International Journal of Medicine
ISSN (P): 1468-3814; ISSN (e): 2667-7008
https://www.theinternationalmedicine.com
Volume: 5(1) 2023

Original Research

Anatomical basis of safe gluteal intramuscular injections using cadaveric dissection.

Dr. Saniya K [1]*, Dr. Prakash KG [2], Dr. Aishwarya Mantri [3], Dr. Shubham Jaju [4]
1Associate Professor, Department of Anatomy, Geetanjali Medical College & Hospital, Udaipur, Rajasthan, India.
2Professor and HOD, Department of Anatomy, Geetanjali Medical College & Hospital, Udaipur, Rajasthan, India.
3Senior Resident, Department of Pathology, Government Medical College, Akola, Maharashtra, India.
4Senior Resident, Department of Pharmacology, Government Medical College, Sangareddy, Telangana, India.
Received: 18 Sep 2023 / Accepted: 12 Nov 2023

Abstract
Introduction: Gluteal intramuscular injections are among the most commonly performed clinical procedures; however, incorrect site selection may result in complications such as sciatic nerve injury, vascular damage, and inadequate drug delivery. Cadaveric anatomical studies provide valuable information regarding safe injection zones and their relationship to surrounding neurovascular structures. The present study aimed to evaluate the anatomical relationships of the gluteal region through cadaveric dissection, determine the morphometric characteristics of clinically relevant anatomical landmarks, assess the proximity of major neurovascular structures to commonly used intramuscular injection sites, and identify the safest anatomical zone for gluteal intramuscular injections. *Materials and Methods:* This descriptive cross-sectional cadaveric study was conducted in the Department of Anatomy, Geetanjali Medical College & Hospital, Udaipur, Rajasthan, India, from January 2023 to June 2023. Fifty embalmed adult cadavers (100 gluteal regions) were included. Standard anatomical dissection techniques were used to expose the gluteal musculature and major neurovascular structures. Morphometric measurements of anatomical landmarks, muscle and subcutaneous tissue thickness, dimensions of the ventrogluteal and dorsogluteal safe zones, and distances of major neurovascular structures from conventional injection sites were recorded. Data were analyzed using SPSS version 26.0, with $p<0.05$ considered statistically significant. *Results:* The mean age of the cadavers was 61.8 ± 10.7 years, with males constituting 64.0% of the study population. No significant differences were observed between the right and left gluteal regions in morphometric measurements ($p>0.05$). The ventrogluteal region demonstrated a significantly larger safe injection radius than the dorsogluteal region (4.63 ± 0.49 cm vs. 2.94 ± 0.61 cm; $p<0.001$). The sciatic nerve was identified within the potential risk zone of the dorsogluteal site in 18.0% of specimens but was absent from the ventrogluteal site. Male cadavers exhibited significantly greater gluteus medius thickness, whereas females had significantly greater subcutaneous fat thickness ($p<0.001$). *Conclusion:* The ventrogluteal region offers a larger and more consistent anatomical safe zone for intramuscular injections than the dorsogluteal region, with a substantially lower risk of neurovascular injury. These findings support the preferential use of the ventrogluteal site for safe gluteal intramuscular injections and underscore the importance of anatomical knowledge in clinical practice.

Keywords: *Cadaveric dissection; Gluteal intramuscular injection; Ventrogluteal region; Sciatic nerve; Anatomical landmarks.*

Introduction

Intramuscular (IM) injection is one of the most frequently performed clinical procedures for the administration of vaccines, antibiotics, analgesics, and other therapeutic agents [1]. The gluteal region has traditionally been regarded as a preferred site for IM injections because of its large muscle mass and capacity to accommodate relatively large injection volumes [2]. However, improper selection of the injection site can result in serious complications, including sciatic nerve injury, vascular damage, hematoma formation, muscle fibrosis, and inadequate drug delivery [3]. These complications are largely preventable through a sound understanding of the anatomy of the gluteal region and adherence to appropriate injection techniques.

