

SURGICAL ANATOMY OF DORSAL ROOT ENTRY ZONE OF CERVICAL SPINAL NERVES : CADAVERIC STUDY

A.Arun Kumar ^{*1}, Sudha Seshayyan ², V.Tamilalagan ³, M.Sindou ⁴.

^{*1} Department of Anatomy, Sri Lakshmi Naryana Institute of Medical Sciences, Puducherry, India.

² Institute of Anatomy, Madras Medical College, Chennai, India.

³ Department of Anatomy, National Institute of Siddha, Chennai, India.

⁴ Department of Neurosurgery, Neurological Hospital P.Wertheimer, University of Lyon, France.

ABSTRACT

Background: The main purpose of this study is to determine the detailed morphometric data of Dorsal Root Entry Zone (DREZ) of cervical spinal nerves. This knowledge is necessary for diagnosis, treatment and surgical management of pain due to many conditions like brachial plexus avulsion injury, post-herpetic neuralgia, phantom pain and cancer pain involved in cervical myelo-radiculopathy. There are fewer studies reported in this field of DREZ.

Materials and Methods: Twenty five adult formalin fixed cadavers are taken for this study. Conventional Spinal cord dissection is followed as per Cunningham's Dissection Manual.

Findings: The parameters included are Number of dorsal rootlets, Longitudinal Length of DREZ, Distance between two successive DREZ, Length of dorsal rootlets, Distance between right and left DREZ, Distance between DREZ and Ligamentum denticulatum, Cranial angles of Superior & inferior rootlets.

Results: Results were noted for all the parameters and are compared with the previous studies. The significant observations are obtained.

Conclusion: Surgical anatomy of Dorsal Root Entry Zone (DREZ) of cervical spinal nerves will be useful for the neurosurgeons doing Drezotomy procedure, in which the nociceptive fibres alone are specifically severed with preservation of other sensations.

KEYWORDS: DREZ, Dorsal Root Entry Zone, Cervical Spinal Nerves, Pain.

Address for Correspondence: Dr.A.Arunkumar, Department of Anatomy, Sri Lakshmi Narayana Institute of Medical Sciences, Osudu, Agaram Village, Villianur Commune, Kudupakkam Post, Puducherry-605502, India. Mobile no: +91 9962972243. **E-Mail:** arivalaganarun@gmail.com

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INTRODUCTION

Dorsal Root Entry Zone (DREZ) is the region on the posterolateral sulcus of spinal cord, where the dorsal rootlets carrying sensory fibers enter into the spinal cord. It is the junction between spinal cord (CNS) and spinal nerves (PNS).

Through these dorsal rootlets, all the sensations are carried to the spinal cord. Number of dorsal rootlets is not constant for all the spinal nerves. Region between entry points of first to last rootlet of one spinal nerve is called as Dorsal

Root Entry Zone of that nerve.

Chronic patients with cancer, brachial plexus avulsion injuries [1,2,3,4], paraplegia[5,6], spinal cord lesions[2,7], peripheral nerve lesions, phantom limb pain[1,8], post herpetic neuralgia[2,9,10]etc., suffer severe intolerable pain. When conservative treatments fail to abolish pain, surgeons prefer any one of the following.

They are:

1. Rhizotomy[11], 2. Sympathectomy,
3. Cordotomy, 4. Neurostimulation,
5. Ganglionectomy[12,13]
6. DREZotomy[14,15,16,17,18,19,20,21,22]

Of these, DREZotomy is considered to be the recent advanced procedure which selectively destroys nociceptive fibres alone and preserve other sensations.

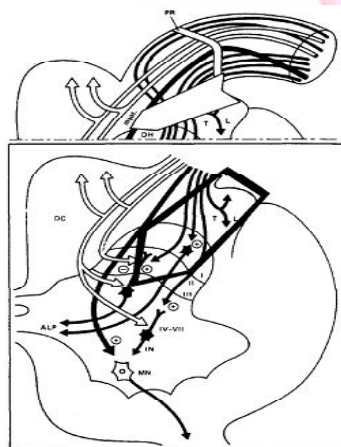
At the root entry zone each rootlet presents medial and lateral divisions. Medial division consists of thickly myelinated fibers. These fibers carry touch, pressure and vibration sensations.

Lateral division consist of thinly myelinated and unmyelinated fibers. These fibers conveys pain and temperature sensations.

In lateral division, the temperature carrying fibers are dorsal and pain carrying fibers are ventral in position. Making an incision along the lateral aspect of the DREZ will cut the pain carrying fibres alone. Other sensations like touch, pressure, vibration and position senses carried by medial division are preserved.

