International Journal of Anatomy and Research,
Int J Anat Res 2021, Vol 9(2.2):7970-75. ISSN 2321-4287
DOI: https://dx.doi.org/10.16965/ijar.2021.104

Original Research Article

Biometric Assessment of Superior Gluteal Neurovascular Bundle to Acetabulum of Hip Joint

Nidhi Mangla [1], Sushant Swaroop Das *[2], Sabita Mishra [3], Neelam Vasudeva [4].

[1] Senior Resident, Department of Anatomy, All India Institute of Medical Sciences, New Delhi, India.

*[2] Assistant Professor, Shyam Shah Medical College, Rewa, Madhya Pradesh, India

[3] Director Professor and Head, Department of Anatomy, Maulana Azad Medical College, New Delhi, India.

[4] Ex-Director Professor, Department of Anatomy, Maulana Azad Medical College, New Delhi, India.

ABSTRACT

Introduction: The superior gluteal nerve (SGN) is a branch of sacral plexus with root value of L4, L5 and S1. It leaves pelvic cavity through greater sciatic foramen along with superior gluteal artery above piriformis. This neurovascular bundle lies in close proximity to superior acetabular rim. Iatrogenic damage to SGN is common during hip arthroplasties and may be primarily attributed to inappropriate placement of retractors. Alarmingly high percentage of affected individuals are stuck with persistent irreversible damage to SGN. Vascular injuries are not as common but pose a challenging scenario to surgeons. Hence in both situations prevention is of supreme importance. Precise knowledge of course and relation of superior gluteal neurovascular bundle (SGNVB) to clinically useful landmarks such as the superior rim of acetabulum is desired. With an aim to provide baseline data for the Indian population we conducted this study.

Material and methods: 200 dry adult Indian hip bones {Left side -109(male:66, female:43); Right side-91(male:66, female:43)} were photographed in anatomical position. Two lines- line A and line B were drawn. Line A corresponded to a horizontal passing through the anterior inferior iliac spine (AIIS) and roof of GSN while line B passed tangentially through the highest point on the acetabular rim parallel to line A. The vertical distance (white line) between the 2 lines was measured (Fig.2) using Image J software.

Results: The mean distance calculated was 0.62 ± 0.16 cm (0.68 ± 0.38 cm in right hip bones and 0.60 ± 0.30 cm in left side hip bones). The difference between the two sides and the two genders were compared and found to be statistically non- significant.

Conclusion: A safe zone of 0.5 to 0.7 cm beyond the superior acetabular rim should be considered during surgeries around hip joint. The safe zone can be easily measured by the surgeons intraoperatively and be used as a guide to careful positioning of the retractors while performing surgeries around the hip joint. Better localization of SGNVB using the anatomic landmark defined in this study may be used to decrease surgical morbidity.

KEY WORDS: Superior Gluteal, Acetabulum, Hip Joint, Total hip arthroplasty, Safe Zone.

Corresponding Author: Dr. Sushant Swaroop Das, Assistant Professor, Shyam Shah Medical College, Rewa-486001, Madhya Pradesh, India. **E-Mail:** susvick@gmail.com

Access this Article online	Journal Information
Quick Response code	**International Journal of Anatomy and Research** ISSN (E) 2321-4287 | ISSN (P) 2321-8967 **https://www.ijmhr.org/ijar.htm** **DOI-Prefix:** https://dx.doi.org/10.16965/ijar
DOI: 10.16965/ijar.2021.104	**Article Information**
	Received: 21 Dec 2020 — Accepted: 23 Apr 2021 Peer Review: 21 Dec 2020 — Published (O): 11 May 2021 Revised: 04 Mar 2021 — Published (P): 05 Jun 2021

INTRODUCTION

The superior gluteal nerve (SGN) is formed by the dorsal branches of the ventral rami of L4, L5 and S1 nerve roots in the lesser pelvis. It leaves the pelvic cavity through the roof of the greater sciatic notch (GSN) above the piriformis muscle along with the superior gluteal artery (SGA) to enter the gluteal region. Here the neurovascular bundle lies between the gluteus medius and minimus muscle. The SGN then divides into superior and inferior branches while the SGA divides into superficial and deep branches. The deep branch of the artery further bifurcates into an upper and a lower branch. The superior branch of the nerve runs with the upper branch of the deep division of the artery to supply gluteus medius. The inferior branch of SGN accompanies the lower branch of the deep division of the SGA across gluteus minimus. It supplies the gluteus medius, gluteus minimus and tensor fasciae lata muscle. The superficial branch of the artery courses deep to the gluteus maximus and supplies it (Fig. 1). The superior gluteal neurovascular bundle (SGNVB) in the gluteal region lies in close proximity to the superior rim of the acetabulum at a variable distance [1].