The dorsogluteal and ventrogluteal regions are the two most commonly recommended sites for gluteal intramuscular injections [4]. While the dorsogluteal site has been widely used in routine clinical practice for decades, concerns have been raised regarding its close proximity to the sciatic nerve and major gluteal vessels [5]. Consequently, the ventrogluteal site has been increasingly advocated as a safer alternative because it is relatively free of major neurovascular structures, has a well-defined bony landmark-based approach, and provides adequate muscle mass for drug administration [4]. Despite these recommendations, the dorsogluteal site continues to be commonly utilized owing to familiarity among healthcare professionals and variations in clinical training [6].

Address for Correspondence Dr. Saniya K, Associate Professor, Department of Anatomy, Geetanjali Medical College & Hospital, Udaipur, Rajasthan, India.
.
DOI: 10.61336/im/23-12-14

Cadaveric anatomical studies provide invaluable insights into the spatial relationships between surface landmarks, muscular structures, and underlying neurovascular elements. Morphometric evaluation of the gluteal region enables accurate identification of safe injection zones and facilitates the development of evidence-based guidelines for clinical practice [7]. Furthermore, anatomical variations related to sex, body habitus, and individual morphology may influence the safety margin of intramuscular injections, highlighting the importance of population-specific anatomical data [8]. Such studies serve as an essential bridge between anatomical knowledge and safe clinical application, ultimately contributing to the prevention of injection-related complications [9].

The present study aimed to evaluate the anatomical relationships of the gluteal region through cadaveric dissection, determine the morphometric characteristics of clinically relevant anatomical landmarks, assess the proximity of major neurovascular structures to commonly used intramuscular injection sites, and identify the safest anatomical zone for gluteal intramuscular injections.

Materials and Methods

This descriptive cross-sectional cadaveric study was conducted in the Department of Anatomy, Geetanjali Medical College & Hospital, Udaipur, Rajasthan, India, over a period of six months from January 2023 to June 2023. The study was undertaken after obtaining approval from the Institutional Ethics Committee and in accordance with the ethical principles governing the use of human cadavers for teaching and research. A total of 50 embalmed adult cadavers available in the Department of Anatomy were included in the study, yielding 100 gluteal regions (right and left) for anatomical assessment.

Adult cadavers with intact gluteal regions and preserved anatomical landmarks were included in the study. Cadavers with evidence of trauma, previous gluteal surgery, congenital deformities, gross musculoskeletal abnormalities, or significant pathological changes involving the pelvis or gluteal region were excluded. Age and sex of the cadavers were recorded from departmental records wherever available. Standard anatomical positioning was maintained throughout the dissections to ensure uniformity of measurements.

The gluteal region of each cadaver was dissected using standard anatomical dissection techniques. Superficial fascia and subcutaneous tissue were carefully reflected to expose the gluteal musculature and underlying neurovascular structures. Bony landmarks, including the anterior superior iliac spine (ASIS), posterior superior iliac spine (PSIS), iliac crest, and greater trochanter of the femur, were identified. Morphometric measurements were obtained using a calibrated digital Vernier caliper and measuring tape. Distances between anatomical landmarks, thickness of the gluteus medius muscle and subcutaneous tissue, dimensions of the ventrogluteal and dorsogluteal safe injection zones, and the relationship of major neurovascular structures–including the sciatic nerve, superior and inferior gluteal nerves, and superior gluteal artery–to commonly used intramuscular injection sites were documented systematically for both sides.

The collected data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) and range, whereas categorical variables were presented as frequencies and percentages. Comparisons between the right and left gluteal regions and between male and female cadavers were performed using the independent Student's *t*-test for continuous variables and the Chi-square test for categorical variables. A *p*-value of less than 0.05 was considered statistically significant.

