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Original Research Article

OSTEOLOGICAL STUDY TO RELATE AURICULAR SURFACE EXTENT IN SACRUM WITH PREVALENCE OF LUMBOSACRAL TRANSITIONAL VERTEBRA

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ABSTRACT

Introduction: Lumbosacral transitional vertebra (LSTV) is one of recognized morphological variant associated with back pain. As sacrum has very crucial role in weight transmission via sacroiliac joint, any change in morphology of auricular surface of sacrum should have impact in morphology of lumbosacral region.

Aim: To study relation between the variable extent of auricular surface in Sacrum and prevalence of Lumbosacral Transitional Vertebra (LSTV) along with changes in morphological index.

Materials and Methods: Present study was done by taking total 40 adult dry human sacra of both sexes which were collected from the Department of Anatomy at Himalayan Institute of Medical Sciences, SRHU, Dehradun. All sacra were initially divided into two sacral groups of normal sacra and atypical sacra based on absence and presence of any type of lumbosacral transitional vertebra (LSTV) respectively. Further each group subcategorized into three, namely A (normal sacra), B (high sacra) and C (low sacra) based on extend of auricular surface. Metric traits like maximum auricular length, maximum sacral length, maximum sacral width and sacral index were measured and compared.

Result: In this study sacra with higher type of auricular surface were found to be associated with more incidence of sacralization whereas sacra with lower type of auricular surface were associated with lumbarization. There was significant difference noticed in mean sacral index of these two sacral groups. Sacral index in sacral group with LSTV (Mean 95.06) was found to be less on comparing with sacral group without LSTV (Mean 108.20). Increased mean maximum sacral length (mean 109.62) seen in sacral group with LSTV without significant change in maximum sacral width (mean 103.75) which can be due to shift of weight transmission axis from lower sacral vertebrae to higher vertebrae.

Conclusion: Variable extents of auricular surface of sacrum are associated with variant of lumbosacral transition vertebra due to change in biomechanics of weight transmission. Thus this study may be helpful to clinicians to predict and treat root cause of LSTV associated back pain.

KEY WORDS: Lumbosacral transitional vertebra, Lumbarization, Sacralization.

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INTRODUCTION

Body weight is transmitted bilaterally to the ilium from sacrum through the strong sacroiliac articulation and associated ligaments and muscles and therefore variations in sacrum morphology are common. Most of the morphological variations are load related fusion or dissociation. Apart from this, sacrum has been studied in reference to sexual dimorphism. Inverted 'L' shaped auricular surface on lateral mass of sacrum has important role in weight transmission. Different studies showed significant linear relationship between the areas of the auricular surface versus that of the lunate surface of acetabulum of hip bone. A positive correlation between the length of auricular surface and length of sacrum has been noticed by researchers. Study by Pal et al (1988) showed auricular surface of sacrum normally extend from first sacral vertebra to middle of third sacral vertebra [1].

Auricular surface area or its sacral extension level indicates magnitude of participation in weight transmission. Any variation in extent of auricular surface can alter the dynamics of load transmission at the lumbosacral and sacroiliac articulations. Morphological variations due to altered dynamics may lead to Lumbosacral Transitional Vertebrae (LSTV). LSTV are recognized common congenital anatomical variant extending from sacralization of fifth lumbar vertebra to lumbarization of first sacral vertebra. Bertolotti et al was first who explained the association between LSTV and low back pain [2]. Numerical abnormalities due to complete type of LSTV may lead to improper counting of spines with serious consequences in spinal surgeries and spinal anesthesia [3]. The high incidence of low back pain, intervertebral discs prolapse and its association with LSTV attracted the attention to study role of auricular surface in it.

MATERIALS AND METHODS

Total 40 adult dry human sacra of both sexes were collected from the Department of Anatomy at Himalayan Institute of Medical Sciences, Dehradun (Uttarakhand). All 40 sacra were primarily divided into two groups based on absence and presence of LSTV

Normal sacral group (Nor Sac): included sacra without LSTV

Atypical sacral group (Aty Sac): includes sacra with presence of any type of LSTV

Each of the two groups further categorized into subgroups (A, B, C) based on extend of auricular surface [4].

