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Original Article

Anatomical and Radiological Study of Adult Human Sacrotuberous Ligament and Its Relation to the Sacroiliac Joint

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ABSTRACT

Introduction: Low back pain (LBP) is an important problem that increased nowadays and affects quality of life. Sacroiliac joint (SIJ) is one of the important causes of LBP in about 15%_25% of the cases. Sacrotuberous ligament (STL) is a part of the fibromuscular network of the joint that may alter its biomechanics and become a diagnostic or management tool in dealing with LBP patients and sacroiliitis.

Aim of the Work: The study aimed to give an anatomical and radiological review of the STL and correlate it with LBP and sacroiliitis.

Materials and methods: Cadaveric study: 20 formalin fixed and 20 fresh frozen specimens of adult male human hip, gluteal and upper thigh were dissected exposing the STL and surrounding communications, also the pelvic cavity was dissected. The length and width of the ligament were measured and calculated as Mean ±SD.

Radiological study: In a retrospective study, 35 pelvic reconstructed CT scans were collected from adult human male ranging from 20-40 years old and divided into three groups: 2 control groups, group (A): no LBP nor sacroiliitis, group (B): LBP but no sacroiliitis and group (C): LBP and sacroiliitis and this group was further subdivided into: group (C-): Normal STL and group (C+): Redundant free limb of the STL. Shape and length of STL in each group and measurements were statistically analyzed.

Results: In cadaveric study: STL was divided to three limbs: two attached, one extending from posterior superior iliac spine to back of S3 and its length ranged from 20mm-35mm in formalin fixed specimens and from 32.9mm-44mm in fresh frozen specimens, and the other one extending from back of S3 to back of S5 and back of the coccyx and measured 28.1mm-38.4mm in formalin fixed specimens and from 35.2mm-45mm in fresh frozen specimens. The third limb (free limb) extending from the previous point to midpoint of medial surface of ischial tuberosity and its mean length was 45.21± 6.04mm in formalin fixed specimens and 52.17± 8.39mm in fresh frozen specimens.

In radiological study: Redundancy of free limb of the STL was found in 10 out of 16 of CT scans with sacroiliitis with increased mean length up to 69.38 mm.

Conclusion: Wide attachment of STL to the surrounding was observed and may affect SIJ biomechanics and increases probability of LBP. We recommend in further studies to consider STL in diagnosis and treatment of LBP patients and clinically evaluate the intensity of the condition and correlate it with the degree of the laxity of the ligament in CT scans.

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Key Words: Low back pain, sacroiliitis, sacroiliac joint, sacrotuberous ligament.

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INTRODUCTION

Sacroiliac joint (SIJ) is considered the largest axial joint in the human body that typically formed between ilium and sacral segment S1, S2 and S3 ***(Vleeming & Stoeckart, 2007)***. It varies in its histological composition as the sacral part is hyaline in nature, but the iliac part consists of columns of fibrocartilage perpendicular to joint surface interposed with islands of hyaline cartilage ***(Schuncke, 1938)*** that become also fibrocartilage with age ***(Kampen &Tillmann, 1998)***. The joint architecture is altered throughout life and vary in description from diarthrotic, synarthrotic and amphiarthrotic ***(Solonen, 1957)***.

The joint is subjected to higher load and bigger lever arm in males than in females due to different relation of the center of gravity to the joint. This supports the stronger male joint with restricted mobility ***(Bellamy et al., 1983)***.

Innervation of the SIJ was described by many authors but in conclusion, it receives nerve supply from dorsal primary rami of the lower lumbar and upper sacral sections ***(McGrath & Zhang, 2005; Patel et al., 2012 and Umimura et al., 2012)***

The main function of the SIJ is to absorb weight from the trunk and transmit it to the lower extremities through the pelvic girdle. Many authors described the joint movement, but the gold standard is the RSA (roentgen stereo photogrammetric analysis) technique. It was proved that the maximum sagittal rotation of the joint never exceeds 3.6° and translation of the joint never exceeds 2 mm ***(Kibsgård et al., 2012)***.

SIJ has a strong fibromuscular network that is adjusted to joint stability. Muscles such as, the lower lumbar multifidi, the coccygeus muscle, the piriformis muscle, biceps femoris muscle and the gluteus maximus muscle ***(Woodley et al., 2005 and Vleeming & Stoeckart, 2007)***. Ligamentous support of the joint includes the interosseous ligaments, ventral and dorsal sacroiliac ligaments, sacrotuberous ligaments (STLs), sacrospinous ligaments (SSLs) and the iliolumbar ligaments ***(Vleeming & Stoeckart, 2007)***. Integrity of this fibromuscular composite in addition to the interlocking bony articular surfaces and posterosuperior wedging of the sacrum into the ilia, are important for joint stability by generating a perpendicular compressional response pressure to the joint to overcome the forces of gravity ***(Vleeming et al., 1990-a &1990-b)***.

Low back pain (LBP) is a growing problem due to increasing dependency on non-human techniques in work and in life. The problem has enlarged to the extent that one in each seven visits to the primary care center complains about a musculoskeletal disorder and back pain accounts for about 20% of those cases with 14% specifically pointing to the lower back ***(Jordan et al., 2010)***.

SIJ acquired a great attention in studies recently due to its great participation in LBP and responsibility for about 15% -25% of patients ***(Cohen, 2005)***. Sacroiliac pain may be referred to one of these points, buttocks in 94% of patients, lower lumbar in 72%, thigh in 48% and lower limb in about 28% ***(Slipman et al., 2000)***. SIJ affection may directly affects the discs and most probably the higher lumbar joints as well ***(Vleeming & Stoeckart, 2007)***.

STL is an important component of the SIJ fibrous apparatus that connects the sacrum to the ischial tuberosity extending up to joint capsule and it gives many connections to the surrounding muscles and ligaments ***(Bierry et al.,2014)***.

STL contributes to the joint biomechanics and stability as loading forces on the STL in different positions decreases the total amount of rotation "nutation and counternutaton" significantly ***(Vleeming et al., 1989-b)*** and sacral mobility is increased in stiffness of the STL and the SSL ***(Hammer et al.,2013)***.

The main function of the STL is to resist nutation of the sacrum during weight loading of the pelvis ***(Vleeming et al., 1989-b)***. Weight is transmitted from sacrum to iliac bones through posterior interosseous ligaments " primary loading ligament" causing sacral rotation that subsequently causes secondary load on the STL that balance the primary force and this mechanism is called “force couple”. So sacral movement axis must exist between these two levers. This mechanism takes action to antagonize lumbar lordosis produced by standing position as the line of gravity in this posture is anterior to sacral axis and posterior to acetabular axis. ***(Dontigny, 2011-a)***.

On the other hand, during walking, the pelvis become asymmetrical when the leg is raised from the ground and it bends laterally to the side of supported leg forming an oblique axis from S1 on the loaded supported side to S3 on the unsupported side ***(Dontigny, 2011-a)***. Here, the gravity line is ventral to this axis and the sacrum rotates ventrally at S1 on the unsupported side and dorsally at S3 at the supported loaded side to oppose the loading force ***(Dontigny, 2007)*** and this is called controlled instability ***(Gracovetsky, 2007)***. To compensate this instability, the gluteus maximus muscle at its sacral attachment pulls the sacrum obliquely downward in the same direction of the STL and piriformis muscle pulls it laterally in the direction of the SSL ***(Dontigny, 2011-a)***.

Also, the STL may participate in pelvic pain when the sacrum rotates anteriorly causing loosening of the ligament and destabilize sacral mobility and pelvic diaphragm causing pelvic pain ***(Dontigny, 2011-b)***.

So, the aim of this study is to give a detailed anatomical and radiological study of the STL as an important component of the fibromuscular network affecting stability and the biomechanics of the SIJ that in turn may generate or relieve LBP and influence the quality of life.

MATERIALS AND METHODS

Cadaveric study

20 formalin fixed hip and gluteal region specimens of adult male human were used in the present study from the dissecting room of the Anatomy and Embryology Department-Faculty of medicine- Ain Shams university after approval was obtained from the department.

To approach the region of the SIJ, a curved incision was made from the posterior superior iliac spine downward and inward and along the iliac crest till sacrum then downward and vertically till coccyx then downward and outward to the back of the thigh. A large flap of skin and superficial fascia was reflected outward exposing deep fascia and gluteus maximus muscle ***(Romanes, 1986)***.

Then the gluteus maximus muscle was dissected from the STL and reflected laterally to expose the extension of the STL completely, piriformis muscle projecting from greater sciatic foramen and sciatic nerve below it. Another incision was made in the inner aspect of the back of the thigh. A flap of the skin, superficial fascia and deep fascia was dissected and reflected outward exposing the hamstring muscles.

