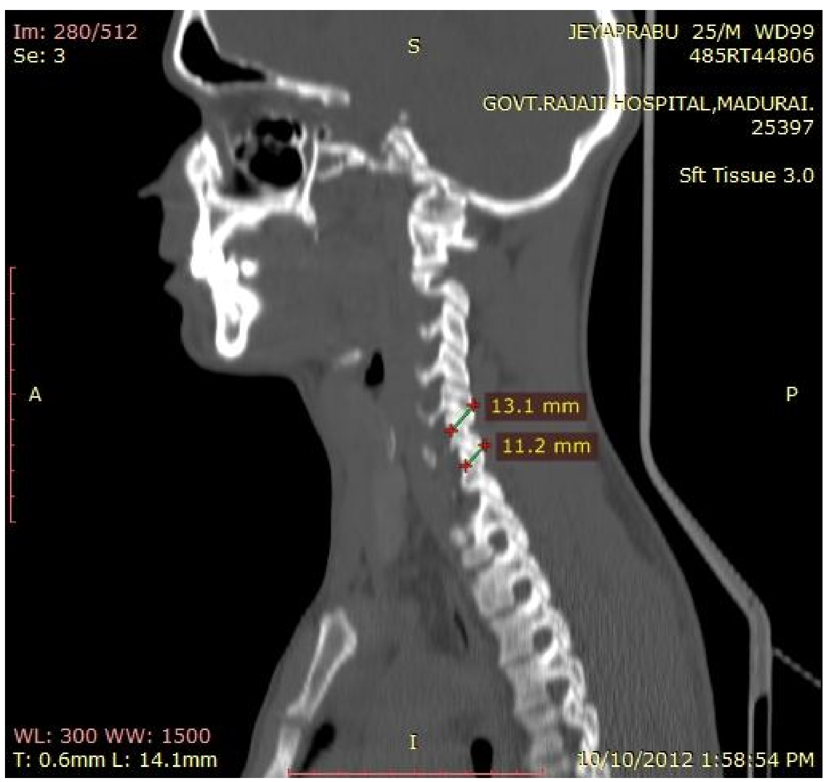


Measured sagittal angle of the right side & left side of the facet joints of all patients