Group A (Normal): sacra with auricular surface extending from upper part of first sacral vertebra to middle of third sacral segment [Fig.1]

Group B (High type): included sacra with auricular surface beginning from high above of first sacral segment and terminating just above of third sacral segment (fifth lumbar vertebra not included if sacralization of fifth lumbar segment was present) [Fig.2]

Group C (Low type): included all those sacra having auricular surface starting from lower mid half of first sacral segment to inferior part of third sacral segment (first sacral vertebra included if lumbarization of first sacral segment was present) [Fig.3]

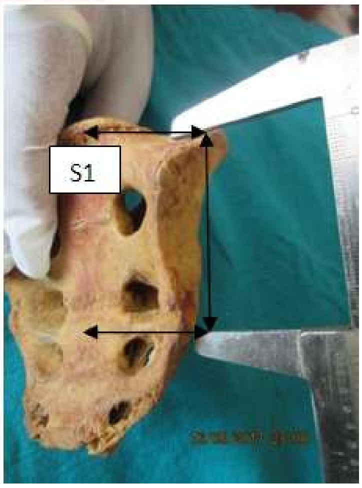

Fig. 1: Group A normal sacra

S1: First sacral segment

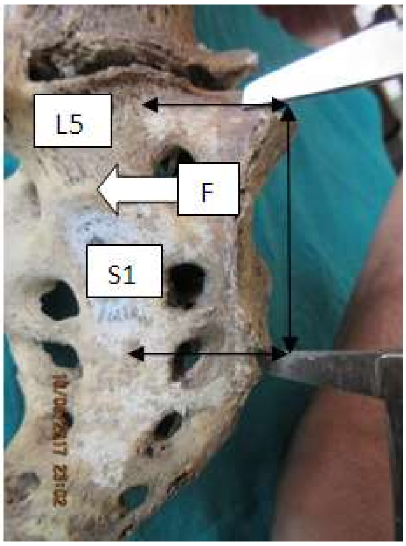

Fig. 2: Group B high sacra

S1: First sacral segment

F: Fused sacral segment

L5: Fifth lumbar vertebra

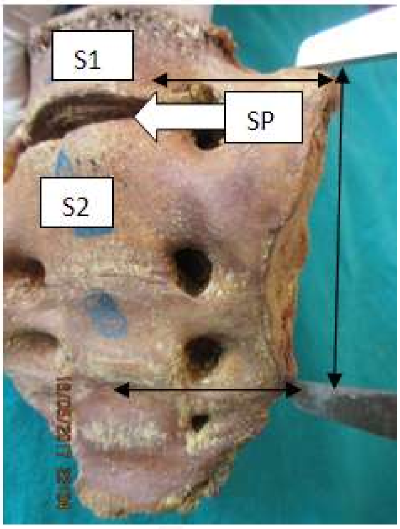

Fig. 3: Group C low sacra

S1: First sacral segment
S2: Second sacral segment
SP: Separated sacral segment

With the help of sliding caliper maximum length of auricular surface, maximum length of sacrum and maximum width of sacrum were measured and recorded in millimeters. Sacral index of all sacra was later calculated using formula,

Sacral Index = (Maximum width of sacrum **/** Maximum length of sacrum) × 100

Sacral Index (SI) calculated and compared among two groups namely Normal (Nor Sac) and Atypical sacral (Aty Sac) group.

Fig. 4: AL Max Maximum auricular length

Fig. 5: SL Max Maximum sacral length

Fig. 6: SW Max Maximum sacral width

Maximum auricular length (AL Max): distance measured between the highest point on upper part of auricular surface and the lowest point on lower part of auricular surface [Fig. 4]

Maximum sacral length (SL Max): distance measured from mid sacral promontory to the lowest point on sacrum from pelvic surface [Fig. 5]

Maximum sacral width (SW Max): distance measured between the two extreme lateral ends of the ala [Fig. 6]

OBSERVATIONS

On external examination of all sacra, total 8 sacra (20%) were noted with presence of Lumbosacral Transitional Vertebrae.