The pelvic cavity was sawed into two halves. Skin, superficial fascia, pelvic organs and internal iliac branches were removed exposing the pelvic wall covered by parietal layer of pelvic fascia. Piriformis fascia was removed gently to expose sacral plexus sparing a part of obturator internus fascia to see pudendal nerve entering the pudendal canal. The coccygeus muscle was dissected to expose the SSL.

20 fresh frozen cadaveric hip and gluteal regions ranging from 20-40 years old were obtained from the Faculty of medicine- Ain Shams University dissection room and they were preserved in a standard morgue refrigerator at -20°C. As the hip joints in the specimens were previously removed in orthopedic studies, the remaining flap of the gluteus maximus muscle was carefully separated from its insertion and followed till its origin from the back of the STL, iliac crest and sacrum. The STL and the SSLs were traced. A medial incision was done in the back of the upper thigh and skin and superficial fascia were reflected laterally to expose the attachment of the STL to the ischial tuberosity, the origin of the hamstring muscles and the sciatic nerve.

Focusing on the STL, it was divided into three parts (Figure 1):

a) Attached part

Which was further sub -divided to two parts:

The limb (AB):

extending from posterior superior iliac spine to the back of S3.

The limb (BC):

extending from the back of S3 to the back of S5 and back of coccyx.

b) Free part

The limb (CD) extending from the back of S5 and coccyx to the medial aspect of ischial tuberosity.

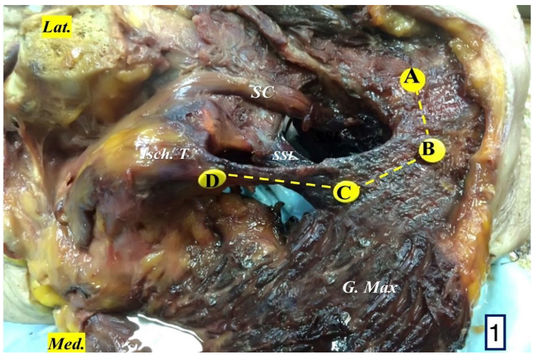


Fig. 1: A photograph of a fresh frozen hip and gluteal region showing the subdivision of the sacrotuberous ligament into three limbs (AB, BC and CD).
SC: sciatic nerve, Isch.T: Ischial tuberosity, G. Max: Gluteus maximus muscle,
SSL: sacrospinous ligament

The length of each limb and the width of the two ends of the free limb (sacral and tuberous ends) were measured by an Electronic Digital Caliper and were calculated as Mean + SD.

Radiological study

In a retrospective study from February 2017 till June 2017, 35 cases of adult males ranging from 20-40 years old pelvic CT scans were collected. All the scans were studied and supervised by an expert radiologist.

They were divided into 3 groups

Group A: 9 scans of patients did the scans for reasons other than LBP and their SIJs showed normal appearance.

Group B: 10 scans of patients were complaining of LBP and their SIJs showed normal appearance (Group A and B represent the control groups in the present study).

Group C: 16 scans of patients did the scans because of LBP and their SIJs showed signs of sacroiliitis and this group was further subdivided into 2 subgroups:

Group C-: 6 scans showed normal STL.

Group C+: 10 scans showed redundancy of the STL.

The CT scans were done in TechnoScan Radiology Center, Cairo, Egypt, using Toshiba Aquilion 64 Slice CT Machine, Cairo, Egypt. The axial view was cut in 0.5 mm thickness slices with 1 cm window length. Reconstructed coronal CT images and sagittal views using Multi Planner Reconstruction (MPR) technique were used to create multiple sequential sagittal and coronal images to expose the full extension of free limb of the STL.

Bone window density was used to visualize bony articular plates and trabeculations for better observation of the pathological signs and density changes and soft tissue window density was used for better visualization of muscles and ligaments.

The shape and the outline of the STL were studied and the length of the free limb of the ligament was measured in the sagittal MPR reconstructed scans.

Statistical analysis

Statistical analysis of variance (ANOVA) and Bonferroni post hoc t-test were used to compare the length of free part of the STL in all groups. The results were calculated as Mean + SD. *P-value* was calculated using the SPSS program. The significance of the data was determined by *P-value* ($P < 0.05$ or equal to 0.05 was considered significant and $P < 0.001$ or equal to 0.001 was considered highly significant) ***(Sawilowsky, 2005)***.

P-value was corrected according to Bonferroni procedure by dividing the α value by the number of the compared groups (m) (α / m) so the significant *P-value* became ($P \leq 0.0125$) and highly significant *P-value* became ($P \leq 0.00025$) ***(Frane, 2015)***.

RESULTS

Cadaveric results

Through dissection, the study found that STL extends from posterior superior iliac spine to midpoint of medial surface of ischial tuberosity (Figure 2). The study found that the ligament has three limbs: 2 attached limbs: one extending from posterior superior iliac spine to the back of S3 and measured 20mm-35mm in formalin fixed specimens and from 32.9mm-44mm in fresh frozen specimens, and the other one extending from back of S3 to the back of S5 and back of the coccyx and measured 28.1mm-38.4mm in formalin fixed specimens and from 35.2mm-45mm in fresh frozen specimens. The third limb was free limb extending from the previous point to the midpoint of medial surface of ischial tuberosity and its mean length was 45.21± 6.04mm in formalin fixed specimens and 52.17± 8.39mm in fresh frozen specimens.

The study found variation in the direction of the ligament fibers: they were broad fan shaped in the upper part, twisting upon themselves as they pass downward, laterally and to some extent anterior (Figure 3), they diverge again as they become anchored in the ischial tuberosity (Figures 3,4) and finally they extend as a sickle shaped sharp edged ligament to the ischial ramus "falciform ligament" (Figure 5).

The STL was found blending with the surrounding ligaments: it was found to be partially blending with SSL forming greater and lesser sciatic foramina (Figure 6).

It was also found to be blending by its upper attached limb with the long dorsal sacroiliac ligament (Figure 3).

The STL was found to give attachments to the surrounding muscles such as: Gluteus maximus muscle that originates from the dorsal surface of the ligament in oblique manner (Figures 3,4,10). And it was found that the ligament is partially continuous by its superficial fibers with the biceps femoris-semitendinosus conjoint tendon meanwhile, its deep fibers are anchored directly in the ischial tuberosity (Figure 4) and the sheath covering the conjoint tendon was also found continuous with the ligament fibers (Figure 7).

From dissection of the pelvic cavity and the back of the thigh, the study found two nervous structures related to the STL: the pudendal nerve was found passing between the STL and the SSL while traversing the pudendal canal (Figure 8). The sciatic nerve was found passing lateral and parallel to the ligament and the width of the ligament free limb altered the proximity of the nerve to the STL as well altered the width of the sciatic foramina (Figures 9,10). The mean width of the free limb of the ligament at its sacral end was 36.86± 5.57mm and 12.12± 1.09mm at the tuberous end in formalin fixed specimens. The mean width in fresh frozen samples was 41.64±3.54 mm at the sacral end and 17.78± 1.63mm at the tuberous end.

Radiological results

Control groups: in group A (Patients without LBP nor sacroiliitis), the shape of the STL was uniform (Figure 11) and the mean length of the free part of the ligament was 47.4 mm & in group B (patients with LBP but without sacroiliitis), the STL showed uniform shape (Figure 12) and the mean length was 51.9 mm. In both groups, axial and coronal views of the sacroiliac joint showed normal joint space with regular outlines and end plates (Figures 13,14).

In group C (patients with LBP and sacroiliitis), axial and reconstructed coronal views showed abnormal sacroiliac joint with variable degrees of subchondral sclerosis at the iliac side that exceeds 5mm and less commonly at the sacral side, narrowing of the joint space less than 2mm according to El Gafy *et al*., (2001), appearance of vacuum phenomenon as a sign of degeneration of the joint articular plates with irregular outlines and in some cases subchondral cysts were found (Figures 15,16). This group was further subdivided into 2 subgroups:

Group C- (Scans showed normal uniform of the STL): the mean length of the free part of the STL was 59.6mm (Figure 17).

Group C+ (Scans showed redundancy of the STL) (Figure 18): the mean length was 69.33mm (Figure 19).

Statistical analysis

Quantitative image analysis and ANOVA statistical analysis revealed that there was a highly significant difference in the length of free limb of the STL (P= 0.000018) among all the groups (Table 1; Bar chart 1).

Bonferroni corrected post hoc test (t-test) for ANOVA revealed statistically significant increase in the length of free limb of the STL in patients complaining of LBP with sacroiliitis and redundant ligament (group C+) (P= 0.0019) compared to the control groups (Table 2).

On the other hand, there was non-significant but noticeable increase in the length of free limb of the STL in patients with LBP with sacroiliitis and uniform shaped ligament (group C-) (P = 0.0145) compared to control groups (Table 3).