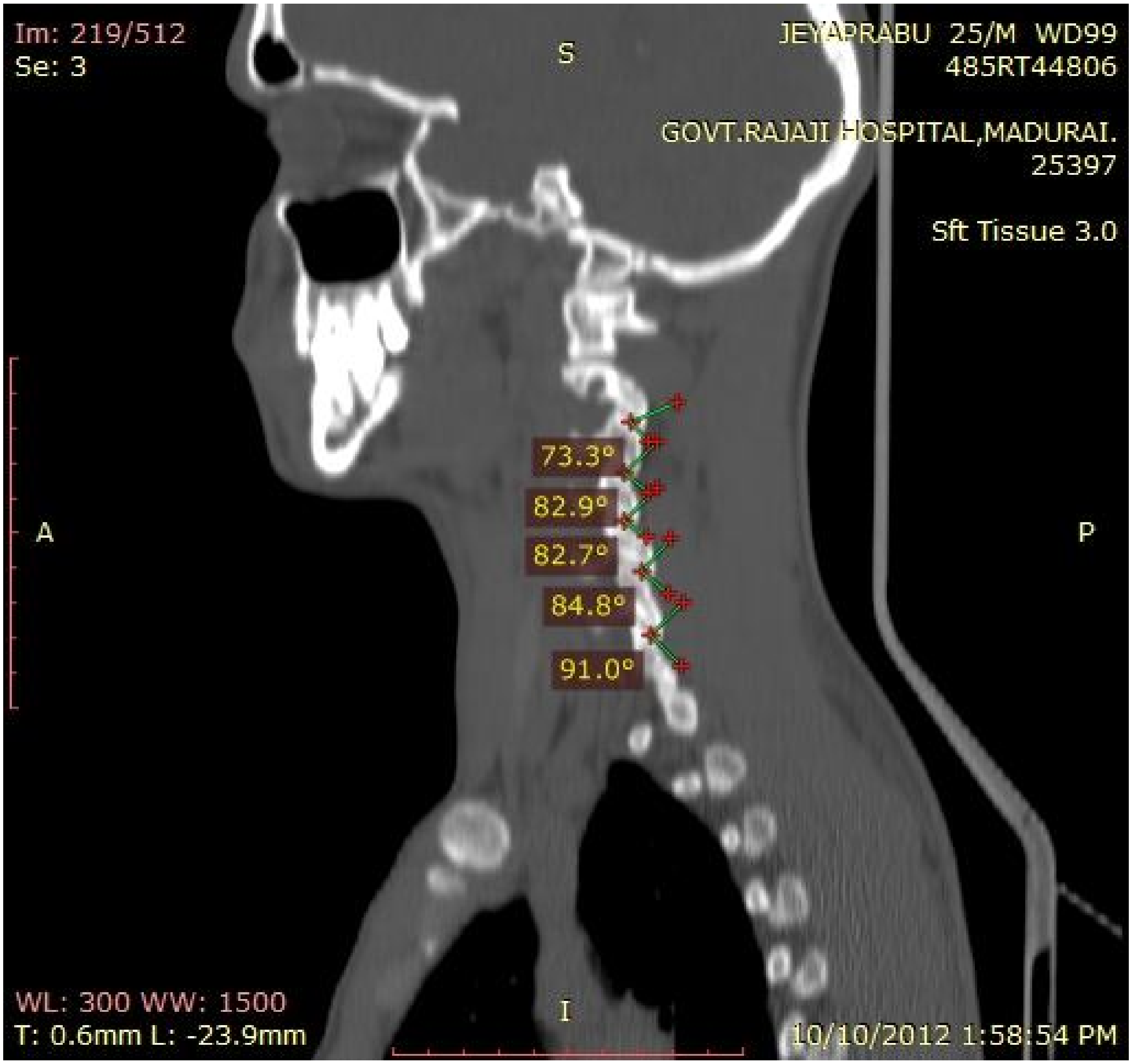


Measured screw length of the right facet joints in a male

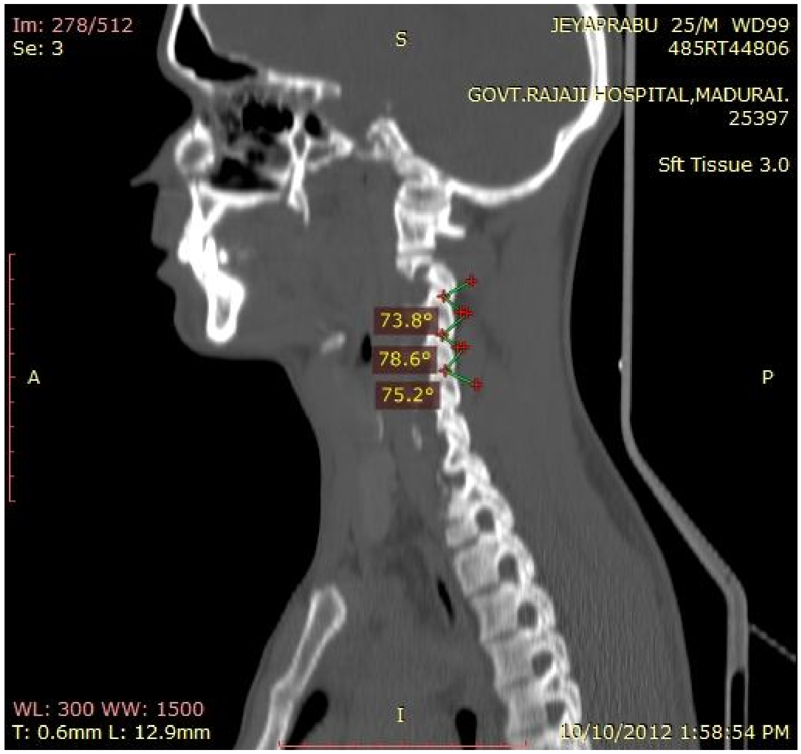


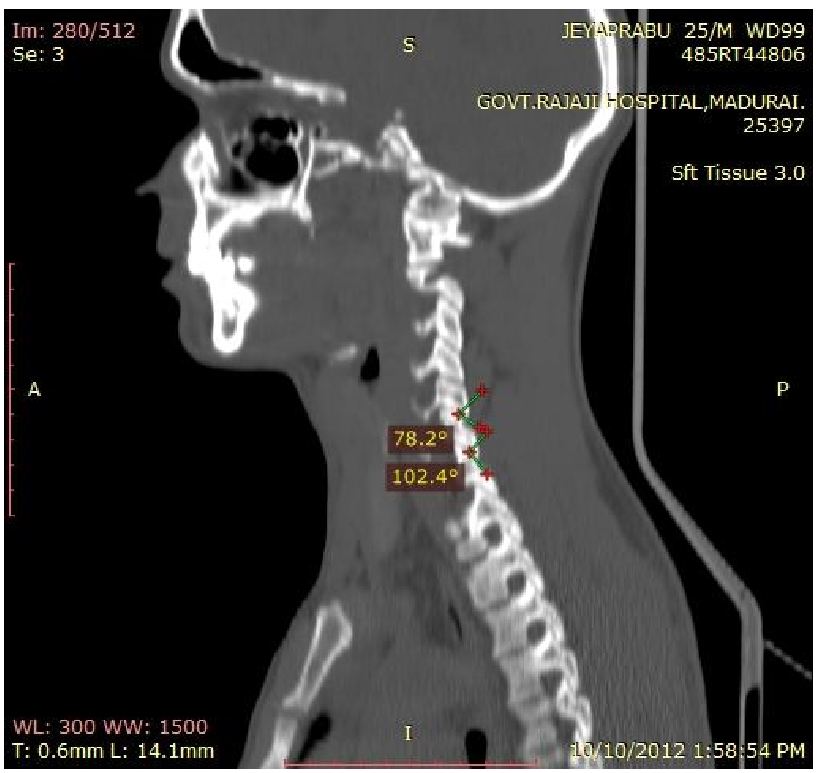


Measured screw length of the left facet joints in a male

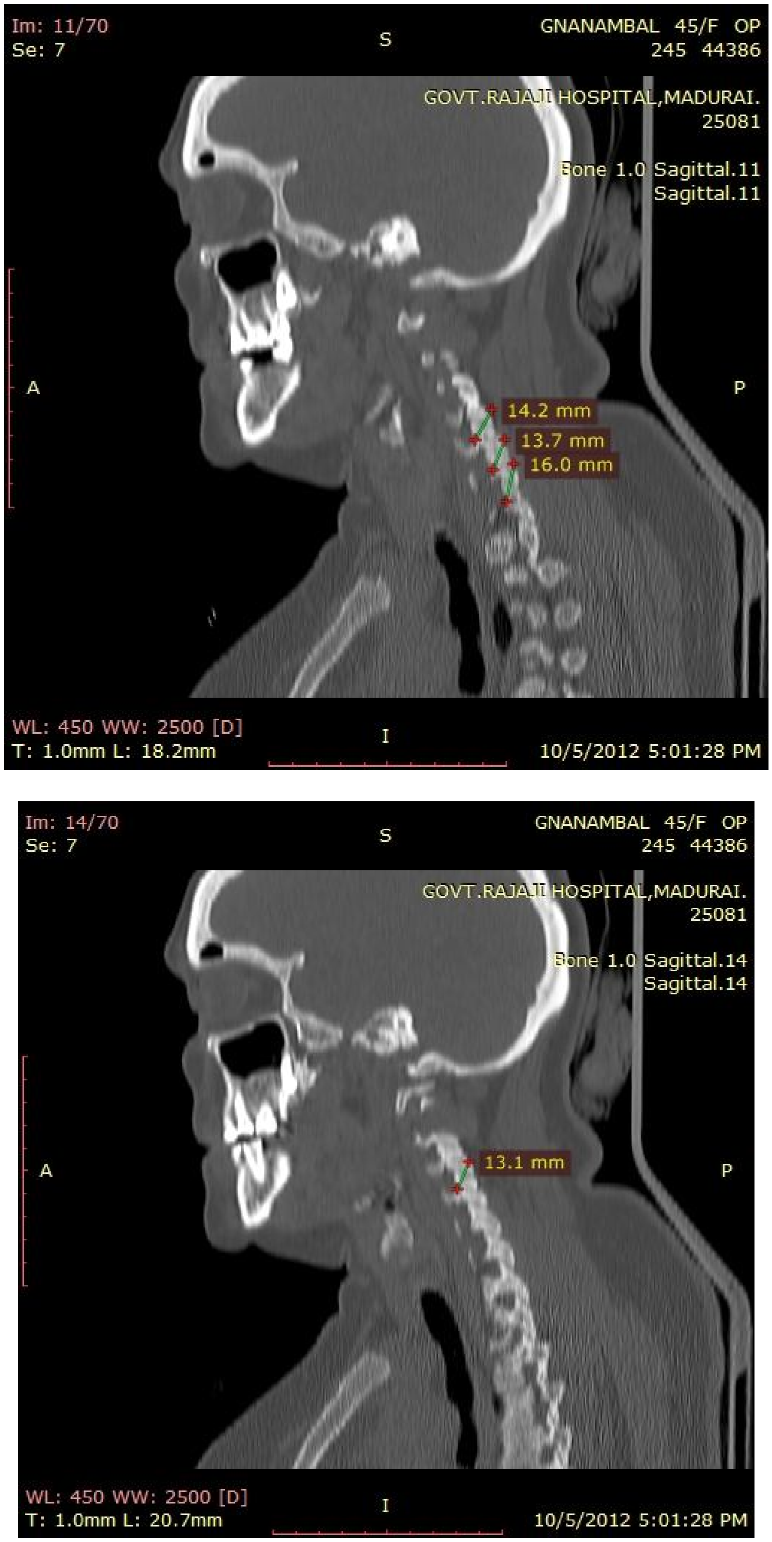


Measured sagittal angle of the left facet joints in a male

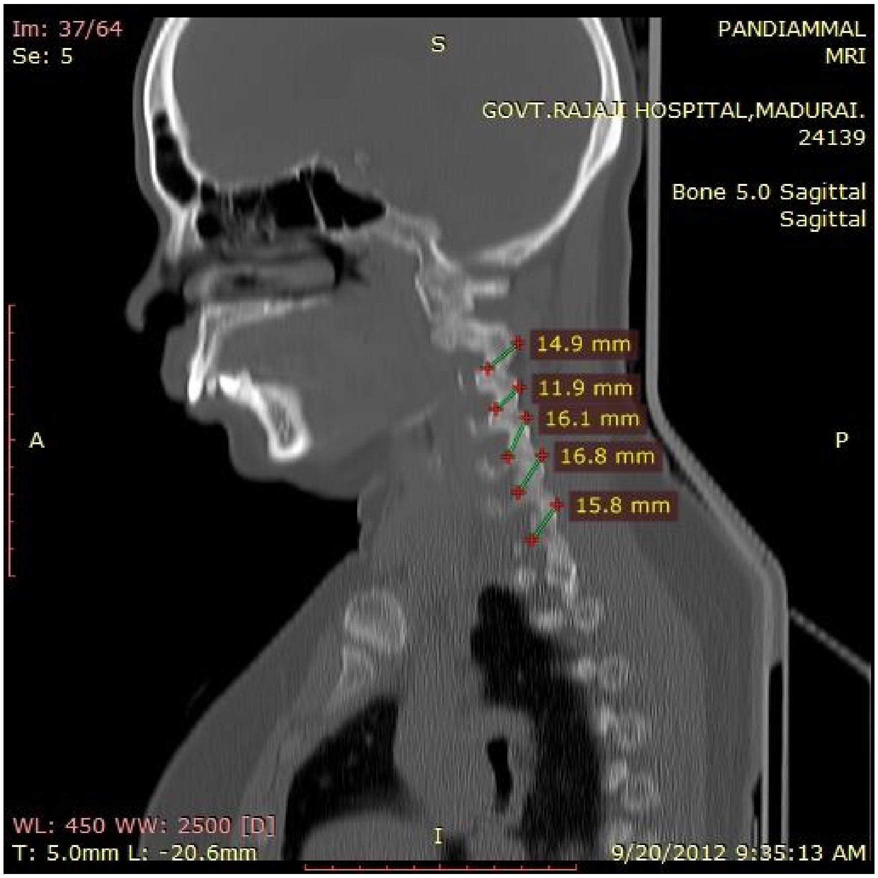




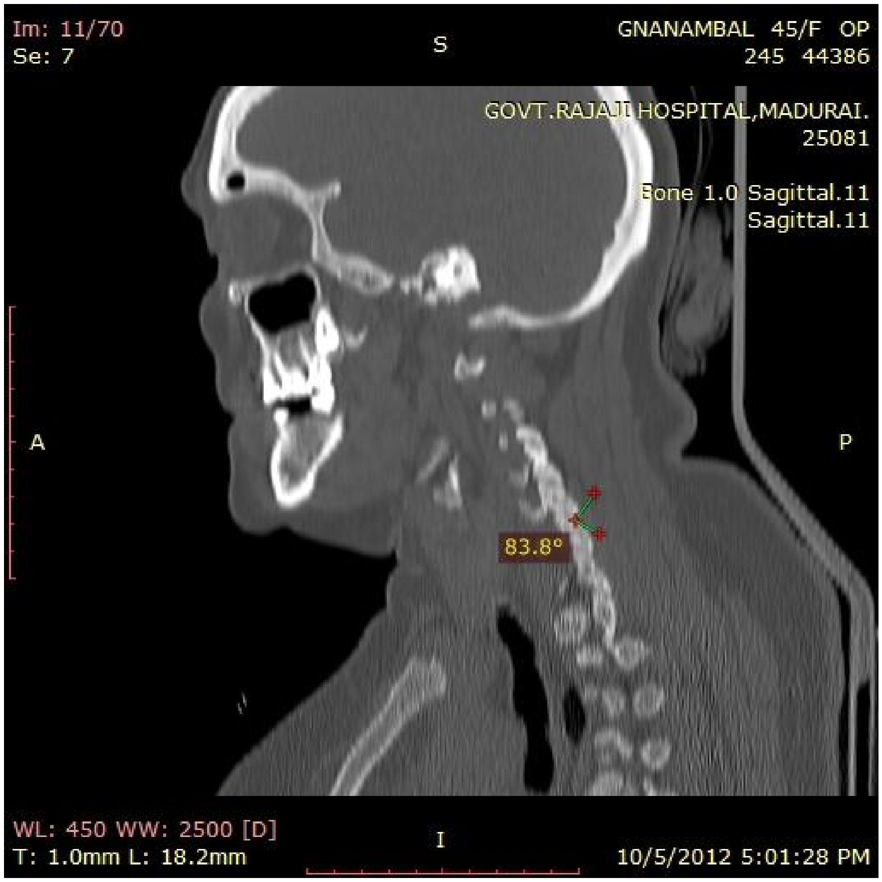
Measured sagittal angle of right facet joint of a male



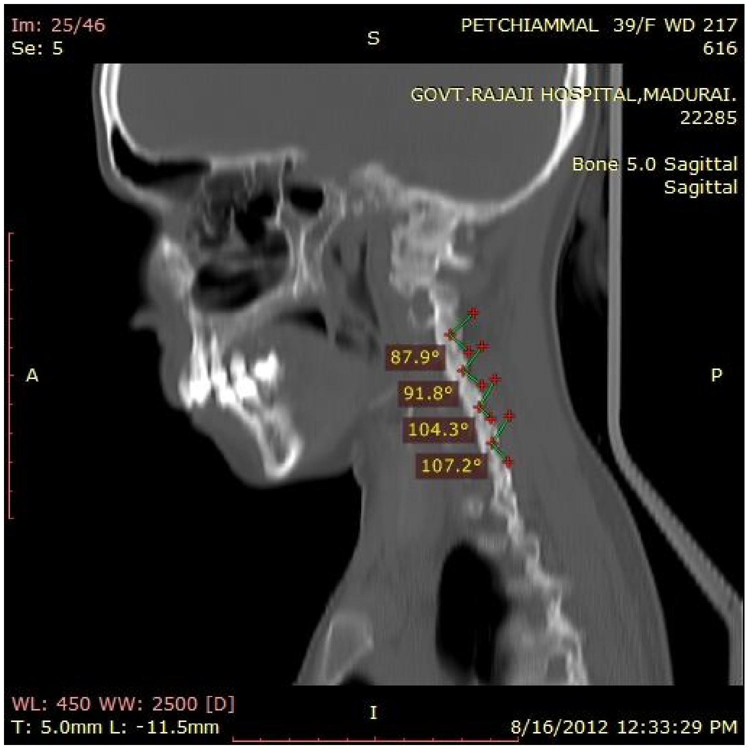
Measured screw length of the right facet joints in a female



Measured screw length of the left facet joints in a female



Measured sagittal angle of the right facet joint in a female