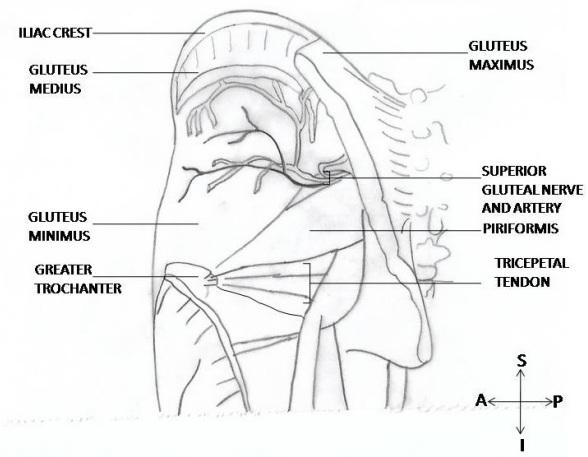


Fig. 1: Showing the course of superior gluteal nerve and artery.

Total hip arthroplasty (THA) is the most common cause of iatrogenic damage to this neurovascular bundle. During this surgery inappropriate placement of retractors is a leading cause of nerve injury. The nerve may be contused, compressed or penetrated by the tips of the retractors [2,3].

Prevalence rate of neurologic injury after primary hip arthroplasty is estimated as 0.7- 3.5% and as 7.6% after revisional hip arthroplasty [4]. This data however primarily reflects the incidence of injury to sciatic nerve. There is paucity of data specifying the individual incidence of injury to SGN. This may be due to under reporting by patients, as there is absence of any sensory loss and attributing the abductor weakness to mechanical rather than to neurological deficit[5]. Clinical examination in such cases may underestimate nerve injury after THA[6]. This is further supported by an alarmingly high incidence of subclinical gluteal nerve injury in 77% patients undergoing THA[7]. In addition to this, about 80 % of patients who sustain a THA-related nerve injury have persistent neurologic dysfunction, including paraesthesia, neuropathic pain, or motor weakness[8]. Such injuries have severe effects on patients' prognoses and reduce their quality of life[9]. Thus prevention is the first principle in managing nerve injuries associated with THA[3]. In order to preserve the SGN during THA, the surgeons must have a sound knowledge of its course, relation and distance to clinically useful landmarks such as the superior rim of acetabulum.

Superior gluteal artery injuries are relatively uncommon during hip arthroplasties however they are a common complication during pelvic fractures. Pseudoaneurysms in SGA have been reported with injuries during pelvic surgeries and intramuscular injections [10,11,12,13]. Anatomical details regarding the course of the artery and its relation to prominent bony landmarks will help surgeons in rapid localization of such vessels.

With an aim to provide baseline data for the Indian population to assist the surgical scenario we conducted this study.

MATERIALS AND METHODS

The study was conducted on 200 dry adult hip bones {Left side -109(male:66, female:43); Right side-91(male:66, female:43) obtained from the osteological museum of the Department of Anatomy at Maulana Azad Medical College. Sexing of skulls was documented through the museum catalog. Hip bones exhibiting

obscuring pathologies such as bone deterioration were excluded from the study. Photographs were taken keeping the bone in anatomical position, that is, with the anterior superior iliac spine (ASIS) and the pubic tubercle in the same coronal plane along with a measuring scale using Nikon D3300 DSLR camera. Image J software was used to do the measurements. Two lines- line A and line B were drawn. Line A corresponded to a horizontal passing through the anterior inferior iliac spine (AIIS) and roof of GSN while line B passed tangentially through the highest point on the acetabular rim parallel to line A. The vertical distance (white line) between the 2 lines was measured (Fig.2). This distance was recorded and the values tabulated for all the bones.