DREZotomy PROCEDURE:

It is done by creating incision and bipolar coagulations on the ventro-lateral aspect of the Dorsal Root Entry Zone. Incision is done at the lateral part of DREZ and medial part of Tract of Lissauer. The incision is about 2 mm depth at an angle of 45°. The incision cuts selectively the nociceptive fibers grouped in lateral division, excitatory medial fibers of tract of Lissauer and hyperactive neurons of dorsal horn.



It is the schematic representation of DREZ and target of micro-DREZotomy[22]. (thanks to Co-author M.Sindou)

Upper part of the schematic representation shows pial ring which divides the rootlet into a

peripheral and a central segment. The transition between the two segments is at the pial ring (PR), which is located approximately 1mm outside the penetration of the rootlet.

As they approach PR, the fine fibers (nociceptive) move toward the rootlet surfaces. In the central segment, they group in the ventrolateral portion of the DREZ, to enter the dorsal horn (DH) through the tract of Lissauer (TL). The large myotatic fibers (myot) are situated in the middle of the DREZ, whereas the large lemniscal fibers are located dorsomedially to reach the dorsal column (DC).

Lower part of schematic representation shows Dorsal Horn (DH) circuitry.

Rexed's laminae are marked from I to VII. MDT (arrowhead) cuts most of the fine and myotatic fibers and enters the medial (excitatory) portion of TL and the apex of the dorsal horn. This procedure preserves most lemniscal presynaptic fibers, the lateral (inhibitory) portion of TL, and most of the DH.

AIM

Aim of this study is to determine the cadaveric morphometric data of Dorsal Root Entry Zone (DREZ) of cervical spinal nerves. Detailed anatomical knowledge of DREZ is necessary for the diagnosis, treatment and surgical management of many diseases. Morphometric data of DREZ has been reported in many previous studies. Previous studies were done in Turkey [23], Georgia [24], China [25], France [16, 17, 18, 19, 20, 21, 22] etc. As for as Indian population are concerned there are no studies available in the field of DREZ. Hence this study is intended to record the basic anatomic data of DREZ of South Indian population.

Knowledge of the parameters mentioned below will be useful for the surgeons in planning the surgeries and management of post-operative complications. They are.,

1. Number of dorsal rootlets.
2. Longitudinal Length of DREZ.
3. Distance between two successive DREZ.
4. Length of dorsal rootlets.
5. Distance between right and left DREZ.
6. Distance between DREZ and Ligamentum denticulatum.
7. Cranial angles of Superior & inferior rootlets.

MATERIALS AND METHODS

MATERIALS:

Twenty five formalin fixed adult human cadavers of South Indian origin are taken for this study from the Institute of Anatomy, Madras Medical College, Chennai. The mean age of this group is 55. Study sample included both male and female cadavers with no history of diseases.

Required materials for dissection are scalpel, BP handle and blades, Bone cutter, Spine saw, spatula, artery forceps, toothed forceps, blunt forceps, chisel, hammer, scissors, hand lens, loupes, gloves, cotton, gauze, token, thread, formalin container,

Required materials for measurement are inch tape, Digital Vernier Caliper – 15 cm, protractor, Digital Camera – used in this study is- Sony (DSC-WX- 150, 18.1 Megapixels).

METHOD:

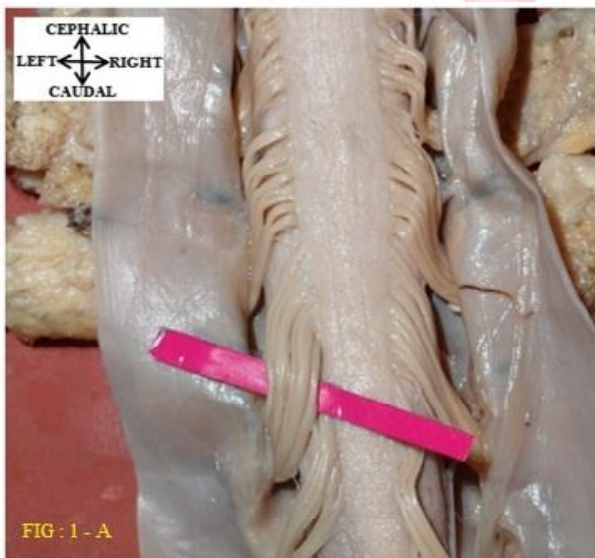
Dissection method is followed as the Conventional dissection method given in the Cunningham’s Manual of Practical Anatomy, Volume Three - Head, Neck and Brain, fifteenth edition, p.no 192 to 202. The spinal cords removed from the cadaver are stored in a formalin filled container. Unique token number for each spinal cord is given. The parameters taken for this study are measured and noted.