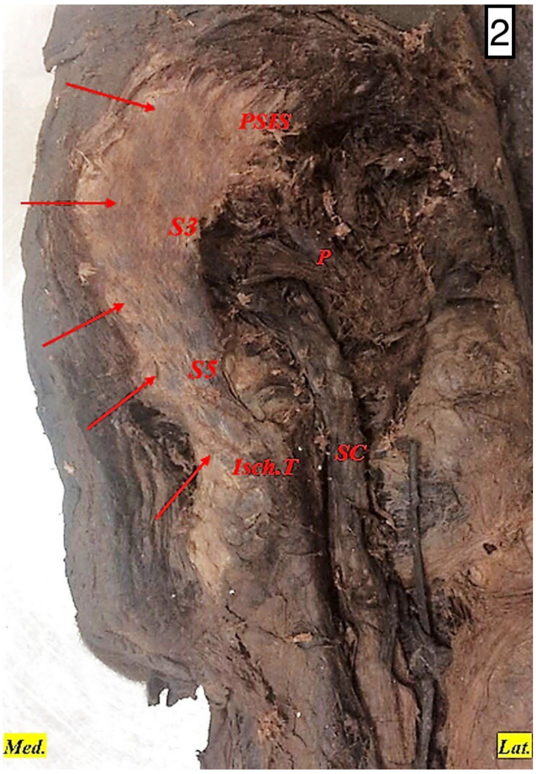


Fig. 2: A photograph of a formalin fixed adult male human gluteal region and back of the upper thigh showing a fully dissected sacrotuberous ligament (arrows) and its different attachments.
PSIS: Posterior superior iliac spine.
S3: Third sacral segment, S5: Fifth sacral segment.
Isch. T: Ischial tuberosity.
SC: Sciatic nerve.
P: Piriformis muscle.
Med: Medial, Lat: Lateral

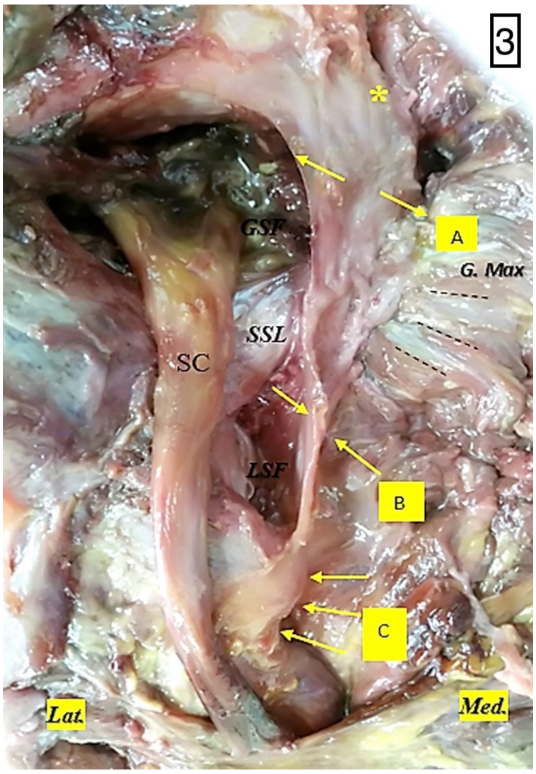


Fig. 3: Dorsal view of adult male human fresh frozen hip showing attachment of sacrotuberous ligament. Starting from its broad fan shaped superomedial attachment(A), the fibers twist downward,
laterally and slightly anteriorly (B). Then fan again as they reach their destination in the medial margin of the ischial tuberosity (C). Notice the blending of the upper fibers of the sacrotuberous ligament with the dorsal sacroiliac ligament (*). Notice also the oblique fibers (interrupted line) of the gluteus maximus muscle (G.Max) in relation to the STL.

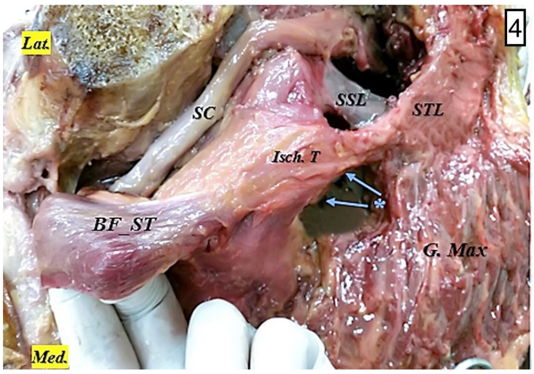


Fig. 4: A photograph of a fresh frozen adult male specimen of the gluteal region and back of upper thigh showing the fanning (*) of the sacrotuberous ligament (STL)after its twist as it become attached to the ischial tuberosity (Isch.T). Notice the attachment of the gluteus maximus muscle (G. Max) to the ligament. Notice also the continuity of the STL with the conjoint origin of the long head of biceps femoris and semitendinosus(BF_ST) from inferomedial aspect of ischial tuberosity (Isch.T).
SC: Sciatic nerve., SSL: sacrospinous ligament.

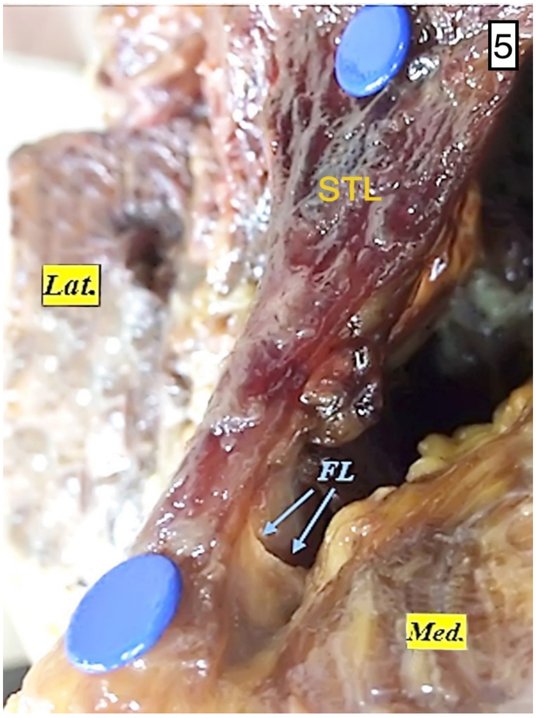


Fig. 5: A Photograph of deep dissection of adult male human fresh frozen gluteal region showing the medial falciform extension (FL) of the sacrotuberous ligament (STL) to the ischial ramus. Notice the sharp margin of the FL.

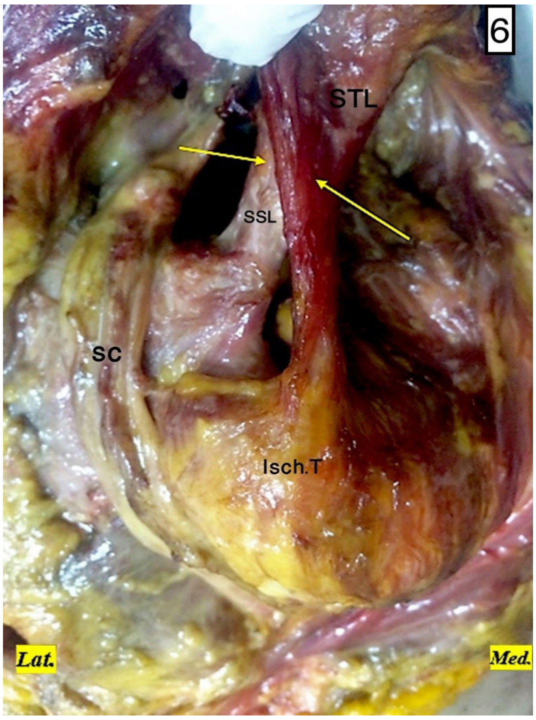


Fig. 6: A photograph of deep dissection of an adult human gluteal region showing the partial blending (the arrows) of the sacrotuberous(STL) and sacrospinous ligament(SSL) forming the greater and the lesser sciatic foramina.
Isch.T: ischial tuberosity, SC: Sciatic nerve

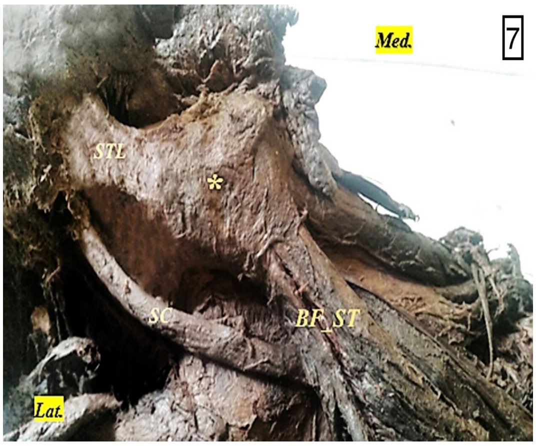


Fig. 7: A photograph showing a closer view of the previous specimen showing continuity (*) of the fascial covering the BF_ST with fibers of STL.
SC: Sciatic nerve.