Statistical analysis was done using the Statistical Package for the Social Science (SPSS version 20). Student T test was used to compare results between sides and gender. Statistical significance was set at $p< 0.05$.

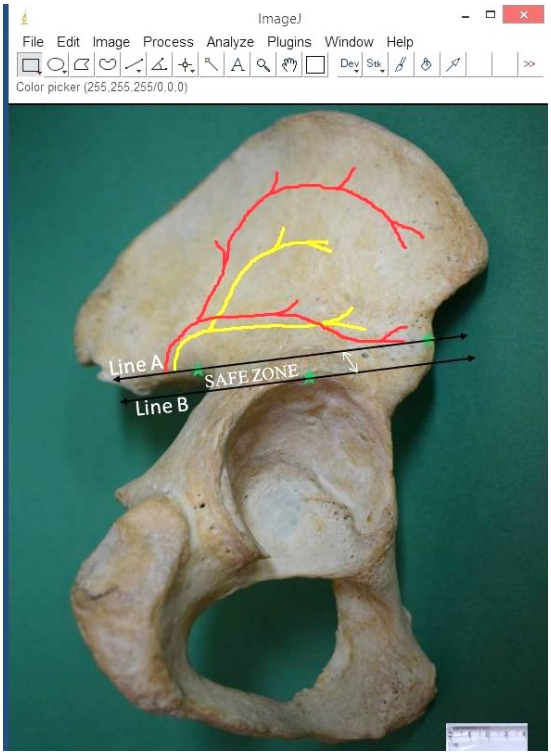


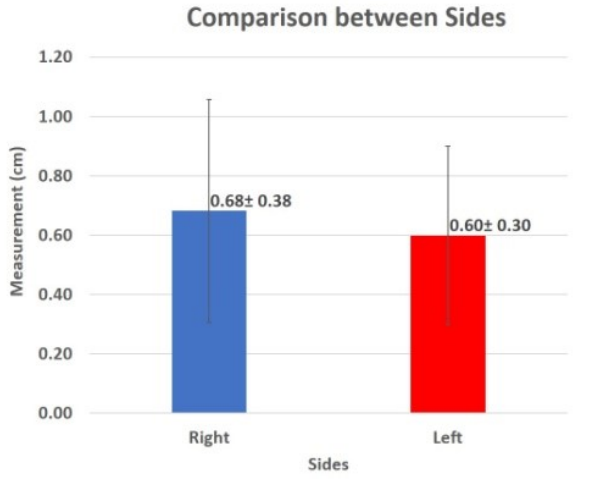
Fig. 2: Showing Image J software in use along with the superior gluteal nerve (Yellow line) and artery(Red line); Measured distance(white line);Line A(Line passing through AIIS and roof of GSN);Line B (Parallel line tangent to the acetabular rim).

OBSERVATION AND RESULTS

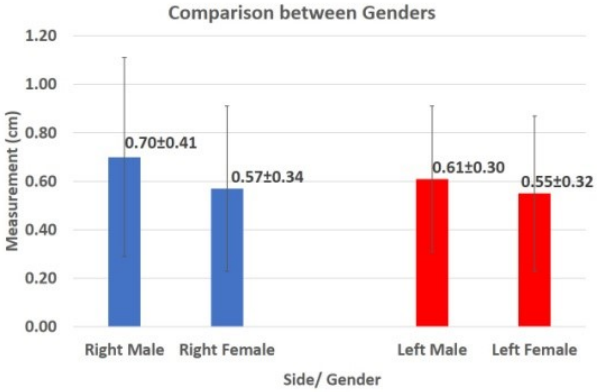
The mean distance calculated was 0.62 ± 0.16 cm (0.68 ± 0.38 cm in right hip bones and 0.60 ± 0.30 cm in left side hip bones). The values were different in male and female hip bones of right and left sides. The distance in male hip bones of right side was measured as 0.70 ± 0.41 cm and in females was 0.57 ± 0.34 cm. The distance in male hip bones of left side was measured as 0.61 ± 0.30 cm and in females was 0.55 ± 0.32 cm(Table 1, Graph 1,2)). These differences between the two sides and the two genders were statistically non- significant (Table 1).