RESULTS AND DISCUSSION

1. NUMBER OF DORSAL ROOTLETS:

In this parameter the total number of rootlets present in dorsal root of each cervical spinal

Fig. 1: Dorsal View, shows dorsal rootlets at cervical level.



nerve is counted. These rootlets are the central process of dorsal root ganglion. They enter the spinal cord through the postero lateral sulcus for each spinal nerve. Numbers of rootlets are counted on both sides.

Fig : 1 – A , shows the dorsal surface of the spinal cord at cervical level. Number of dorsal rootlets in cervical level is counted on both sides. The rootlets are variable in thickness.

Table (1a): Observed Results - Number of Dorsal Rootlets (NODR).

Sl. No	SEGMENT	NODR-LEFT (MEAN) (Nos.)	NODR-RIGHT (MEAN) (Nos.)
1	C 1	7.6	7.56
2	C 2	8.56	8.92
3	C 3	6.28	6.88
4	C 4	9.12	9.44
5	C 5	9.96	10.36
6	C 6	7.24	7.4
7	C 7	6.52	6.68
8	C 8	5.48	5.56

Table (1b): Discussion - Number Of Dorsal Rootlets (NODR).

NUMBER OF DORSAL ROOTLETS (NODR)				
AUTHOR	YEAR	CADAVER COUNT	SEGMENT TAKEN FOR STUDY	OBSERVED RESULT (Numbers)
SINDOU ^[22]	1974	-	C4-T1	C2,C3,C4 = 4 C5,C6,C7,C8 = 6
KUBA Y ^[26]	1994	18	C5 – T1	5 to 16
CARGILL H.ALLEYNE,Jr ^[24]	1998	10	C3- T1	C6 = 8.7 T1= 6.7
TANAKA ^[27]	2000	18	C5 – C8	8 to 12
A.KARATAS ^[23]	2004	15	C1 – T1	2 to 13
JIAN-PING XIANG,M.D ^[25]	2007	20	C5 – T1	7.76
Present study	2013	25	C1 – T1	CERVICAL SEGMENTS : Maximum: C5 (10.16 ± 1.595) Minimum: C8 (5.52 ± 0.646)

Previous studies were mainly done for the diagnosis and treatment of brachial plexus injuries. When compared with the present study the observations for the same level, show correlation with the range 3 -10 number of dorsal rootlets in the studies of CARGILL H.

ALLEYNE, Jr[24] et al, TANAKA[27] et al, KUBA Y[26] et al and JIAN-PING XIANG,M.D[25].,et al.

2. LONGITUDINAL LENGTH OF DREZ :

In this parameter, length between superior and inferior rootlet of each dorsal root is measured using a digital vernier caliper and it is noted in millimeters. It is the point of entry of dorsal rootlets into the substance of spinal cord through postero lateral sulcus. It is measured on both sides.

Fig : 2 – A , shows the dorsal surface of the spinal cord at cervical level. Longitudinal length of DREZ in cervical level is measured on Right side.

When compared with the previous studies, the present study shows correlation for this parameter.

Fig. 2-A: Dorsal View, longitudinal length of DREZ at Cervical level.



Table (2-A): Observed results of longitudinal Length of DREZ(LLODREZ).

Sl. No	SEGMENT	LLODREZ-LEFT MEAN - mm	LLODREZ-RIGHT MEAN - mm
1	C 1	5.64	5.75
2	C 2	7.45	7.93
3	C 3	11.62	11.45
4	C 4	12.47	12.54
5	C 5	13.12	12.91
6	C 6	10.1	9.98
7	C 7	10.88	10.3
8	C 8	10.03	10.1

Table (2b): Discussion of Longitudinal Length of Drez (LLODREZ).

LONGITUDINAL LENGTH OF DREZ (LLODREZ)				
AUTHOR	YEAR	CADAVER COUNT	SEGMENT TAKEN FOR STUDY	OBSERVED RESULT(mm)
KUBA Y ^[26]	1994	18	C5 – T1	6 – 14 mm, Lower cervical segment – Decreases
CARGILL H.ALLEYNE,Jr ^[24]	1998	10	C3- T1	C7 = 10.7 mm (range 8-16) C4= 12.7 mm (range 10-16)
A.KARATAS ^[23]	2004	15	C1 – T1	4.3 – 17.7 LONGEST – C5
Present study	2013	25	C1 – T1	CERVICAL SEGMENTS : Maximum: C5 (13.01 ±1.380) Minimum : C1 (5.70 ± 0.781)

3. DISTANCE BETWEEN SUCCESSIVE DREZ:

In this parameter the distance between successive spinal segments is measured. This measurement is done by measuring the distance between inferior rootlet of spinal nerve above to the superior rootlet of spinal nerve below. This measurement is done on both sides. Measurement is taken using digital vernier caliper and it is noted in millimeters.