Measured sagittal angle of the left facet joints in a female

BIBLIOGRAPHY

1) You man's text book of neuro surgery.

2) Takayasu M, Hara M, et al. Transarticular screw placement in the middle and lower cervical spine. J Neurosurg Spine. 2003; 99:132–136.

3) Klekamp et al, Ugbo JL, and a biomechanical study for comparing the cervical transfacetal versus lateral mass screws: a biomechanical comparison'**s Spinal Disorder 13:**515–517, 2000.

4) Comparison of two techniques for Transarticular facetal Screw fixation in the Subaxial Cervical Spine Liujun Zhao, MD, Rongming Xu, (J Spinal Disorder Tech 2010;00:000–000).

5) Magerl F, Seemann PS: Stable posterior fixation of the atlas and axis by transarticular facetal screw fixation, in Kehr P, Weidner A (eds): **Cervical Spine I.** Berlin: Springer-Verlag, 1985, pp 322–327

6) Roy-Camille R, Sailliant G: [Surgery of the cervical spine. 2. Dislocation. Fracture of the articular processes.] **Nouv Presse Med 1:**2484–2485, 1972 (Fr).

7) Dalcanto RA, Lieberman I, Inceoglu S, et al. Biomechanical comparison of transarticular facet screws to lateral mass plates in

two-level instrumentations of the cervical spine. Spine. 2005; 30:897–892.

8) Zhao L, Xu R, Liu J, Sochacki KR, Ma W, Jiang W, et al: The study on comparison of three techniques for transarticular screw placement in the lower cervical spine.

9) Jeanneret B: Posterior rod system of the cervical spine: a new implants allowing optimal screw insertion. **European journal of spine 5:**350–356, 1996.