In 3 sacra following features were observed [Fig. 2]

* Complete fusion between fifth lumbar vertebra and first sacral segment
* High type of auricular surface i.e. belongs to Group B
* Appeared as false low type (due to fusion of L5)
* Sacral foramina five in number
* Ala formed by fifth lumbar vertebra

In 5 sacra features observed were [Fig.3]

* Partial separation present between first and second sacral segment
* Low type of auricular surface i.e. belongs to Group C
* Sacral foramina four in number
* Second sacral segment had more robust ala like structure

Statistical analysis

Sacral index was calculated by using formula

Sacral Index = (Maximum breath of sacrum / Maximum length of sacrum) × 100

Statistical analysis was performed using Statistical Program for Social Sciences (SPSS) software version 20.

Table 1: Statistical results of different metric traits measured.

	Parameters	AL Max (Rt+Lft) (n=80)	SL Max (n=40)	SW Max (n=40)	SI (n=40)
1	Mean	58.22	100.27	105.27	105.58
2	Standard error	0.52	1.53	1.05	1.38
3	Median	58.5	99	106.5	105.95
4	Mode	61	99	104	101.8
5	Standard deviation	± 4.73	± 9.68	± 6.67	± 8.73
6	Range	42-70	82-126	85-119	79.3-121.5

Statistical result of unpaired't' test performed between sacral group without LSTV (Nor Sac) and sacral group with LSTV (Aty Sac). The $p < 0.05$ was considered as statistically significant.

Table 2: Comparative statistical analysis.

	Parameters	Normal sacra (n=32)	Atypical sacra (n=8)	P value	Significant (p<0.05)
1	Mean SL Max	97.93	109.62	0.007	Significant
2	Mean SW Max	105.65	103.75	0.607	Not significant
3	Mean SI	108.2	95.06	0.011	Significant
4	Mean AL Max (right)	57.68	59.5	0.48	Not significant
5	Mean AL Max (left)	57.9	60.37	0.22	Not significant

DISCUSSION

Prevalence of LSTV varies from 4-35%. Cheng & Song (2003) reported 2% lumbarization, which was very less in comparison to incidence of sacralization in general population [5]. In present study incidence of lumbosacral transition vertebra was observed in 20% of sample taken. Complete lumbarization of the first sacral vertebrae is rare & less reported. The bony pelvis is divided into two arches by a trans-acetabular plane. Posterior arch formed of the upper three sacral vertebrae and strong pillars of bone from the sacroiliac joints to the acetabular fossa. Anterior arch formed by the pubic bones and their superior rami. Posterior arch is concerned with weight transmission whereas posterior arch function as tie beam preventing separation [6]. GP Pal et al observed strong trabeculae pattern extending from the superior surface of the body towards the auricular surface which supports the idea stating that sacrum as a fused mass has role in transfer of body weight towards sacroiliac joint [1]. Jaffar et al (2005) in his Finite Element Analysis model showed that stress distribution (when a 70kg load was applied) using the Von Mises Stress Method was mainly in acetabulum (32.5 %) , auricular surface of SIJ (24.6%) and ischial tuberosity (40.3%) [7]. It is considered that the ability to dissipate load depends on auricular size and its surface area with the sacroiliac joint. Ligaments like sacrotuberous and sacrospinous, act as a strong mechanical beams. Ligament having more vertical inclination are more effective ligament, as in sacrotuberous ligament extending from ala to ischial tuberosity instead of horizontal as in sacrospinous ligament [8]. The thick and strong posterior sacroiliac ligament has direct contribution to stability of sacroiliac joint.