Fig: 3 – A , shows the dorsal surface of the spinal cord at cervical level. Distance between successive DREZ in cervical level is measured on left side.

Fig. 3: Distance between successive DREZ at Cervical level.



The present study showed, distance between successive DREZ is maximum at the interval C2 & C3 (2.42 ± 1.272) and minimum at the interval C7 & C8 (0.56 ± 1.010). This parameter is reported for the first time. There are no previous studies for discussion.

Table (3a): Observed results of Distance Between Successive DREZ (DBSDREZ).

SI. No	SEGMENT	DBSDREZ-LEFT MEAN - mm	DBSDREZ-RIGHT MEAN - mm
1	C ₁ &C ₂	1.92	1.6
2	C ₂ &C ₃	3.24	1.61
3	C ₃ &C ₄	2.03	2.42
4	C ₄ &C ₅	1.81	1.67
5	C ₅ &C ₆	1.29	1.24
6	C ₆ &C ₇	1.45	1.84
7	C ₇ &C ₈	0.54	0.59
8	C ₈ &T ₁	0.4	0.69

4. DISTANCE BETWEEN LEFT AND RIGHT DREZ:

In this parameter the distance between left and right DREZ of same segment is measured. Measured using digital vernier calipers and noted in millimeters.

Fig : 4 – A , shows the dorsal surface of the spinal cord at cervical level. Distance between left and right DREZ at cervical level is measured.

Fig. 4: Dorsal View, Distance between Left& Right DREZ at Cervical level.



Table (4a): Observed Results of Distance Between Left And Right DREZ (DBL&RDREZ).

SI. No	SEGMENT	DBL&RDREZ (MEAN) (mm)
1	C 1	6.44
2	C 2	6.85
3	C 3	6.83
4	C 4	6.34
5	C 5	6.82
6	C 6	7.15
7	C 7	6.2
8	C 8	4.86

Table (4b): Discussion of Distance Between Left And Right DREZ (DBL&RDREZ).

DISTANCE BETWEEN LEFT & RIGHT DREZ (DBL&RDREZ)				
AUTHOR	YEAR	CADAVER COUNT	SEGMENT TAKEN FOR STUDY	OBSERVED RESULT(mm)
KUBA Y ^[26]	1994	18	C5 – T1	5 to 9 mm LONGEST = C6
KARATAS ^[23]	2004	15	C1 – T1	2.2 to 9.4 mm LONGEST - C2 & C3 LOWER CERVICAL SEGMENT- DECREASES
JIAN-PING XIANG,M.D ^[25]	2007	20	C5 – T1	5.90 mm C5 = 3.54 mm T1 = 2.23 mm
Present Study	2013	25	C1 – T1	CERVICAL SEGMENTS : Maximum: C6(7.15 ± 0.494) Minimum: C8(4.86 ± 0.628)

When compared with the previous studies, the present study shows correlation for this parameter. In this present study, distance between left & right DREZ showed maximum at C6 segment, minimum in C8.

5. LENGTH OF DORSAL ROOTLETS :

In this parameter the length of dorsal rootlets from postero-lateral sulcus to the point where it pierces the duramater is measured. This measurement is taken for the middle rootlet using a digital vernier caliper and noted in millimeters. Length of dorsal rootlets is measured on both sides.

Fig : 5 – A , shows the dorsal surface of the spinal cord at cervical level. This picture shows length of dorsal rootlets at cervical level.

Fig. 5: Dorsal View, shows length of dorsal rootlets at cervical level.



Table (5a): Observed results of Length of Dorsal Rootlets (LODR).

Sl. No	SEGMENT	LODR-LEFT (MEAN)(mm)	LODR-RIGHT (MEAN) (mm)
1	C 1	7.1	6.92
2	C 2	9.08	9.04
3	C 3	11.1	10.94
4	C 4	10.61	10.46
5	C 5	12.93	12.82
6	C 6	15.17	14.56
7	C 7	17.88	16.8
8	C 8	18.69	17.94

Table (5b): Discussion of Length of Dorsal Rootlets (LODR).