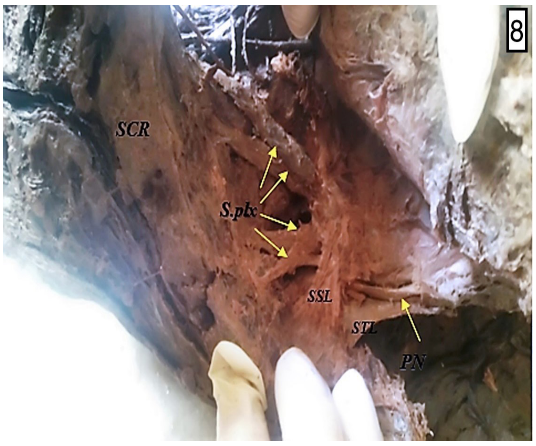


Fig. 8: A photograph of side view of a sagittaly cut pelvic cavity in a formalin fixed adult male cadaver showing the pudendal canal containing pudendal nerve (PN) as one of the two terminal branches of sacral plexus(S.plx) passing between the sacrotuberous ligament (STL) and the sacrospinous ligament (SSL).
(SCR): Sacrum.

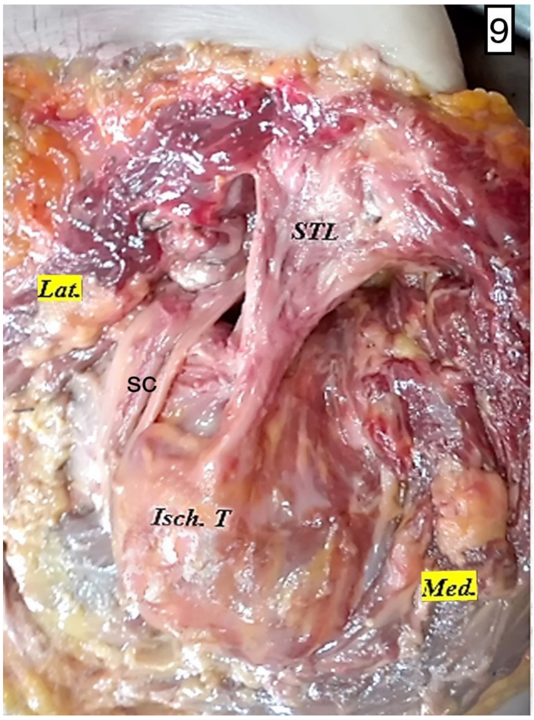


Fig. 9: A photograph of adult male fresh frozen hip and gluteal region showing wide sacrotuberous ligament (STL) with proximity of the ligament with the sciatic nerve (SC).
Isch.T: Ischial tuberosity

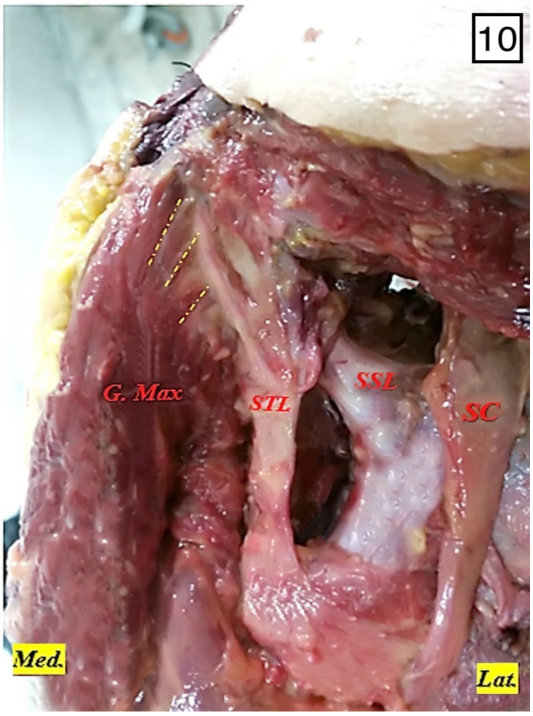


Fig. 10: A photograph of deep dissection of adult male human fresh frozen gluteal region showing a narrow sacrotuberous ligament (STL) with distant sciatic nerve (SC) from it. Notice the oblique origin (interrupted lines) of the gluteus maximus muscle (G.Max) from the STL.
SSL: Sacrospinous ligament.

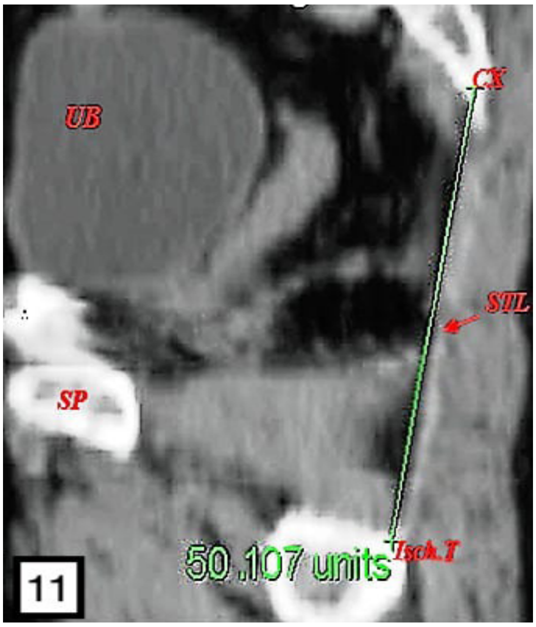


Fig. 11: A photograph of adult male human CT pelvis sagittal view with MPR technique and bone window in an individual with normal sacroiliac joint and the sacrotuberous ligament (STL) shows uniform shape and measures 50.107 units (1 unit = 1 millimeter).
CX: Coccyx, Isch.T: Ischial tuberosity, UB: Urinary bladder, SP: Symphysis pubis.

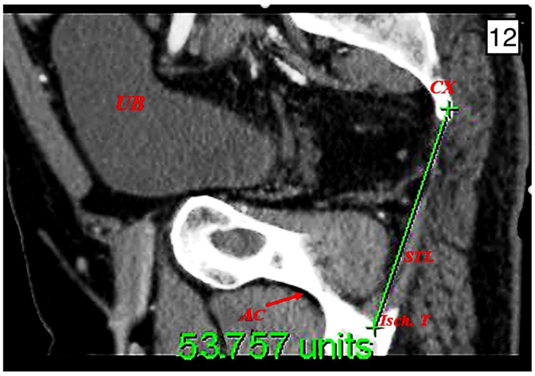


Fig. 12: A photograph of adult male human CT pelvis sagittal view with MPR technique and soft tissue window in an individual with normal sacroiliac joint and the sacrotuberous ligament (STL) shows uniform shape and measures 53.757unit (1 unit = 1 millimeter).
CX: Coccyx, Isch.T: Ischial tuberosity, AC: Acetabulum, UB: Urinary bladder.

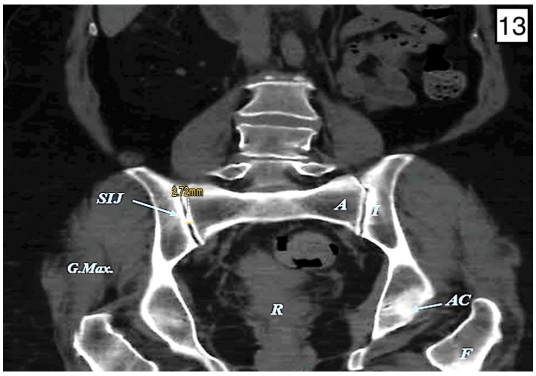


Fig. 13: A Photograph of CT pelvis coronal view with bone window of adult male human showing normal sacroiliac joint(SIJ). Notice that the joint space exceeds 2mm in diameter with regular end plates. G. Max: Gluteus maximus muscle, A: Ala of the sacrum, I: Ileum,
AC: Acetabulum, F: Femur: Rectum

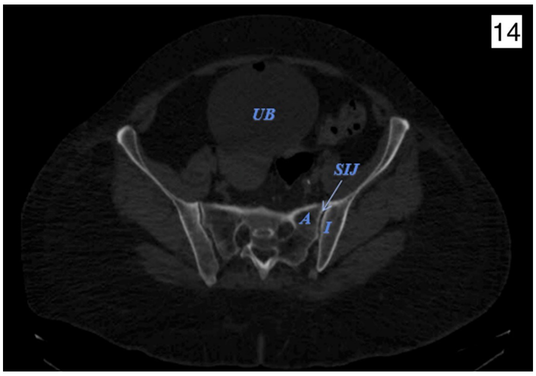


Fig. 14: A photograph of adult male human CT pelvis axial cut with bone window showing bilateral normal sacroiliac joint(SIJ) with preserved joint space and regular end plates.
UB: Urinary bladder, A: Ala of sacrum, I: Ileum.