Table 1: Showing the measured distances in both sides and gender.

Mean distance	0.62 ± 0.16 cm			p value
Mean distance (right)	0.68 ± 0.38 cm	**Mean distance (right male)**	0.70 ± 0.41 cm	0.09
		Mean distance (right female)	0.57 ± 0.34 cm	
Mean distance (left)	0.60 ± 0.30 cm	**Mean distance (left male)**	0.61 ± 0.30 cm	0.46
		Mean distance (left female)	0.55 ± 0.32 cm	



Graph 1: Showing comparison between the right and left side hip bones.



Graph 2: Showing the comparison between right and left sides of male and female hip bones

DISCUSSION

Injury to the SGN would lead to the paralysis of the gluteus medius, gluteus minimus and the tensor fascia lata muscles which would

manifest as weakness of hip abductors. Prevention of iatrogenic damage to the nerve is much more important in light of the fact that a high proportion of patients do not recover completely even after several months of the surgery[8,14].

The distance of SGN with respect to the surrounding bony landmarks like greater trochanter, PSIS, ASIS, AIIS and superior rim of the acetabulum has been measured previously (Table 2) [15,16,17,18]. With this data, a safe zone has been defined by some authors, operating within which would not damage the nerve.

According to Jacobs and Buxton, a zone of 5 cm cranial to the centre of superior border of the greater trochanter could be designated as the safe area for SGN during hip surgeries as well as during intermuscular injections in the gluteus medius[19]. While another study on 20 cadavers proposed a distance of 3 cm from the tip of greater trochanter to be considered as the zone beyond which SGN may be injured[20]. Baker and Bitounis reported that the SGN may be 3 to 5 cm away from the tip of the greater trochanter anteriorly, and 6 to 8 cm posteriorly based on a clinical and electromyographic study on 68 hips of English patients[21]. In a study conducted on 12 Turkish cadavers by Eksioglu et al., the mean distance between superior gluteal nerve and the greater trochanter was found to be 2.7 cm in the anterior regions, and 4.6 cm in the posterior region[22].

Due to the immense variability in the distance of SGN from the greater trochanter, Wang et al., measured the distance of SGN from the superior rim of the acetabulum. This study was based on MRI scans of 263 Chinese patients[3]. They reported the distance to be 2.23±0.28 cm. This distance as per the present study on dry adult bones of Indian origin is much less (0.62 ± 0.16 cm). This may be attributed to the topographical differences between the two study populations. Based on this we can specify a safe zone of 0.5 to 0.7 cm beyond the superior acetabular rim for surgeries around the hip joint. Thus we can conclude that in Indians, this safe zone is less and margin of error during surgeries is very small.

In a study by Solomon et al.[23], on 50 dry bones the mean distance between AIIS and acetabular rim in males was 1.13 ±0.31cm and in females was 0.96 ±0.45 cm whereas in the present study the mean distance recorded is male hip bones: 0.7±0.41cm (right); 0.61±0.3 cm (left); female hip bones: 0.57±0.34cm (right); 0.55±0.32 cm (left). This differences in measurements could be attributed to mixed population used by Solomon et al which included Europeans, Asians along with Indians. The Europeans and Asians have greater dimensions as compared to Indians as shown in previous studies on Germans[24] and Chinese[3].

Guy P et al.[24], measured the same distance on 93 CT Scans and came to the conclusion that the safe zone during acetabular surgeries in relation to sciatic notch was 1.1 cm. However according to the present study this safe zone should be reduced further. A study by Amar E et al.[25], on CT Scans of 50 patients without any hip pathology concluded that no significant difference exists between the

Table 2: Showing a comparison between the previous studies and the present study.