LENGTH OF DORSAL ROOTLETS (LODR)				
AUTHOR	YEAR	CADAVER COUNT	SEGMENT TAKEN FOR STUDY	OBSERVED RESULT (mm)
KUBA Y ^[26]	1994	18	C5 – T1	2- 21 (SHORTEST) 11 – 29 (LONGEST)
CARGILL H.ALLEYNE., Jr ^[24]	1998	10	C3- T1	C5 = 15.1 (SUP ROOTLET) C5 = 11.4 (INF ROOTLET)
TANAKA ^[27]	2000	18	C5 – C8	14 to 26
KARATAS ^[23]	2004	15	C1 – T1	5- 28 (SHORTEST) 6.8 – 30.3 (LONGEST)
Present study	2013	25	C1 – T1	CERVICAL SEGMENTS : Maximum: C8 (18.32 ± 1.203) Minimum: C1 (7.01 ± 0.972)

When compared with KUBA Y[26] et al and A.KARATAS[23] et al studies with respect to the length of dorsal rootlets, longest length alone correlates with the present study.

The studies done by CARGILL H.ALLEYNE., Jr[24] et al and TANAKA[27] et al shows correlation with present study.

6. DISTANCE BETWEEN DREZ & LIGAMENTUM DENTICULATUM:

In this parameter the distance between DREZ and ligamentum denticulatum at the same level is measured. Distance is measured on both sides using digital vernier caliper and noted in millimeters.

Fig : 6 – A , shows the dorsal surface of the spinal cord at cervical level. Distance between DREZ and ligamentum denticulatum at cervical level is measured on left side.

The present study shows maximum DBDREZ & LD is at C4 (5.63 ± 0.691) and minimum at C1 (3.73 ± 0.508). This parameter is reported for the first time. There are no previous studies for discussion.

Fig. 6 – A: Dorsal view , distance between DREZ & Ligamentum Denticulatum at cervical level.

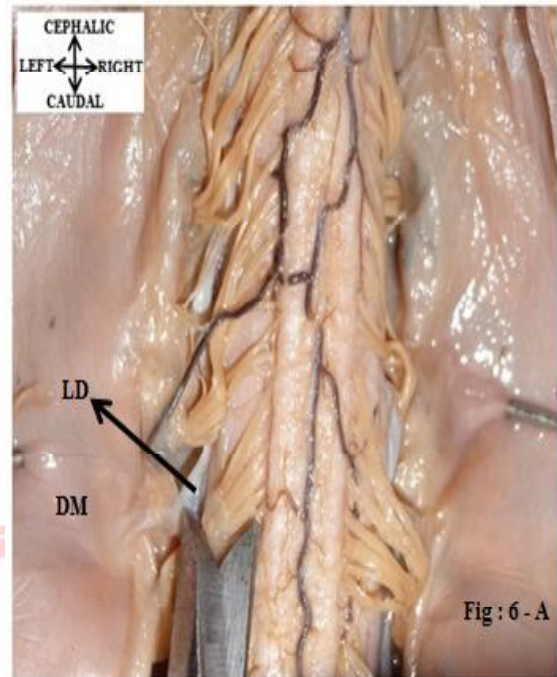


Table (6a): Observed results of Distance Between DREZ & Ligamentum Denticulatum (DBDREZ&LD):

SL.NO	SEGMENT	DBDREZ&LD (LEFT) (MEAN) (mm)	DBDREZ&LD(RIGHT) (MEAN) (mm)
1	C 1	3.78	3.69
2	C 2	5.12	4.9
3	C 3	5.4	5.12
4	C 4	5.71	5.55
5	C 5	5.1	5.01
6	C 6	4.63	4.73
7	C 7	4.51	4.54
8	C 8	4.5	4.43

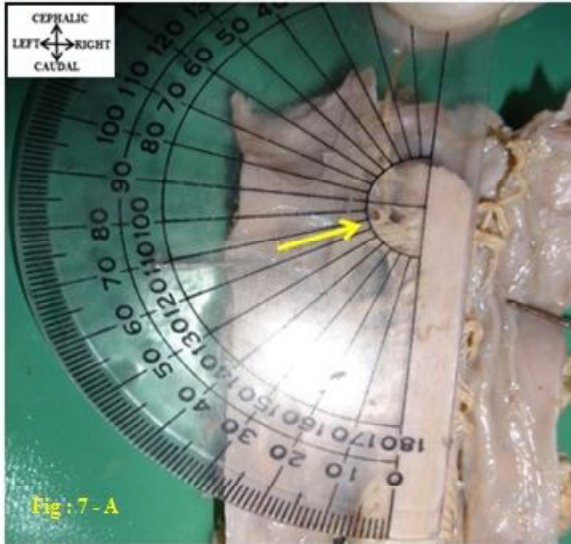
7. CRANIAL ANGLE OF SUPERIOR AND INFERIOR ROOTLET OF EACH SPINAL SEGMENT:

A. CRANIAL ANGLE OF SUPERIOR ROOTLET:

In this parameter the angle formed in the cranial aspect at the point where the superior or inferior rootlet enters postero-lateral sulcus is measured. Cranial angle is measured using protractor on both sides and noted in degrees.

Fig : 7 – A , shows the dorsal surface of the spinal cord at cervical level. Angle formed in between superior rootlet and posterolateral sulcus in cranial aspect is noted using protractor.

Fig. 7-A: Dorsal View, yellow arrow – Superior Rootlet, shows cranial angle of superior rootlet with posterolateral sulcus of spinal cord.



B. CRANIAL ANGLE OF INFERIOR ROOTLET:

Fig : 7 – B , shows the dorsal surface of the spinal cord at cervical level. Angle formed in between inferior rootlet and posterolateral sulcus in cranial aspect is noted using protractor.

Fig. 7 – B: Dorsal View, yellow arrow – Inferior Rootlet, shows cranial angle of inferior rootlet with posterolateral sulcus of spinal cord.

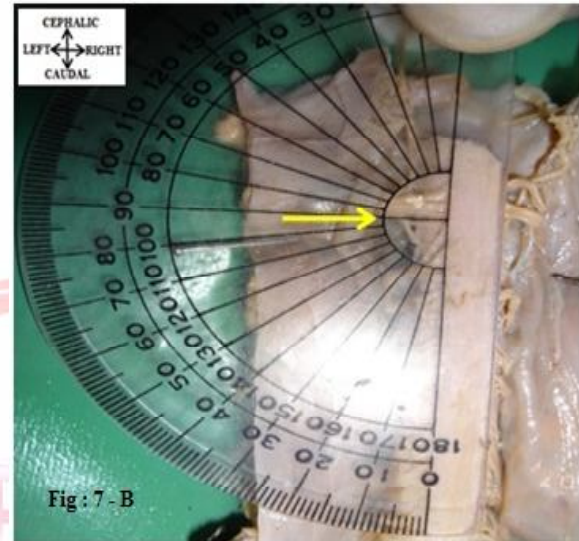


Table (7a): Observed results of Cranial Angle of Superior And Inferior Rootlet of Each Spinal Segment (CAOSR).

SL. NO	SEGMENT	CAOSR-LEFT (MEAN) (°)	CAOSR-RIGHT (MEAN) (°)
1	C 1	111.6	108.8
2	C 2	121.2	119.2
3	C 3	138	135.2
4	C 4	143.6	141.2
5	C 5	121.8	120
6	C 6	146.8	146
7	C 7	144.4	144
8	C 8	144	143.6

According to CARGILL H.ALLEYNE.,Jr [24] et al cranial angle of superior rootlet at C5 (116°) is minimum. In the present study, when compared among the cervical segments cranial angle of superior rootlet at C1 (110°) is minimum. The present study shows CAOSR is maximum at C5 and minimum at C1 segment.(Ref : Fig 7-A).

Table (7b): Discussion of Cranial Angle of Superior and Inferior Rootlet of Each Spinal Segment (CAOSR).

CRANIAL ANGLE OF SUPERIOR ROOTLET (CAOSR)				
AUTHOR	YEAR	CADAVER COUNT	SEGMENT TAKEN FOR STUDY	OBSERVED RESULT (in degrees)
CARGILL H.ALLEYNE.,Jr [24]	1998	10	C3- T1	C5 = 116° Smallest T1 = 156° Largest
Present study	2013	25	C1 –T1	CERVICAL SEGMENTS : Maximum : C5 (144.20 ± 5.379) Minimum : C1 (110.20 ± 8.204)

The present study shows CAOIR is maximum at C8 segment. Then it decreases in cranial direction, minimum in C1 (Ref : Fig 7-B).

Table (8a): Observed results of Cranial Angle of Inferior Rootlet of Each Spinal Segment (CAOIR).