In normal sacra of **Group A,** the body weight from above is primarily dissipated through first two sacral and mid of third sacral segment. This statement was further supported by the presence of robust costal elements, prominent trabecular pattern, sudden narrowing below auricular surface and extent of auricular surface [Fig 1]. In sacra of **group B,** biomechanics of weight transfer changes due to higher shift of auricular surface leading to morphological changes which includes involvement of fifth lumbar vertebra to variable extent, presence of more stronger ilio-lumbar and lumbosacral ligaments and presence of extra articular facets . In my present study morphological changes noticed were complete sacralization of fifth lumbar vertebra, presence of robust upper coastal elements, sudden tapering of lower sacral segments were below auricular surface (below second sacral segment) and comparatively more acute or sloppy ala [Fig 2]. In **group C** with low type auricular surfaces, has body weight transfer via lower (second and third sacral segment) sacral segments. This altered direction of body weight transfer causes morphological changes like separation of first and second sacral segment that may be due to reduced role of first sacral segment in weight transfer and abrupt tapering of lower sacral segments below third sacral segment [Fig 3].

Higher type of auricular surface has more acute angle of weight transfer to sacroiliac joint [9].

Accessory facets in addition to normal can be seen in high type of auricular surface. In present study only two sacra were noticed with accessory facets. GP Pal noticed that normally the plane of the facet joints which gradually moves away from the vertebral body to support weight as a tripod has trend is in decreasing order from low auricular surface to high type[10,11].

In this present study, statistically significant difference was seen in some parameters of two sacral groups made. Maximum sacral length (SL Max) was found to be increased in atypical sacral group (with LSTV) whereas there was no significant difference was observed in maximum sacral width (SW Max) of two groups. This resulted in significant decrease in mean sacral index (95.06) of atypical group of sacrum (with LSTV) in comparison to normal sacral group (mean SI 108.20). This decrease in mean sacral index of atypical sacral group (with LSTV) can be explained as a result of higher shift of weight transmission in most cases along with increased maximum sacral length in mid-saggital plane.

Clinical significance: Jaffar et al in their study of stress analysis of hip bone found that both the lunate and auricular surfaces are involved in force transmission through the hip bone [7]. Aihara et al found in cadaveric study that the iliolumbar ligaments immediately above transitional vertebrae are thinner and weaker than those in cadavers without lumbosacral transition vertebrae [12]. The weak ilio-lumbar ligaments results in vertebral segment instability, early disc degeneration and bony union between vertebra and sacrum due to adaptive mechanism to compensate and to preserve stability. In 1980, McCulloch and Waddell proposed that the functional fifth lumbar nerve root always originates from the "last mobile" segment of the spine [13]. Chang et al. agreed, concluding that neurologic symptoms caused by the sixth lumbar nerve root compression resemble those of the fifth lumbar rather than the first sacral nerve root compression in the normal configuration [5]. Other researchers like Hinterdorfer et al. found no significant alteration [14]. Seyfert S (1997) with careful use of cremasteric reflex concluded that lumbarization shows a dermatome gap between the lumbar and the sacral dermatomes which make it difficult to find the pain generator [15]. Surgeons must consider occasional presence of vascular variation along with transitional vertebrae. LSTV may produce low back pain due to arthritic changes occurring at the site of pseudoarthrosis, disc herniation or degeneration and spinal canal stenosis

CONCLUSION

The sacroiliac joint on the side of transition results in changed dynamic of body weight transmission leading to greater wear and irritation of the joint. Early identification of type of auricular surface in sacra can help to predict and identify potential presence of transition vertebrae and associated back pain. Auricular surface status and subtype of transition vertebra would allow clinicians to correlate well and be alert during giving epidurals or selective nerve root blocks.

ABBREVIATIONS

LSTV: lumbosacral transition vertebra

Nor Sac: normal sacral group

Aty Sac: atypical sacral group

SI: sacral index

AL Max: maximum auricular length

SL Max: maximum sacral length

SW Max: maximum sacral width

Conflicts of Interests: None

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