10) Lee YP, Robertson C, Maher A, Kuper Metal: Biomechanical evaluation of transfacetal screw fixation for stabilisation of multilevel cervical corpectomies. **J Spinal Disorder 24:258**–263, 2011.

11) Dalcanto RA, Lieberman I, and Inceoglu: a study of biomechanical comparison of the transarticular facet screws and the lateral mass in two-level instrumentations of the cervical spine. **Spine 30:**897–902, 2005.

12) Abumi et al. Transpedicular screw fixation for traumatic Lesions of the middle and lower cervical spine. *Journal of Spinal Disorder.* 1994; 7:19-28.

13) Abddu. Publications of Techniques of subaxial posterior cervical spine fusions: *Orthopaedics*. 1992 :287-295.

14) Abumi K, Pedicle screw fixation technique in no traumatic lesions of the cervical spine disease Spine journal of *Spine*. 1997; 22: 1853-1863.

15) Park SH, Park WM, et al. Minimally invasive anterior Lumbar interbody fusion followed by percutaneous translaminar Facet screw fixation in elderly patients. Journal of Neurosurgery Spine. 2009; 10: 610–616.

16) Peng CW, Yue WM, Poh SY, et al. a study of Clinical and radiological outcomes of minimally invasive versus open transforaminal lumbar Interbody fusion. Spine (Phila Pa 1976). 2009; 34:1385–1389.

17) Regev GJ, Lee YP, and Taylor WR, et al. Nerve root injury to posterior medial branch during the placement of the pedicle screws: comparison of mini-open versus percutaneous pedicle screws insertion techniques. Spine (Phila Pa 1976). 2009; 34:1239–1242.

18) Selznick LA, Shamji MF, et al. Minimally invasive interbody Fusion for revision lumbar surgery: technical feasibility and safety.J Spinal Disorder Tech. 2009; 22:207–213.

19) Deen HG, Birch BD, et al. the study about Lateral mass screw-rod Fixation of the cervical spine: a prospective clinical series with 1-yearFollow-up. Spine J. 2003; 3:489–495.

20) Kandziora F, Mittlmeier T et al. Stage-related surgery for cervical spine instability in the rheumatoid arthritis. Euro Spine J.1999; 8:371–381.

21) Schultz KD Jr, McLaughlin MR et al. Single-stage anterior-posterior decompression and stabilisation for complex cervical spine disease. J Neurosurg. 2000; 93:214–221.

22) Swank ML, Sutterlin CE III et al. Rigid internal Fixation with lateral mass plates in multilevel anterior and posterior Reconstruction of the cervical spine. Spine. 1997; 22:274–282.

23) Kawaguchi Y, Yabuki S, et al. Para spinal muscle injury after Posterior lumbar spine surgery. Topographic evaluation of intramuscular Pressure and blood flow in the porcine back muscle during Surgery. Spine. 1996; 21:2683–2688.

24) Sihvonen T, Herno A, Paljarvi L, et al. Local denervation atrophy of the paraspinal muscles in the postoperative failed back syndrome. Spine.1993; 18:575–581.

25) Styf JR, Willen J et al. The effects of external compression by three Different retractors on pressure in the Para spine muscles during and after posterior lumbar spine surgery in the humans. Spine.1998; 23:354–358.

26) Miyanji F, Mahar A, Oka R, et al Biomechanical study to differentiate between transfacet and lateral mass screw-rod constructs for multilevel Posterior cervical spine stabilization. Spine. 2008; 33:E865–E869.

27) Xu R, Zhao L, Chai B, et al. role of Lateral radiological evaluation of the Transarticular screw placement in the sub axial cervical spine. Euro SpineJ. 2009; 18:392–397.

28) Costa F, Ortolina A, Cardia A, et al. Efficacy of treatment with the percutaneous vertebroplasty and kyphoplasty for the traumatic fracture of thoracolumbar junction. J Neurosurg Sci. 2009;53:13–17.

29) Pal et al, a study about the orientation of cervical and upper thoracic facet joints in journal of anatomy; page (431-441).

30) Jaumard et al, spinal biomechanics of facet joint in normal, degenerative process and trauma. Published in journal of biomechanical engineering (June 2011).

31) Heggeness MH et al .study of Trans facet joint screw fixation and lumbosacral fusion.

32) Heller JG, Carlson GD et al. Anatomical study comparison of The Roy-Camille and Magerl techniques for screw placement in the subaxial cervical spine. *Spine* 1991; 16(Suppl 10):S552–7.

33) Heller JG, Estes BT et al. Biomechanical study of screws in the Lateral masses. *J Bone Joint Surg 1996*; 78:1315–21.

34) Heller JG, Silcox H et al. various Complications of the posterior cervical spine Plating. *Spine* 1995; 20:2442–8.*Spine* 1991; 16(Suppl 6):S266–9.

35) Volkmann, Horton W, Hutton W. Transfacet screws along with lumbar Interbody reconstruction: a biomechanical study of to determine the lumbar motion segment Stiffness. *Journal of SpinalDisorder*1996; 9:425–32.

36) Kim SM, Lim TJ, Paterno J, Park. A study of biomechanical Comparison of three surgical approaches in the traumatic bilateral subaxial cervical facet dislocation. Journal of Neurosurgery (Spine 1)1: 108-115, 2004.

37) Uygur et al a case report of trans articular facet screw fixation in a case of bilateral trans articular screw fixation at c6-c7 vertebral level.

38) Ahmad et al; study of percutaneous placement of placement of Trans articular facet screws for posterior cervical spine stabilisation.

39) Liu G, Xu R, Ma W, Sun S, Anatomical considerations For the placement of cervical transarticular facet screws. **J Neurosurg Spine 14:**114–121, 2011.