S.no	Study	Year	Population	Sample size	Bony Reference used	Distance measured	Type of study
1	**Jacobs and Buxton**	1989	British	10 cadavers	Centre of superior border of the greater trochanter	5 cm	Cadaveric study
2	**Bos et al**	1994	Netherlands	20 cadavers	Tip of greater trochanter	3 cm	Cadaveric study
3	**Baker and Bitounis**	1989	British	68 hips	Tip of the greater trochanter	Anterior: 3 to 5 cm Posterior: 6 to 8 cm	Clinical and electromyographic
4	**Eksioglu et al**	2002	Turkish	12 cadavers	Greater trochanter	Anterior: 2.7 cm Posterior: 4.6 cm	Cadaveric study
5	**Wang et al**	2016	Chinese	263 MRI scans	Superior rim of the acetabulum	2.23±0.28 cm	Radiological study
6	**Solomon et al**	2013	Indian, European ,	50 dry bones	Superior rim of the acetabulum	Males :1.13 ±0.31cm Females:0.96 ±0.45 cm	Dry bone study
7	**Guy P et al**	2010	German	93 CT Scans	Superior rim of the acetabulum	1.1 cm	Radiological study
8	**Amar E et al**	2013	Israeli	50 CT Scans	Superior rim of the acetabulum	1.35 cm	Radiological study
9	**Present study**	2017	Indian	200 dry bones	Superior rim of the acetabulum	0.62 ± 0.16 cm	Dry bone morphometry

distance measured on the basis of side or gender in their Israeli study population as also seen in the present study.

This study provides gender and side dependent estimate of a safe area for SGN during surgeries around the hip joint. The side differences are minimal. The values recorded on male hip bones were slightly more than that on female hip bones however the difference was not statistically significant. Nevertheless these gender differences should be borne in mind while performing surgeries. These measurements will also be of help to surgeons in swift exploration for injured SGA during pelvic surgeries or pelvic fractures. Better localization of SGNVB using the anatomic landmark defined in this study may decrease surgical morbidity.

CONCLUSION

We propose a safe zone of 0.5 to 0.7 cm beyond the superior acetabular rim for surgeries around the hip joint. The safe zone can be easily measured by the surgeons intraoperatively and be used as a guide to careful positioning of the retractors while performing surgeries around the hip joint. The gender variability should also be borne in mind during surgeries. This could bring down the incidence level of iatrogenic damage to the superior gluteal neurovascular bundle. In near future we aim to supplement this data from dry bones with cadaveric measurements to provide a holistic anatomical knowledge to the surgeons.

Conflicts of Interests: None

REFERENCES

[1]. S. Standring. Gray's anatomy-The anatomical basis of clinical practice. 41st ed. London: Elsevier; 2016. Pelvic Girdle and Lower Limb; p.1367 and 1374.

[2]. Brown GD, Swanson EA, Nercessian OA. Neurologic injuries after total hip arthroplasty. Am J Orthop (Belle Mead NJ). 2008;37:191–7.

[3]. Wang TI, Chen HY, Tsai CH, Hsu HC, Lin TL. Distances between bony landmarks and adjacent nerves: anatomical factors that may influence retractor placement in total hip replacement surgery. J Orthop Surg Res. 2016 Mar 16;11:31.

[4]. Ick-Hwan Yang. Neurovascular Injury in Hip Arthroplasty .Hip Pelvis.2014 Jun; 26(2): 74–78.

[5]. Kenny P, O'Brien CP, Synnott K, et al. Damage to the superior gluteal nerve after two different approaches to the hip. J Bone Joint Surg Br. 1999;81:979–81.

[6]. Weale AE, Newman P, Ferguson IT, Bannister GC. Nerve injury after posterior and direct lateral approaches for hip replacement. A clinical and electrophysiological study. J Bone Joint Surg Br. 1996 Nov;78(6):899-902.

[7]. Abitbol JJ, Gendron D, Laurin CA, et al. Gluteal nerve damage following total hip arthroplasty. A prospective analysis. J Arthroplasty. 1990;5:319–22.

[8]. Schmalzried TP, Amstutz HC, Dorey FJ. Nerve palsy associated with total hip replacement. Risk factors and prognosis. J Bone Joint Surg Am. 1991;73:1074-80.

[9]. Oldenburg M, Muller RT. The frequency, prognosis and significance of nerve injuries in total hip arthroplasty. Int Orthop. 1997;21:1–3.

[10]. Annu Babu, Amit Gupta, Pawan Sharma, Piyush Ranjan, Atin Kumar. Blunt traumatic superior gluteal artery pseudoaneurysm presenting as gluteal hematoma without bony injury: A rare case report. Chin J Traumatol. 2016 Aug; 19(4): 244–246.