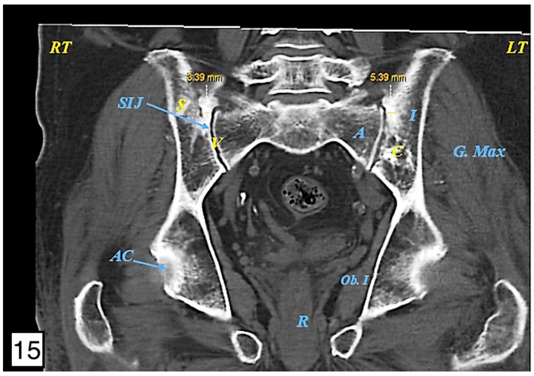


Fig. 15: A photograph of an adult male human reconstructed CT pelvis coronal view with bone window showing bilateral sacroiliitis. Notice bilateral subchondral sclerosis on the iliac side(S) more than 3mm, appearance of vacuum phenomenon(V) on the right side(RT). On the left side(LT), there is space narrowing with subchondral cysts (C) and irregular outlines.
SIJ: Sacroiliac joint, Ob. I: Obturator internus muscle, R: Rectum, G. Max: Gluteus maximus muscle, AC: Acetabulum.

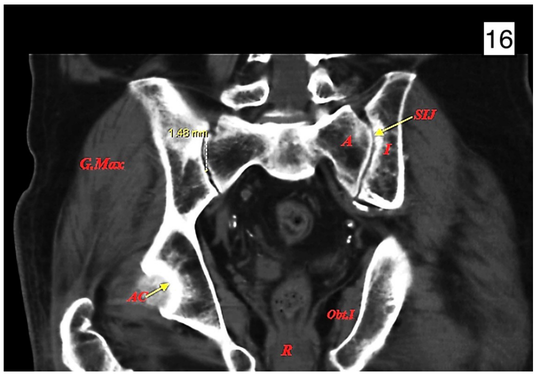


Fig. 16: A photograph of coronal view of adult male human CT pelvis with bone window showing space narrowing less than 2mm as a sign of sacroiliitis.
G. Max: Gluteus maximus muscle, SIJ: Sacroiliac joint, A: Ala of sacrum
I: Ileum, AC: Acetabulum, Ob. I: Obturator internus muscle, R: Rectum.

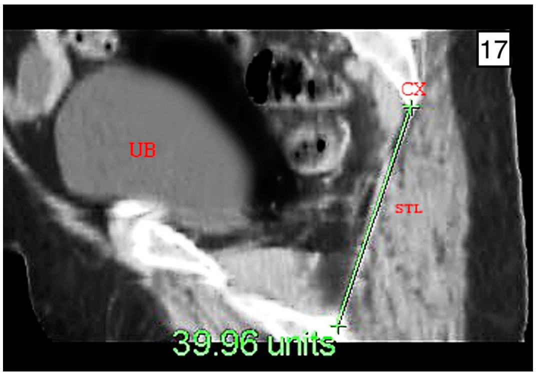


Fig. 17: A photograph of adult male human CT pelvis sagittal view with MPR technique and bone window in a sacroiliitis patient showing uniform shape of the sacrotuberous ligament and measures 39.9 units (1 unit = 1 millimeter).
CX: Coccyx., UB: Urinary bladder.

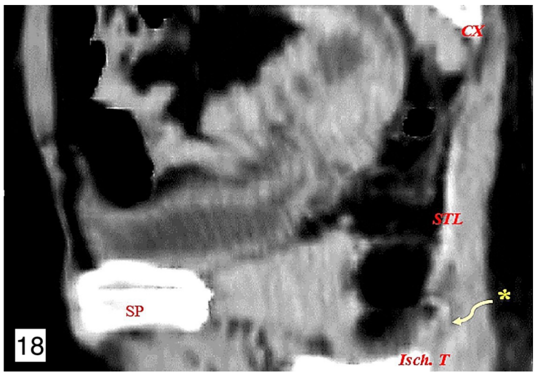


Fig. 18: A photograph of adult male human CT sagittal view with MPR technique and soft tissue window in a sacroiliitis patient showing irregular outline and redundancy (*) of the sacrotuberous ligament(STL).
CX: Coccyx, Isch.T: Ischial tuberosity, SP: Symphysis pubis.

Fig. 19: A photograph of adult male human CT pelvis sagittal view with MPR technique and bone window in a sacroiliitis patient showing redundant sacrotuberous ligament(STL) that measures 67.11 mm.
CX: Coccyx, Isch.T: Ischial tuberosity, SP: Symphysis pubis, PS.m: Psoas major muscle.

Table 1: Average length of free part of the STL in the four groups (ANOVA single factor)

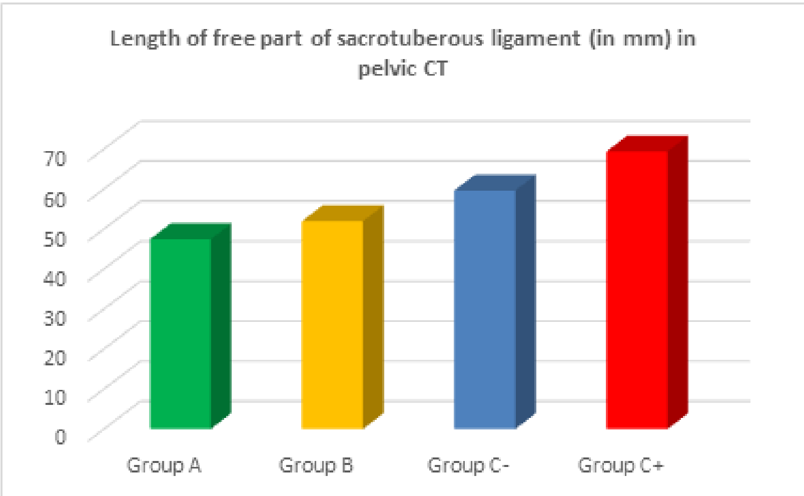
Anova: SingleFactor						
SUMMARY						
Groups	Count	Sum	Average	Variance		
Group A	6	284.4	47.4±2.688	43.356		
Group B	6	311.9	51.983± 3.543	75.333		
Group C+	6	416.3	69.383± 1.424	12.169		
Group C-	6	357.9	59.65± 1.388	11.571		
ANOVA						
Source of Variation	SS	df	MS	F	*P-value*	F crit
Between Groups	1665.918	3	555.305	15.595	1.83075E-05	3.098
Within Groups	712.1517	20	35.607			
Total	2378.07	23				
					Highly significant *P-value* < 0.001	

Table 2: Length of free part of the STL in the control & group C+ (Bonferroni post hoc test)

t-Test: Paired Two Sample for Means		
	Group A	Group C+
Mean	47.4	69.383
Variance	43.356	12.169
Observations	6	6
Pearson Correlation	-0.601	
Hypothesized Mean Difference	0	
Df	5	
t Stat	-5.904	
P(T<=t) one-tail	0.00099	
t Critical one-tail	3.163	
P(T<=t) two-tail	0.0019	
t Critical two-tail	3.810	
Significant α value < 0.0125		

Table 3: Length of free part of the STL in the control & group C- (Bonferroni post hoc test)

t-Test: Paired Two Sample for Means		
	Group A	Group C+
	Group A	Group C-
Mean	47.4	59.65
Variance	43.356	11.571
Observations	6	6
Pearson Correlation	-0.273	
Hypothesized Mean Difference	0	
Df	5	
t Stat	-3.661	
P(T<=t) one-tail	0.007	
t Critical one-tail	3.163	
P(T<=t) two-tail	0.0145	
t Critical two-tail	3.810	
Non-significant α value > 0.0125		



Bar chart 1: Average length of free part of the STL in the four groups

DISCUSSION

SIJ has acquired a great attention recently due to its involvement in LBP as well the STL as a component of its supportive and biomechanical network which is overlooked by many physicians in dealing with LBP.

The study chose to focus on the STL due to its accessibility in dissection and visibility in CT scans. The ligament was found to have two attached limbs: one extending from posterior superior iliac spine to the back of S3 and another one extending from previous point to the back of S5 and coccyx and a free limb extending from that point to midpoint of the ischial tuberosity and the laxity or redundancy of it can be elicited and observed. Vleeming *et al*., (1996) described a similar division of the STL, dividing it into attached tuberoiliac ligament and free STL proper. Woodley *et al*., (2005) proposed that the extension of the STL to the coccyx may have a role in force transmission to the pelvic floor muscles.