40) Panjabi MM, Oxland T, Takata K, Krag M (1993) articular facets of the human spine. *Spine* **18**, 1298±1310.

STUDY PROFORMA

ROLE OF CT IN THE EVALUATION OF SAFE TRAJECTORY FOR THE PLACEMENT OF TRANSARTICULAR FACET SCREWS IN SUBAXIAL CERVICAL SPINE

Name:

Age/Sex:

Ip.no / Op.no:

Chief complaint:

INCLUSION CRITERIA:

- Age greater than 18 years with informed consent to participate in the study,
- CT cervical spine done for evaluation of neck pain .
- CT Cervical spine done as a pre-operative evaluation for patients with cervical spine pathology.

EXCLUSION CRITERIA:

- Patient's refusal to participate in the study
- Patients with severe spondylotic changes
- Patients with inflammatory changes
- Patients with cervical spine fractures
- Patients with cervical spine dislocations
- Pregnant patients

METHODOLOGY:

In this study, thirty one patients were included. They who underwent high resolution CT of the cervical spine for evaluation of neck pain, either due to trauma or degenerative process. Also patients who were evaluated pre operatively for surgical procedures were also included in the study. High resolution CT scans of cervical spines were reconstructed and have been evaluated for safe transarticular facet screw placement (TAFS) in the subaxial cervical spine (C2–C3, C3–4, C4–5, C5–6, and C6–7).

In my study the entry point used was 3 mm above in a vertical midline to the centre point of lateral mass. Exit point was the ventral aspect of caudal lateral mass.

Length of the screws was defined as distance from entry point to exit point. This was measured at each level (C2-C3, C3-C4, C4-C5, and C5-C6) on both sides for 31 patients.

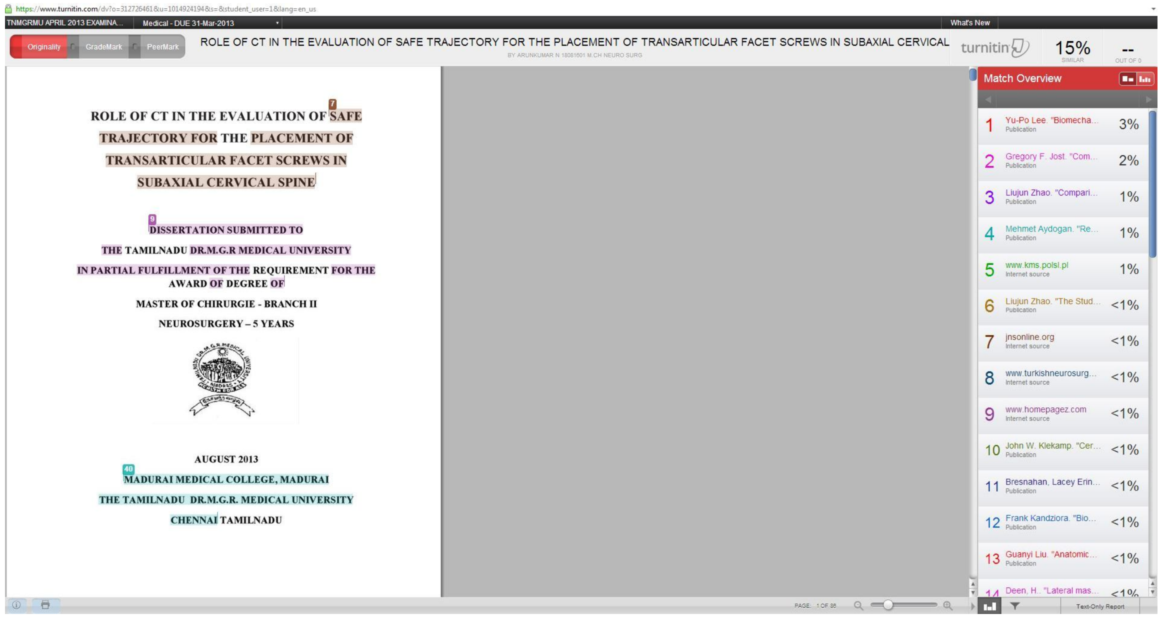
Sagittal angle -The **sagittal angle** was measured to the sagittal projection of the facet joint surface as it passes posterior aspect of lateral mass, sub chondral bone of both articular process ,ventral aspect of the caudal lateral mass at each level (C2-C3,C3-C4,C4-C5,C5-C6) on both sides for 31 patients .

Screws level	Screw length	
	Right side	Left side
C2-C3		
C3-C4		
C4-C5		
C5-C6		
C6-C7		

Screws level	Optimal sagittal angle	
	Right side	Left side
C2-C3		
C3-C4		
C4-C5		
C5-C6		
C6-C7		

ABBREVIATIONS

➢ TAFS	-	Trans articular facets screws
➢ LMSF	-	Lateral mass screw fixation
➢ LMS	-	Lateral mass screw
➢ S.D	-	Standard Deviations
➢ MIS	-	Minimally invasive surgery