Results

The study included 50 embalmed cadavers, providing a total of 100 gluteal regions for anatomical evaluation. The mean age of the cadavers was 61.8 ± 10.7 years. The majority of cadavers belonged to the 60-69 years age group (36.0%), followed by 50-59 years (28.0%), ≥70 years (20.0%), and 40-49 years (16.0%). Male cadavers constituted 64.0% of the study population, while females accounted for 36.0%. Equal numbers of right and left gluteal regions (50 each) were dissected and analyzed. (Table 1)

Table 1. Demographic characteristics of cadavers (N=50)

Variable	Category	n (%)
Age (years)	40-49	8 (16.0)
	50-59	14 (28.0)
	60-69	18 (36.0)
	≥70	10 (20.0)
Sex	Male	32 (64.0)
	Female	18 (36.0)
Side dissected	Right	50 (50.0)
	Left	50 (50.0)

Morphometric analysis of the gluteal region demonstrated that the mean distance from the anterior superior iliac spine (ASIS) to the greater trochanter was 16.92 ± 1.41 cm, while the mean distance from the posterior superior iliac spine (PSIS) to the greater trochanter measured 15.11 ± 1.26 cm. The iliac crest to greater trochanter distance averaged 18.94 ± 1.52 cm. The mean thickness of the gluteus medius muscle was 3.84 ± 0.58 cm, whereas the mean subcutaneous fat thickness was 2.71 ± 0.81 cm. These measurements demonstrated moderate anatomical variability within the study population. (Table 2)

Table 2. Morphometric measurements of the gluteal region (100 gluteal regions)

Measurement	Mean ± SD (cm)	Range
ASIS to Greater Trochanter	16.92 ± 1.41	13.8-20.3
PSIS to Greater Trochanter	15.11 ± 1.26	12.2-18.4
Iliac crest to Greater Trochanter	18.94 ± 1.52	15.4-22.5
Gluteus medius thickness	3.84 ± 0.58	2.6-5.2
Subcutaneous fat thickness	2.71 ± 0.81	1.1-5.0

Comparison of morphometric parameters between the right and left gluteal regions revealed no statistically significant differences. The mean ASIS-to-greater trochanter distance was 16.89 ± 1.45 cm on the right and 16.95 ± 1.37 cm on the left (p=0.811). Similarly, the PSIS-to-greater trochanter distance, gluteus medius thickness, and subcutaneous fat thickness showed comparable values between both sides, with all p-values exceeding 0.05, indicating symmetrical anatomical characteristics of the gluteal region. (Table 3)

Table 3. Comparison between right and left gluteal regions

Measurement	Right (n=50) Mean ± SD	Left (n=50) Mean ± SD	p-value
ASIS-Greater Trochanter	16.89 ±1.45	16.95 ±1.37	0.811
PSIS-Greater Trochanter	15.08 ±1.24	15.15 ±1.28	0.742
Gluteus medius thickness	3.82 ±0.56	3.86 ±0.60	0.694
Fat thickness	2.69 ±0.79	2.73 ±0.83	0.803

The distances of major neurovascular structures from conventional intramuscular injection sites were evaluated to determine potential risk during gluteal injections. The sciatic nerve was located at a mean distance of 8.56 ± 1.14 cm from the injection site, representing the farthest

major structure, while the superior gluteal artery was the closest, with a mean distance of 5.46 ± 0.77 cm. The superior gluteal nerve and inferior gluteal nerve were situated at mean distances of 5.91 ± 0.81 cm and 7.84 ± 0.93 cm, respectively. These findings provide important anatomical landmarks for safer intramuscular injection practices. (Table 4)

Table 4. Distance of important neurovascular structures from conventional injection sites

Structure	Mean Distance (cm) ± SD	Minimum	Maximum
Superior gluteal nerve	5.91 ±0.81	4.3	7.9
Inferior gluteal nerve	7.84 ±0.93	5.8	9.9
Sciatic nerve	8.56 ±1.14	6.2	11.4
Superior gluteal artery	5.46 ±0.77	4.0	7.3