Tracing the fibers of the free limb, it was seen to twist downward, laterally and to some extent forward and then diverge just before anchoring in the middle portion of the medial surface of the ischial tuberosity and finally, the ligament stretches to reach the ischial ramus as a falciform extension. Hammer *et al*., (2009) described the ligament as twisted shape of two triangles connected at their tips. Spirality of the ligament may be of biomechanical importance as it causes the different parts of the STL to be loaded during different stages of movement of the SIJ resembling the cruciate ligaments ***(Van Wingerden et al.,1993)***.

The wide extension of the STL to the SIJ, surrounding muscles, fasciae and ligaments suggested many discussion points that propose the biomechanical role of the STL in SIJ stability and its contribution in LBP:

The study found that the upper part of the ligament is broad fan shaped blending with the long dorsal sacroiliac ligament which is in turn attached to gluteus maximus muscle -that originates also from the back of the STL-, Erector spinae muscle and thoracolumbar fascia. So, the lumbar spine may be also involved in the zone of the biomechanical effect of the STL and its role in generation of LBP ***(Hoek van Dijke et al.,1999)***. Vleeming *et al*., (1996) mentioned that gradual increase in tension in the STL produces tension in the long dorsal sacroiliac ligament and alteration of the SIJ movement. Nutation of the SIJ produces relaxation of the long dorsal sacroiliac ligament and tension in the STL. In contrast, counternutation causes relaxation of the STL that appears only in the free part as the attached part is adjusted and masked by the tension produced in the long dorsal sacroiliac ligament. That composite can be felt just below the posterior superior iliac spine which is a tenderness point in 47% of males complaining of LBP ***(Vleeming et al.,1996)***.

The STL was found partially blending with SSL making a couple with correlated volumes and cross-sectional areas despite of the wide variations of their measurements. They rotate in opposite direction providing oppositional effect on the pelvis as the STL raises while the SSL depresses the ischium in relation to the sacrum which can be of help in pelvic ligamentous surgery ***(Hammer et al.,2009)***. Stiffness of this couple increases the pelvic motion in contrary of the other pelvic ligaments ***(Hammer et al.,2013)***.

The STL was also found to give attachment obliquely from its dorsal surface to the gluteus maximus muscle which is also attached to gluteal surface of ilium crossing the SIJ and its fascia is connected to superficial layer of thoracolumbar fascia and covering the long dorsal sacroiliac ligament ***(Vleeming et al.,1996)***. These different attachments may give about three different lines of force transmission through the muscle ***(Hoek van Dijke et al.,1999)***. Loading application on the gluteus maximus muscle in the direction of its insertion produces a significant tension on the STL ***(Vleeming et al.,1989-a)*** and patients with LBP of sacroiliac origin have gluteus maximus weakness more than other cases of non-sacroiliac origin ***(MassoudArab et al.,2011)***. So, gluteal muscle training is highly recommended in prevention and treatment of LBP ***(Vleeming et al.,1989-b; Van Wingerden et al.,1993)***.

The STL was seen blending by its superficial fibers with biceps femoris-semitendinosus conjoint tendon at their origin while its deep fibers are anchored directly into the ischial tuberosity and some authors described the STL as an embryological remnant of the tendon of the long head of biceps femoris ***(Berry et al.,2014)***. It is emphasized that force is transmitted from biceps femoris muscle to the STL causing its tension to antagonize tilting of the sacrum in transposition from erect to flexed position and this imply the biomechanical role of the blending of the STL with biceps femoris muscle. Moreover, the twisting of the ligament fibers directs the force transmission from the biceps femoris muscle to the sacrum horizontally ***(Van Wingerden et al.,1993)***. Also, a little but statistically significant hamstring shortening was found in LBP as a compensatory mechanism in gluteal weakness to adjust joint instability ***(Massoud Arab et al.,2011)***. An annular fibrous covering was found covering the STL, ischial tuberosity and the proximal attachment of the hamstring muscles and it receives an extension from gluteus maximus fascia. It has macroscopic and microscopic characters of a retinaculum and its function is to connect and anchor these components more than smoothening their movement. it may also play a role in force transmission and collaboration of STL, biceps femoris -semitendinosus and gluteus maximus muscle ***(Pérez-Bellmunt et al.,2015)***. Core strengthening exercises and muscle stretching improves the hamstring flexibility and helps in protection of the STL from injury and share in prophylaxis against LBP ***(Heiser et al.,1984)***.

STL was found in close relation to the pudendal nerve which was found passing between it and the SSL. Pudendal entrapment syndrome was classified to four types and STL may be involved in this condition by different ways like: inter-ligamentous (STL and SSL) compression of the nerve (type II), or type III if the falciform extension fused with obturator fascia with increased thickness may trap the nerve in the

Alcock`s canal, or by increasing width of the STL that may result in narrowing of sciatic foramina and entrapment of the nerve as detectable STL width variation was observed in this study. In addition, sometimes the fascial sheath of the pudendal nerve fuses with the fibers of STL and causes entrapment of the nerve by increasing the traction of this fusion at the exit of the nerve from lesser sciatic foramen ***(Loukas et al.,2006)*** and rarely, STL ossification ***(Sandri et al.,2013)***. STL may also provide a treatment approach through trans-gluteal technique in which the pudendal neurovascular bundle is released through opening a window in the ligament ***(Robert et al.,1998)***.

The present study found proximity between STL and sciatic nerve. Adhesions in some cases of sciatica can be found between the hamstring tendon and the sciatic nerve ***(Puranen & Orava.,1988)*** and the hamstring muscles is continuous strongly with the STL and the fibrous retinaculum connecting them is attached to gluteus maximus fascia which splits laterally forming a canal enclosing sciatic nerve and posterior femoral cutaneous nerve ***(Pérez-Bellmunt et al.,2015)***. A case study was reported about a patient who had a refractory sciatic pain that was relieved after deep transverse friction of the STL ***(Hackett.,1958; Buijs et al.,2007)***. Although STL is connected to almost all the structures involved in gluteal sciatica (gluteus maximus, piriformis and the hamstring muscles), the exact relation between the ligament and the condition is not full justified and needs further research.

In the radiological part of this study, STL in reconstructed CT scans showed signs of irregularity and redundancy in 10 out of 16 of cases of sacroiliitis with a significant increase in its length proposing a significant relationship between sacroiliitis and tension of the STL.

Laxity of the STL may produce or aggravate LBP through increasing SIJ mobility or developing asymmetrical force transmission across the joint that alters its compression and force closure ***(Vleeming et al.,2012)***.

LBP nowadays is not an aging disease but, the incidence in young adults is increasing up to 30%-50% in life time due to psychological distress, increased competitive sports, spending long time watching television and sitting, growing smoking ratio and manual work ***(Sjolie.,2004)***. Relation between physical activity and LBP was proved to be U shaped as both vigorous activities and sports and sedentary lifestyle showed increased LBP incidence ***(Hildebrandt et al.,2000 and Heneweer et al.,2009)***. So, moderate regular exercise is recommended in prevention of such expanding health problem. About 30 minutes at least of daily exercise of moderate intensity was recommended by the Centers for Disease Control and Prevention and American College of Sports Medicine ***(Hildebrandt et al.,2000)***.

CONCLUSION

The present work focused anatomically and radiologically on the STL and its biomechanical role in the stability of the SIJ. The study also tried to correlate the STL with SIJ inflammation and its participation in LBP. The radiological work was retrospective so, we recommend in the further studies to clinically evaluate the patients to assess the degree of severity of the condition in relation to the degree of the laxity of the ligament. This work also recommends considering the STL as one of the tools of diagnosis and management of LBP and sacroiliitis to reach optimum results in treatment and improve this condition as it is a quality of life affecting problem.

CONFLICT OF INTERESTS

There are no conflicts of interest.

REFERENCES

Bellamy N.; Park W. and Rooney P.J (1983): What Do We Know About the Sacroiliac Joint? Seminars in Arthritis and Rheumatism; 12: 282-313.

Bierry G.; Simeone F.J.; Borg-Stein J.P.; Clavert P. and Palmer W.E (2014): sacrotuberous ligament: Relationship to Normal, Torn, and Retracted Hamstring Tendons on MR Images. Radiology; 271: 162-171.

Buijs E.; Visser L. and Groen G (2007): Sciatica and the sacroiliac joint: a forgotten concept. British Journal of Anesthesia; 99: 713-716.

Cohen S.P (2005): Sacroiliac Joint Pain: A Comprehensive Review of Anatomy, Diagnosis, and Treatment. Anesthesia and Analgesia; 101: 1440-1453.