https://www.turnitin.com/dv?o=312726461&u=1014924194&s=&student_user=1&lang=en_us
TNMGRMU APRIL 2013 EXAMINA...
Medical - DUE 31-Mar-2013
What's New
Originality
GradeMark
PeerMark
ROLE OF CT IN THE EVALUATION OF SAFE TRAJECTORY FOR THE PLACEMENT OF TRANSARTICULAR FACET SCREWS IN SUBAXIAL CERVICAL
BY ARUNKUMAR N 18081601 M.CH NEURO SURG
turnitin
15%
SIMILAR
--
OUT OF 0
ROLE OF CT IN THE EVALUATION OF SAFE TRAJECTORY FOR THE PLACEMENT OF TRANSARTICULAR FACET SCREWS IN SUBAXIAL CERVICAL SPINE
DISSERTATION SUBMITTED TO
THE TAMILNADU DR.M.G.R MEDICAL UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF
MASTER OF CHIRURGIE - BRANCH II
NEUROSURGERY – 5 YEARS
AUGUST 2013
MADURAI MEDICAL COLLEGE, MADURAI
THE TAMILNADU DR.M.G.R. MEDICAL UNIVERSITY
CHENNAI TAMILNADU
Match Overview
1 Yu-Po Lee. "Biomecha... Publication 3%
2 Gregory F. Jost. "Com... Publication 2%
3 Liujun Zhao. "Compari... Publication 1%
4 Mehmet Aydogan. "Re... Publication 1%
5 www.kms.polsl.pl Internet source 1%
6 Liujun Zhao. "The Stud... Publication <1%
7 jnsonline.org Internet source <1%
8 www.turkishneurosurg... Internet source <1%
9 www.homepagez.com Internet source <1%
10 John W. Klekamp. "Cer... Publication <1%
11 Bresnahan, Lacey Erin... Publication <1%
12 Frank Kandziora. "Bio... Publication <1%
13 Guanyi Liu. "Anatomic... Publication <1%
14 Deen, H.. "Lateral mas... <1%
Text-Only Report

MASTER CHART

S No	NAME	AGE	SEX	DIAGNOSIS	C2-C3		C3-C4		C4-C5		C5-C6		C6-C7	
					R	L	R	L	R	L	R	L	R	L
1	Alagarsamy	53	M	Cervical spondylotic myelopathy	13.5	16.5	14.5	14.9	14.7	13.8	14	13.8	15	17.4
2	Anandh	24	M	Traumatic neck pain	11	10.2	10.1	10.1	12.1	10.8	11.9	14.5	16.2	17.5
3	Ayyanan	65	M	Cervical spondylotic myelopathy	13.2	14.3	13.8	15.2	13.8	15.4	16.5	16.7	15.8	18.5
4	Devi	35	F	C5 – c6 disc prolapse	15.6	16.7	14.4	16.1	12.4	14.2	10.3	11.3	14.7	10.7
5	Chandran	40	M	Cervical OPLL	13.2	14.4	12.3	14.2	13.7	11.5	14.6	17.5	15.6	17.7
6	Kamalam	42	F	Cervical spondylotic myelopathy	10.5	11.3	14.5	15.7	17.6	15.3	16.4	12.7	17.6	19.8
7	Suresh	25	M	Traumatic neck pain	12.5	14.7	14.9	12.7	16.9	15.9	15.6	13.9	17.9	16.9
8	Dhavamani	31	F	Traumatic neck pain	11.4	13	11.7	15.7	12	12.8	13.6	14.9	17.1	20.1
9	Gnanambal	45	F	Cervical OPLL	13.1	14.9	14.2	11.9	13.7	16.1	16	16.8	15.7	15.8
10	Jeyaprabu	25	M	Traumatic neck pain	14.6	13.8	13.8	12.8	11.6	14	11.6	13.1	13.4	11.2
11	Kalaiarasan	50	M	Cervical spondylotic myelopathy	12.7	13.9	12.8	16.1	14.7	14.9	17.8	16.7	16.3	19.1
12	Kaliraj	23	M	Traumatic neck pain	12	14.4	9.5	13.2	14.7	12.6	14.6	12.8	16.8	18.3
13	Karuppasamy	22	M	Traumatic neck pain	19.6	16.1	15.7	15.7	17.2	15.5	14.8	15.9	16.9	19.7
14	Mohan	55	M	Cervical OPLL	14.4	13.6	14.6	14.8	15.7	13.1	13.9	15.1	19.6	16.3
15	Murugan	32	M	C5 –C6 ,C6-C7,DIC PROLAPSE	10.6	12.5	10.6	13.7	13	12	14	14.8	17.5	15.4
16	Sridhar	32	M	Traumatic neck pain	11	13.2	11.7	15.2	12	12.9	13.6	14.5	17.1	20.6
17	Muthu Krishna veni	38	F	Multiple level cervical disc prolapse	13.7	15.3	17.5	12.7	18.6	12.3	13.4	12.7	17.6	19.8
18	Pandiarajan	24	M	Traumatic neck pain	15.5	11.2	16.4	12.3	13.2	13.7	16.7	11.8	14.8	14.2
19	Pecthiammal	39	F	C6-C7 dic prolapsed	12.9	14.2	12.3	15.7	12.8	16.9	13.2	15.5	13.9	16.8
20	Perumal	41	M	Cervical spondylotic myelopathy	17.4	12.7	14.5	12.2	14	12.6	12.5	15.8	17.5	15.9
21	Ramachandran	26	M	Traumatic neck pain	15.2	13.1	14.6	13.6	13.6	13.4	14.6	12.5	16.4	15.9
22	Solai appan	21	M	Traumatic neck pain	14	14.4	13.3	12.5	11.8	12.6	11.9	16.7	11.5	19
23	Sreenivasan	26	M	C6-C7 dic prolapsed	12	13	11.8	12.9	12.7	12.4	11.8	11.3	14	12.9
24	Surendran	24	M	Traumatic neck pain	15.2	12.6	12.6	12.7	11.8	15.1	11.5	13.8	15.6	13.3