SL.NO	SEGMENT	CAOIR-LEFT (MEAN) (°)	CAOIR-RIGHT (MEAN) (°)
1	C 1	91.2	92.8
2	C 2	100	101.6
3	C 3	115.2	115.6
4	C 4	116.8	117.6
5	C 5	129.2	123.2
6	C 6	130	129.6
7	C 7	130.4	125.2
8	C 8	135.2	126

Table (8b): Discussion of Cranial Angle of Inferior Rootlet of Each Spinal Segment (CAOIR).

CRANIAL ANGLE OF INFERIOR ROOTLET (CAOIR)				
AUTHOR	YEAR	CADAVER COUNT	SEGMENT TAKEN FOR STUDY	OBSERVED RESULT (in degrees)
CARGILL H.ALLEYNE.,Jr [24]	1998	10	C3- T1	C6 = Smallest C5 = next smallest
JIAN-PING XIANG,M.D [25]	2007	20	C5 – T1	65.6 to 19.8
Present study	2013	25	C1 – T1	CERVICAL SEGMENTS : Maximum : C8(130.60 ± 8.184) Minimum : C1 (92.00 ± 8.081)

CONCLUSION

Surgical anatomy of Dorsal Root Entry Zone (DREZ) of cervical spinal nerves will be useful for the neurosurgeons doing Drezotomy procedure, in which the nociceptive fibres alone are specifically severed with preservation of other sensations. The cadaveric data also helps the neuro surgeons to avoid injury to neural structures as well as to avoid post-operative complications. The highest and lowest rootlet number may be a useful intra-dural surgical landmark.

These cadaveric data will be useful in the understanding and treatment of lesions compressing the intra dural nerve roots. It will also help in other intra dural procedures like intra dural nerve stimulation, endoscopic navigation [28] etc.

The cadaveric data may also help in clinical neurophysiology to correlate with any discrepancies in the clinical symptoms and signs or electrophysiological findings with the site of pathology.

The cadaveric data will also be useful for imaging specialists in the interpretation of CT and MRI of spinal cord.

When compared to other surgical procedures, DREZotomy procedure preserves most lemniscal presynaptic fibers, inhibitory portion of tract of Lissauer (lateral portion) and most of dorsal horn. The pain relief from this procedure is long lasting and permanent.

ABBREVIATIONS:

DREZ - Dorsal Root Entry Zone
 C - Cervical
 T - Thoracic
 LD - Ligamentum Denticulatum
 DR - Dorsal Rootlets
 DM - Duramater
 SPR - Selective Posterior Rhizotomy
 MDT - Microsurgical Drezotomy
 TL - Tract of Lissauer
 DH - Dorsal Horn
 DC - Dorsal Column
 PR - Pial Ring
 MN - Motor Neuron
 IN - Inter Neuron
 MYOT - Myotactic fibres
 NODR - Number of Dorsal Rootlets
 LODR - Length of Dorsal Rootlets
 LLODREZ - Longitudinal Length of DREZ

DBSDREZ - Distance between successive DREZ
 DBL&RDREZ - Distance between Left & Right DREZ
 DBDREZ&LD - Distance between DREZ & Ligamentum Denticulatum
 CAOSR - Cranial Angle of Superior Rootlet
 CAOIR - Cranial Angle of Inferior Rootlet

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Conflicts of Interests: None

REFERENCES

- [1]. Campbell. JM. The Hopkins experience with lesions of dorsal horn for pain from avulsion of brachial plexus. *Appl. Neurophysiol* 1988;51:170-174.
- [2]. Friedman AH, Bullitt E. Dorsal root entry zone lesions in the treatment of pain following brachial plexus avulsion, spinal cord injury and herpes zoster. *Appl. Neurophysiol* 1988;51:164-169.
- [3]. Friedman AH, Nashold Jr BS, Bronec P. Dorsal root entry zone lesions for the treatment of brachial plexus avulsion injuries, a follow-up study: *Neurosurgery* 1988;22:369- 373.
- [4]. Thomas DG. Dorsal root entry zone lesions in brachial plexus avulsion : *Neurosurgery* 1984;15:966-968.
- [5]. Botterell. EH. Pain in paraplegia : clinical management and surgical treatment: *Proc R Soc Med* 1954;47:281-288.
- [6]. Nashold Jr BS, Bullitt E. Dorsal root entry zone lesions to control central pain in paraplegics. *J.Neurosurg* 1981;55:414-419.
- [7]. Friedman AH, Nashold Jr BS. DREZ lesion for relief of pain related to spinal cord injury: *J Neurosurg* 1986;65:465-469.
- [8]. Saris SC, Iacono.RP, Nashold BS Jr. Dorsal root entry zone lesions for post amputation pain: *J Neurosurg* 1985;62:72-76.
- [9]. Friedman AH. Dorsal root entry zone lesions for the treatment of post herpetic neuralgia: *Neurosurg* 1984;15:969-970.
- [10].Friedman AH, Nashold Jr BS, Ovelman-Levitt J. Dorsal root entry zone lesions for the treatment of POST HERPETIC NEURALGIA : *J Neurosurg* 1984; 60:1258-1262.
- [11]. Seoville. W.B. Extradural spinal sensory rhizotomy. *J.Neurosurg* 1966;25:94-95.
- [12].Osgood.C.P, Dujovny.M, Faille.R, Abassy.M. Microsurgical ganglionectomy for chronic pain syndromes. *J.Neurosurg* 1976;45:113-115.
- [13]. Smith.F.P. Trans-spinal ganglionectomy for relief of intercostals pain. *J.Neurosurg* 1970;32:574-577.
- [14]. Charles E, Rawlings III. The DREZ procedure : An update on technique. *British Journal of Neurosurgery* 1989;3:633-642.