DonTigny R (2007): A detailed and critical biomechanical analysis of the sacroiliac joints and relevant kinesiology: The implications for lumbopelvic function and dysfunction. In Vleeming A, Mooney V, Stoeckart R (eds) Movement, Stability & Lumbopelvic pain: Integration of research and therapy. Churchill Livingstone Edinburgh: 265-279.

DonTigny R (2011-a): Sacroiliac 101; Form and Function: A biomechanical study. Journal of Prolotherapy; 3: 561-567.

DonTigny R (2011-b): Sacroiliac 201: Dysfunction and Management: A Biomechanical solution. Journal of Prolotherapy;3 :644-652.

Frane A (2015): Are per-family Type I error rates relevant in social and behavioral science? Journal of Modern Applied Statistical Methods; 14: 12-23.

Gracovetsky S. (2007): Stability or controlled instability. In Vleeming A, Mooney V, Stoeckart R (eds) Movement, Stability & Lumbopelvic pain: Integration of research and therapy. Churchill Livingstone Edinburgh: 279-293.

Hackett G.S (1958): Ligament and Tendon Relaxation Treated by Prolotherapy. 3rd ed. Springfield: Charles C. Thomas.

Hammer N.; Steinke H.; Lingslebe U.; Bechmann I.; Josten C.; Slowik V. and Böhme J (2013): Ligamentous influence in pelvic load distribution. The spinal journal;13 :1321-1330.

Hammer N.; Steinke H.; Slowik V.; Josten C.; Stadler J.; Böhme J. and Spanel-Borowski K (2009): The sacrotuberous and the sacrospinous ligament_ A virtual reconstruction. Annals of Anatomy; 191: 417-425.

Heiser T.M.; Weber J.; Sullivan G.; Clare P. and Jacobs R.R (1984): Prophylaxis and management of hamstring muscle injuries in intercollegiate football players. The American Journal of Sports Medicine; 12: 368-370.

Heneweer H.; Vanhees L. and Picavet H.S.J (2009): Physical activity and low back pain: A U-shaped relation? PAIN; 143 :21-25.

Hildebrandt V.H.; Bongers P.M.; Dul J.; Van Dijk F.J.H. and Kemper H.C.G (2000): The relationship between leisure time, physical activities and musculoskeletal symptoms and disability in worker populations. International Archives of Occupational and Environmental Health; 73: 507-518.

Hoek Van Dijke G.A.; Snijders Ch.J.; Stoeckart R. and Stam H.J (1999): A biomechanical model on muscle forces in the transfer of spinal load to the pelvis and legs. Journal of Biomechanics; 32: 927-933.

Jordan K.P.; Kadam U.T.; Hayward R.; Porcheret M.; Young C and Croft P (2010): Annual consultation prevalence of regional musculoskeletal problems in primary care: an observational study. BMC Musculoskeletal Disorders; 11:144.

Kampen W.U. and Tillmann B (1998): Age-related changes in the articular cartilage of human sacroiliac joint. Anatomy and Embryology (Berl);198 :505-513.

Kibsgård T.J.; Røise O.; Stuge B. and Röhrl S.M (2012): Precision and accuracy measurement of radiostereometric analysis applied to movement of the sacroiliac joint. Clinical Orthopaedics and Related Research; 470: 3187-3194.

Loukas M.; Louis Jr R.G.; Hallner B.; Gupta A.A. and White D (2006): Anatomical and surgical considerations of the sacrotuberous ligament and its relevance in pudendal nerve entrapment syndrome. Surgical and Radiologic Anatomy; 28: 163-169.

MassoudArab A.; RezaNourbakhsh M. and Mohammadifar A (2011): The relationship between hamstring length and gluteal muscle strength in individuals with sacroiliac joint dysfunction. Journal of Manual and Manipulative Therapy; 19: 5-10.

McGrath M.C. and Zhang M (2005): Lateral branches of dorsal sacral nerve plexus and the long posterior sacroiliac ligament. Surgical and Radiologic Anatomy; 27: 327-330.

Patel N.; Gross A.; Brown L. and Gekht G (2012): A randomized, placebo-controlled study to assess the efficacy of lateral branch neurotomy for chronic sacroiliac joint pain. Pain Medicine;13: 383-398.

Pérez-Bellmunt A.; Miguel-Pérez M.; Brugué M.B.; Cabús J.B.; Casals M.; Martinoli C. and Kuisma R (2015): An anatomical and histological study of the structures surrounding the proximal attachment of the hamstring muscles. Manual Therapy; 20: 445-450.

Puranen J. and Orava S (1988): The hamstring syndrome: A new diagnosis of gluteal sciatic pain. The American Journal of Sports Medicine; 16: 517-521.

Robert R.; Prat-Pradal D.; Labat J.J.; Bensignor M.; Raoul S.; Rebai R. and Leborgne J (1998): Anatomic basis of chronic perineal pain: role of the pudendal nerve. Surgical and Radiologic Anatomy; 20: 93-98.

Romanes G.J (1986): Cunningham`s Manual of Practical Anatomy: Volume I: Upper and Lower limbs (15th Ed.). Oxford Medical Publications; 157-169.

Sandri A.; Regis D.; Toso M. and Bartolozzi P (2013): Surgical removal of a partial ossified sacrotuberous ligament for refractory pudendal nerve entrapment syndrome. Journal of Orthopaedic Science; 18:671-674.

Sawilowsky S (2005): Misconceptions leading to choosing the t test over the Wilcoxon Mann-Whitney U test for shift in location parameter. Journal of Modern Applied Statistical Methods; 4: 598-600.

Schuncke G.B (1938): The anatomy and development of the sacroiliac joint in man. The Anatomical Record; 72: 313-331.

Sjolie A.N (2004): Associations between activities and low back pain in adolescents. Scandinavian Journal of Medicine & Science in Sports; 14: 352-359.

Slipman C.W.; Jackson H.B.; Lipetz JS, Chan KT, Lenrow D, Vresilovic EJ (2000): Sacroiliac joint pain referral zones. Archives of Physical Medicine and Rehabilitation; 81: 334-338.

Solonen K.A (1957): The sacroiliac joint in the light of anatomical, roentgenological and clinical studies. Acta Orthopaedica Scandinavica; 28: 3-127.

Umimura T.; Miyagi M.; Ishikawa T.; Kamoda H.; Wakai K.; Sakuma T.; Sakai R.; Kuniyoshi K.; Ochiai N.; Kishida S.; Nakamura J.; Eguchi Y.; Iwakura N.; Kenmoku T.; Arai G.; Orita S.; Suzuki M.; Sakuma Y.; Kubota G.; Oikawa Y.; Inoue G.; Aoki Y.; Toyone T.; Takahashi K. and Ohtori S (2012): Investigation of dichotomizing sensory nerve fibers projecting to the lumbar multifidus muscles and intervertebral disc or facet joint or sacroiliac joint in rats. Spine; 37: 557-562.

Van Wingerden J.P.; Vleeming A.; Snijders C.J. and Stoeckart R (1993): A functional-anatomical approach to the spine-pelvis mechanism: interaction between the biceps femoris muscle and the sacrotuberous ligament. European Spine Journal; 2:140-144.

Vleeming A.; Stoeckart R. and Snijders C.J (1989-a): The sacrotuberous ligament: a conceptual approach to its dynamic role in stabilizing the sacroiliac joint. Clinical Biomechanics; 4: 201-203.

Vleeming A.; Van Wingerden J.P.; Snijders C.J.; Stoeckart R. and Stijnen T (1989-b): Load application to the sacrotuberous ligament; influences on sacroiliac joint mechanics. Clinical Biomechanics; 4: 204-209.

Vleeming A.; Stoeckart R.; Volkers A.C.W and Snijders C.J (1990-a): Relation between form and function in the sacroiliac joint, part I: clinical anatomic aspects. Spine; 15:130-132.

Vleeming A.; Volkers A.C.W.; Snijders C.J. and Stoeckart R (1990-b): Relation between form and function in the sacroiliac joint. Part II: biomechanical aspects. Spine; 15:133-136.

Vleeming A.; Pool-Goudzwaard A.L.; Hammudoghlu D.; Stoeckart R.; Snijders C.J. and Mens J.M.A (1996): The function of the long dorsal sacroiliac ligament: its implication for understanding low back pain. Spine; 21:556-562.

Vleeming A. and Stoeckart R (2007): The role of the pelvic girdle in coupling the spine and the legs: a cinical-anatomical perspective on pelvic stability. In: Vleeming A, Mooney V and Stoeckart R, editors. Movement, Stability and Lumbopelvic Pain: Integration and Research. Edinburgh: Churchill Livingstone:113-137.

Vleeming A.; Schuenke M.D.; Masi A.T.; Carreiro J.E.; Danneels L. and Willard F.H (2012): The sacroiliac joint: an overview of its anatomy, function and potential clinical implications, Journal of Anatomy; 221: 537-567.