25	Velayutham	40	M	Cervical spondylotic myelopathy	13.2	15.5	13.4	11.8	13	14.8	15.8	14.6	17.6	16.9
26	Yagappan	55	M	Cervical spondylotic myelopathy	12.1	14.4	13.3	15.3	12.7	14.7	13.5	13.9	16.7	17.1
27	Selvam	35	M	Traumatic neck pain	12.7	13.9	12.8	16.1	14.7	14.9	15.8	18.7	15.3	19.1
28	Steepan	40	M	C6-C7 dic prolapsed	10.6	12.5	10.6	13.7	13	12	14	15.8	17.5	23.4
29	Rani	50	F	Cervical spondylotic myelopathy	12.5	11.2	13.4	14.3	13.2	13.7	16.7	14.8	14.8	20.2
30	Pandiammal	47	F	Cervical spondylotic myelopathy	15.2	14.9	14.6	11.9	13.6	16.1	14.6	16.8	12.4	15.8
31	Manimala	38	F	C5 – c6 disc prolapse	14.2	17.3	12.8	12.2	16.8	14.4	16.5	16.3	15.8	18.4

S No	NAME	AGE	SEX	DIAGNOSIS	C2-C3		C3-C4		C4-C5		C5-C6		C6-C7	
					R	L	R	L	R	L	R	L	R	L
1	Alagarsamy	53	M	Cervical spondylotic myelopathy	89.6	87.7	98.9	85.3	108.4	101.1	111.7	104.1	102.1	98.5
2	Anandh	24	M	Traumatic neck pain	74.3	80.1	87.8	79.9	88	91.1	102.8	102.5	123.1	119.4
3	Ayyanan	65	M	Cervical spondylotic myelopathy	81.5	89.3	65.7	65.3	87.8	73.2	86.2	83.3	96.9	96.2
4	Devi	35	F	C5 – c6 disc prolapse	66.4	69.3	94.3	83.7	71.2	68.3	63.9	88.3	110.2	94.3
5	Chandran	40	M	Cervical OPLL	77.3	83.4	82.9	75.3	81.2	78.3	71.3	95.9	117.9	94.2
6	Kamalam	42	F	Cervical spondylotic myelopathy	61.5	88.8	71.3	71.2	91.2	92.3	67.2	99.3	91.3	82.3
7	Suresh	25	M	Traumatic neck pain	73.4	71.9	66.3	91.3	102.2	89.2	82.4	91.3	88.2	98.1
8	Dhavamani	31	F	Traumatic neck pain	83.8	89.2	90.2	77.2	118.2	91.2	93.3	81.2	110	91.2
9	Gnanambal	45	F	Cervical OPLL	77.3	92.6	91.5	87.9	77	91.8	83.8	104.3	97.8	107.2
10	Jeyaprabu	25	M	Traumatic neck pain	73.8	73.3	78.6	82.9	75.2	82.7	78.2	84.8	102.4	91
11	Kalaiarasan	50	M	Cervical spondylotic myelopathy	90.8	85	94.4	83.5	95.9	88.7	107.4	103.8	94.8	99.4
12	Kaliraj	23	M	Traumatic neck pain	94.7	101.1	87.1	98.9	106.3	90.1	113.5	99.5	105.3	110.9
13	Karuppasamy	22	M	Traumatic neck pain	77.2	81.8	89.2	87.8	92.2	102.8	72.1	90.7	91.5	105.7
14	Mohan	55	M	Cervical OPLL	75.6	70.5	84.6	86.2	87	84.4	86.7	82.9	92.4	93.6
15	Murugan	32	M	C5 –C6 ,C6-C7,DIC PROLAPSE	87.6	91.4	96.59	93.4	107.1	92.5	114.5	104	108.4	116.6
16	Sridhar	32	M	Traumatic neck pain	63.4	79.5	75.8	92.2	73.3	98.3	92.9	65.4	89.3	90.3
17	Muthu Krishna veni	38	F	Multiple level cervical disc prolapse	82.3	75.4	81.3	91.3	89.3	79.2	112.2	108.2	103.3	102.4
18	Pandiarajan	24	M	Traumatic neck pain	94.3	87.7	87.7	97.4	106.2	87.2	111.4	98.5	104.2	100.3
19	Pecthiammal	39	F	C6-C7 dic prolapsed	106.4	87.9	104.7	91.8	90.7	104.3	96.4	107.2	108.9	104.7
20	Perumal	41	M	Cervical spondylotic myelopathy	91.4	93.4	95	93.2	100.3	93.8	80.9	97	102.8	103.9
21	Ramachandran	26	M	Traumatic neck pain	82.8	79.3	83.1	99.3	84.6	97	91.6	107.6	91.2	103.8
22	Solai appan	21	M	Traumatic neck pain	86.3	87.6	86.5	90.9	93.8	98.5	97.6	95.3	106.5	95.5
23	Sreenivasan	26	M	C6-C7 dic prolapsed	72.4	73.2	76.8	75.5	88.8	82.6	100	100.8	98.7	98.4
24	Surendran	24	M	Traumatic neck pain	78.2	82.1	72	83.5	88.7	99.5	106.8	93.5	105.4	93.3
25	Velayutham	40	M	Cervical spondylotic myelopathy	82.3	87.2	72.3	81.6	75.5	80.8	92.5	75	100.2	113

26	Yagappan	55	M	Cervical spondylotic myelopathy	65.9	66.9	87.1	90.6	73.4	79.7	71.1	86	94.7	100.4
27	Selvam	35	M	Traumatic neck pain	70.3	67.8	74.4	91.3	85.5	97.1	83.3	82.4	99.3	100.2
28	Steepan	40	M	C6-C7 dic prolapsed	62.4	69.2	78.8	82.4	78.4	79.4	76.3	77.3	92.3	121.1
29	Rani	50	F	Cervical spondylotic myelopathy	79.5	75.3	72.9	77.3	90.1	75.8	91.3	69.4	89.3	98.2
30	Pandiammal	47	F	Cervical spondylotic myelopathy	84.4	88.8	74.8	69.4	91.3	77.9	90.6	69.2	78.8	82.4
31	Manimala	38	F	C5 – c6 disc prolapse	64.5	68.9	89.9	78.2	66.3	74.8	91.3	78.4	91.2	83.2