- [15]. Nashold Jr BS. The DREZ operation : modern techniques in surgery : Neurosurgery 1984;35:1–17.
- [16]. Sindou.M, Fischer.G, Goutelle.A, Schott.B, Mansuy.L. La radicellotomie posterieure dans le traitement des spasticites.Rev.neurol. 1974 b;130:201-215.
- [17]. Sindou.M, Fischer.G, Mansuy.L. Posterior spinal rhizotomy and selective posterior rhizidotomy. Prog. Neurol.surg. 1976;7:201-205.Basel;karger
- [18]. Sindou.M, Keravel,Y. Analgesie par la method d'electro stimulation transcutanee. Neurochirurgie 1980;26:153–157.
- [19]. Sindou.M, Fischer.G, Goutelle.A, Allegre.G.E. Microsurgical selective posterior rhizotomy (69 cases). Pain 1981;suppl.1, abstract no.354,289.
- [20]. Sindou.M, Lapras, C. Neurosurgical treatment of pain in the Pancoast-Tobias syndrome: selective posterior rhizotomy and open anterolateral C2-cordotomy.In; Advances in Pain Research and Therapy1982;.4:199-209.
- [21]. Sindou.M And A.Gotelle. Surgical posterior rhizotomies for the treatment of pain: Advances and Technical Strandards in Neurosurgery Vol.10. Springer-Verlag Wien New York: 193;147-185.
- [22]. Sindou.M. Microsurgical DREZotomy(MDT) for pain, spasticity and hyperactive bladder: a 20-year experience: Acta Neurochir (wien) 1995;137:1-5.
- [23]. Karatas.A, Caglar.S, Savas.A, Elhan.A And Erdogan.A. Anatomical Research: Microsurgical anatomy of the dorsal root entry zones : Springer-Verlag 2004.
- [24]. Cargill.H Alleyne, Jr., M.D., C.Michael Cawley,M.D., Danieal L.Barrow, M.D, And Gary D.Bonner,M.B.A. Microsurgical Anatomy of the dorsal cervical nerve roots and the cervical dorsal root ganglion / ventral root complexes: Elsevier Science Inc, Surg Neurol 1998;50:213-218.
- [25]. Jian-Ping Xiang,M.D, Xiao-Ling Liu,M.D, Yang-Bing Xu,M.D, Jian-Yun Wang,M.D, And Jun Hu, M.D. Microsurgical anatomy of dorsal root entry zone of brachial plexus : Wiley-Liss,Inc. Microsurgery 2008;28:17–20.
- [26]. Kuba. Y, Waga.S, Kojima.T, Matsubara.T, Kuga.Y, Nakagawa.Y. Microsurgical anatomy of the lower cervical spine and cord : Neurosurgery 1994;34:895–890:discussion 901-902.
- [27]. Tanaka.N, Fujimoto.Y, AN HS, Ikuta.Y, Yasuda.M. The anatomic relation among the nerve roots , intervertebral foramina and intervertebral discs of the cervical spine : Spine (Phila Pa 1976) 2000;25:286-291.
- [28]. Takuya Fujimotoa. Visualization of sacral nerve roots via percutaneous intraspinal navigation (PIN) : Spine 2005.
- [29]. Cunningham's Manual Of Practical Anatomy: Fifteenth edition, Volume -3, Head, Neck and Brain., p.no-192-202.
- [30]. Datta.A.K (3rd edition): Essentials of Neuroanatomy, Current Books International, Kolkatta. p.no: 209-234.

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