Woodley S.J.; Kennedy E. and Mercer S.R (2005): Anatomy in practice: the sacrotuberous ligament. New Zealand Journal of Physiotherapy; 33: 91-94.

دراسة تشريحية و اشعاعية للرباط العجزي الحدبي وعلاقته بالمفصل العجزي في الانسان البالغ

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ملخص البحث

مقدمة: يعتبر المفصل العجزي الحرقفي من اكبر المفاصل المحورية في جسم الانسان. فهو يقوم بنقل قوة وزن الجسم من الجزء الي الاطراف مما يعرضه لاحمال عالية من القوة من الاعلي (وزن الجسم) ومن الاسفل (وزن الاطراف السفلية اثناء المشي) كما يتصل المفصل بشبكة قوية من الاربطة والعضلات واللفائف لضبط اتزانه وميكانيكيته الحيوية. تعد الام اسفل الظهر من المشاكل الصحية المتزايدة في الاونة الاخيرة بسبب نمط الحياة الغير نشط والاعتماد في العمل والحياة علي العناصر غير البشرية والالات وقد تصل هذه المشكلة الي حد الاعاقة حتي في الاعمار الصغيرة. ويعتبر المفصل العجزي الحرقفي احدي اسبابها حيث انه مسئول عن ١٥٪-٢٥٪ من الحالات التي تعاني من الام اسفل الظهر. كما ان المكونات العضلية والليفية المتصلة بالمفصل قد تؤثر بدورها علي اتزان المفصل ومن ثم قد تشارك في زيادة الشكوى من هذا العرض. الرباط العجزي الحدبي هو من احدي هذه المكونات كما انه يتصل بالكثيرمن العضلات والاربطة المجاورة مما يؤثر علي اتزان المفصل ومن ثم ميكانيكيته الحيوية ولذلك فقد يستعمل كاداة في تشخيص وعلاج مرضي الام اسفل الظهر وما يصاحبها من التهاب بالمفصل العجزي الحرقفي.

الهدف من الدراسة: التركيز علي منطقة المفصل العجزي الحرقفي والرباط العجزي الحدبي حيث ان دوره المؤثر في الام اسفل الظهرغير مستوفي دراسته بعد. وتهدف هذه الدراسة الي اعطاء منظور تفصيلي تشريحي واشعاعي للرباط العجزي الحدبي وتوضيح علاقته بالام اسفل الظهر والتهاب المفصل العجزي الحرقفي.

المواد والطرق المستخدمة: الدراسة التشريحية: تم تشريح ٢٠ عينة محفوظة بالفورمالين و٢٠ اخري مثلجة لذكر الانسان البالغ لمنطقة الورك، المنطقة الالوية والمنطقة العلوية للفخذ كما تم تشريح الجدار الداخلي للحوض بالعينات. وقد تم استعراض الرباط العجزي الحدبي كاملا وما يتصل به. وقد قسمت الدراسة الرباط الي ثلاثة اضلاع: ضلعين مثبتين بعضمة العجز: احداهما يمتد من الشوكة العلوية الخلفية الحرقفية الي الفقرة العجزية الثالثة والاخر يمتد من الفقرة العجزية الثالثة الي الفقرة العجزية الخامسة والعصعص. اما عن الضلع الثالث فهو ضلع حر يمتد من الفقرة العجزية الخامسة والعصعص الي الحدبة الاسكية. و قد تم دراسة اتصال الرباط بما يجاوره و قياس طول كل ضلع وعرض الضلع الحر للرباط وقد تم حساب المتوسط والانحراف المعياري للقياسات.

الدراسة الاشعاعية: في دراسة ذات اثررجعي تم جمع ٣٥ اشعة مقطعية للحوض باستخدام نظام الاستبناء المتعدد من ذكور بالغين تتراوح اعمارهم من ٢٠ الي ٤٠ سنة وتم تصنيف الحالات الي ثلاثة مجموعات:

مجموعتين ضابطتين للدراسة وهم: المجموعة (أ): تضمنت ٩ أشعة مقطعية لمرضي لا يعانون من الام اسفل الظهر او التهاب المفصل العجزي الحرقفي.

المجموعة (ب): تضمنت١٠ أشعة مقطعية لمرضي يعانون من الام اسفل الظهر ولكن لا يصاحبها التهاب بالمفصل العجزي الحرقفي.

المجموعة (ج): تضمنت ١٦أشعة مقطعية لمرضي يعانون من الام اسفل الظهر ويصحبها التهاب المفصل العجزي الحرقفي. وقد قسمت الدراسة هذه المجموعة الي مجموعتين فرعيتين:

المجموعة (ج-):٦ اشعة مقطعية حيث كان الرباط العجزي الحدبي متناسق الشكل.

المجموعة (ج+):١٠ اشعة مقطعية حيث اظهر الرباط العجزي الحدبي ارتخاء بالضلع الحر للرباط .

و قد تفحصت الدراسة الشكل و الطول للرباط في كل مجموعة و تمت معالجة القياسات احصائيا.

النتائج: وجدت الدراسة ان الرباط العجزي الحدبي يمتد من الشوكة العلوية الخلفية الحرقفية الي منتصف السطح الوسطي للحدبة الاسكية متصل بينهم بالفقرات العجزية الثالثة و الخامسة و العصعص و قد قسمت الدراسة الرباط الي ثلاثة اضلاع: ضلعين مثبتين بعضمة العجز: احداهما يمتد من الشوكة العلوية الخلفية الحرقفية الي الفقرة العجزية الثالثة ويتراوح طوله من ٢٠مم الي ٣٥مم في العينات المحفوظة بالفورمالين ومن ٣٢,٩ مم الي ٤٤ مم بالعينات المثلجة والاخر يمتد من الفقرة العجزية الثالثة الي الفقرة العجزية الخامسة و العصعص و يتراوح طوله من٢٨,١ مم الي٣٨,٤ مم في العينات المحفوظة بالفورمالين و من ٣٥,٢ مم الي ٤٥ مم بالعينات المثلجة. اما عن الضلع الثالث فهو ضلع حر يمتد من الفقرة العجزية الخامسة والعصعص الي منتصف الحدبة الاسكية وكان متوسط طوله ٤٥,٢١±٦,٠٤ مم في العينات المحفوظة بالفورمالين و٥٢,١٧±٨,٣٩ مم في العينات المثلجة.

اظهرت الياف الرباط العجزي الحدبي بعد التشريح تباين في اتجاهاتها. فهي عريضة مروحية الشكل في اعلاه ثم تقوم بالالتواء علي نفسها في ادناه اثناء اقترابها من الحدبة الاسكية حتي تصل الي الذراع الأسكي مكونة امتداد منجلي الشكل. كما رصدت الدراسة اتصال الرباط بالعضلات و الاربطة المجاورة كاتصاله بالرباط العجزي الشوكي اتصالا جزئيا و التحام الضلع العلوي للرباط العجزي الحدبي بالرباط العجزي الحرقفي الخلفي الطويل . و ايضا تتصل العضلة الالوية القصوي بالسطح الخلفي للرباط حيث ظهرت اليافها بمسقط مائل علي المحور الطولي لالياف الرباط. كما رصدت الدراسة اتصال الرباط العجزي الحدبي بالوتر المشترك للعضلة الفخذية ذات الراسين و العضلة الوترية و اتصال اليافه ايضا بلفافة العضلة. كما وجدت الدراسة قرب العصب الفرجي من الرباط اثناء مروره في القناة الفرجية بين الرباط العجزي الحدبي و الرباط

العجزي الشوكي وقد لوحظ ايضا قرب الرباط العجزي الحدبي من العصب الوركي و اختلاف عرض الرباط قد يؤثر علي مدي اقتراب او ابتعاد العصب عن الرباط.
الدراسة الاشعاعية: في ١٠ من ١٦ اشعة مقطعية لمرضي يعانوا من الام اسفل الظهر المصاحبة لالتهاب
المفصل العجزي الحرقفي اظهر الرباط العجزي الحدبي ارتخاء بشكله مع زياده بمتوسط طوله تصل الي ٦٩,٣٨مم.
الخلاصة: تفحصت الدراسة اتصال الرباط العجزي الحدبي المتعدد بما يجاوره من عضلات و اربطة و التي قد تؤثر بدورها علي قوة الشد و التوتر بالرباط و من ثم تغير في الميكانيكا الحيوية للمفصل العجزي الحرقفي و زيادة احتمالية ظهور اعراض الام اسفل الظهر. و لذلك توصي الدراسة بالاخذ في الاعتبار الرباط العجزي الحدبي كاداة فعالة في تشخيص و علاج الام اسفل الظهر. كما توصي ايضا بالتقييم المباشر للمرضي بالدراسات المستقبلية لدراسة العلاقة بين شدة الالم و درجة ارتخاء الرباط.