[11]. Suk Kang, Phil Hyun Chung, Jong Pil Kim, Young Sung Kim, Ho Min Lee, Gyeong Soo Eum. Superior Gluteal Artery Injury during Percutaneous Iliosacral Screw Fixation: A Case Report.Hip Pelvis. 2015 Mar; 27(1): 57–62.

[12]. Claudia De Gregorio, Flavia Spalla, Andrea Padricelli, Donatella Narese, Umberto Bracale, Doriana Ferrara, Luca del Guercio, Umberto Marcello Bracale. The Endovascular Management of an Iatrogenic Superior Gluteal Artery Rupture Following Bone Marrow Biopsy. Intern Med. 2017 Oct 1; 56(19): 2639–2643.

[13]. Brown JJ, Greene FL, McMillin RD. Vascular injuries associated with pelvic fractures. Am Surg. 1984 Mar;50(3):150-4.

[14]. Ramesh M, O'Byrne JM, McCarthy N, Jarvis A,Mahalingham K, Cashman WF. Damage to the superior gluteal nerve after the Hardinge approach to the hip. J Bone Joint Surg Br. 1996;78:903-6.

[15]. Ince A, Kemper M, Waschke J, Hendrich C. Minimally invasive anterolateral approach to the hip: risk to the superior gluteal nerve.Acta Orthop. 2007 Feb;78(1):86-9.

[16]. Apaydin N, Kendir S, Loukas M, Tubbs RS, Bozkurt M. Surgical anatomy of the superior gluteal nerve and landmarks for its localization during minimally invasive approaches to the hip. Clin Anat. 2013 Jul;26(5):614-20.

[17]. Ray B, D'Souza AS, Saxena A, Nayak D, Sushma RK, Shetty P, Pugazhendi B. Morphology of the superior gluteal nerve: a study in adult human cadavers. Bratisl Lek Listy. 2013;114(7):409-12.

[18]. Grob K, Manestar M, Ackland T, Filgueira L, Kuster MS. Potential Risk to the Superior Gluteal Nerve During the Anterior Approach to the Hip Joint: An Anatomical Study. J Bone Joint Surg Am. 2015 Sep 2;97(17):1426-31.

[19]. Jacobs LG, Buxton RA. The course of the superior gluteal nerve in the lateral approach to the hip. J Bone Joint Surg Am. 1989;71:1239–43.

[20]. Bos JC, Stoeckart R, Klooswijk AI, et al. The surgical anatomy of the superior gluteal nerve and anatomical radiologic bases of the direct lateral approach to the hip. Surg Radiol Anat. 1994;16:253–8.

[21]. Baker AS, Bitounis VC. Abductor function after total hip replacement: an electromyographic and clinical review. J Bone Joint Surg [Br] 1985;71-B:47-50.

[22]. Eksioglu F, Uslu M, Gudemez E, et al. Reliability of the safe area for the superior gluteal nerve. Clin Orthop Relat Res. 2003;412:111–6.

[23].Lucian B Solomon, Donald W. Howie ,Maciej Henneberg. The Variability of the Volume of Os Coxae and Linear Pelvic Morphometry. Considerations for Total Hip Arthroplasty. Int J Morphol.2012;30(3):1042-9.

[24]. Guy p, Al-Otaibi M, Harvey EJ, Helmy N. The 'safe zone' for extra-articular screw placement during intra-pelvic acetabular surgery. J Orthop Trauma.2010 May;24(5):279-83.

[25]. Amar E, Druckmann I, Flusser G, Safran MR, SalaiM, Rath E. The anterior inferior iliac spine: size, position, and location. An anthropometric and sex survey. Arthroscopy. 2013 May;29(5):874-81.

How to cite this article:

Nidhi Mangla, Sushant Swaroop Das, Sabita Mishra, Neelam Vasudeva. Biometric Assessment of Superior Gluteal Neurovascular Bundle to Acetabulum of Hip Joint. Int J Anat Res 2021;9(2.2):7970-7975. **DOI:** 10.16965/ijar.2021.104