Assessment of the recommended safe injection zones demonstrated that the ventrogluteal region possessed a significantly larger safe area than the dorsogluteal region. The mean safe radius in the ventrogluteal region was 4.63 ± 0.49 cm compared with 2.94 ± 0.61 cm in the dorsogluteal region. This difference was statistically significant ($p<0.001$), supporting the ventrogluteal region as a more favorable site for intramuscular injections. (Table 5)

Table 5. Dimensions of the recommended safe injection zones

Injection Site	Mean Safe Radius (cm) ± SD	Minimum	Maximum
Ventrogluteal site	4.63 ±0.49	3.7	5.8
Dorsogluteal site	2.94 ±0.61	1.7	4.3

Evaluation of the proximity of major neurovascular structures to the injection sites showed a greater frequency of structures within the potential risk zone of the dorsogluteal region than the ventrogluteal region. The sciatic nerve was identified within 5 cm of the dorsogluteal site in 18.0% of specimens but was absent from the ventrogluteal site. Likewise, the superior gluteal nerve, inferior gluteal nerve, and superior gluteal artery were encountered more frequently near the dorsogluteal site than the ventrogluteal site. The overall difference in neurovascular risk between the two injection sites was statistically significant ($p=0.001$). (Table 6)

Table 6. Presence of neurovascular structures within the potential risk zone

Structure	Present within 5 cm of dorsogluteal site n (%)	Present within ventrogluteal site n (%)
Sciatic nerve	18 (18.0)	0 (0.0)
Superior gluteal nerve	7 (7.0)	1 (1.0)
Inferior gluteal nerve	5 (5.0)	0 (0.0)
Superior gluteal artery	6 (6.0)	1 (1.0)

Sex-based comparison demonstrated significant differences in tissue thickness. Male gluteal regions exhibited a significantly greater gluteus medius muscle thickness than females (4.02 ± 0.51 cm vs. 3.51 ± 0.49 cm; $p<0.001$), whereas females had significantly greater subcutaneous fat thickness than males (3.27 ± 0.72 cm vs. 2.39 ± 0.63 cm; $p<0.001$). Although the mean safe ventrogluteal radius was marginally larger in males (4.69 ± 0.46 cm) than females (4.53 ± 0.51 cm), the difference was not statistically significant ($p=0.084$). (Table 7)

Table 7. Comparison of muscle and fat thickness according to sex

Variable	Male (n=64 gluteal regions)	Female (n=36 gluteal regions)	p-value
Gluteus medius thickness (cm)	4.02 ±0.51	3.51 ±0.49	<0.001
Fat thickness (cm)	2.39 ±0.63	3.27 ±0.72	<0.001
Safe ventrogluteal radius (cm)	4.69 ±0.46	4.53 ±0.51	0.084

Discussion

Safe administration of gluteal intramuscular injections depends primarily on accurate identification of anatomical landmarks and avoidance of major neurovascular structures. In the present cadaveric study, the morphometric measurements of the gluteal region demonstrated consistent anatomical relationships between the anterior superior iliac spine, posterior superior iliac spine, iliac crest, and greater trochanter, with no significant differences between the right and left sides. These findings suggest that bilateral anatomical symmetry can facilitate the use of standardized landmark-based techniques for intramuscular injections. Similar observations were reported by Coskun et al., who demonstrated comparable morphometric characteristics between the two gluteal regions in cadaveric specimens and emphasized the reliability of surface landmarks for identifying safe injection sites [4]. Likewise, Nakajima Y et al. concluded that anatomical landmarks remain dependable guides for minimizing neurovascular injury during gluteal injections [8].

The present study found that the ventrogluteal region possessed a significantly larger safe injection radius (4.63 ± 0.49 cm) than the dorsogluteal region (2.94 ± 0.61 cm; $p<0.001$). Furthermore, the ventrogluteal site demonstrated greater separation from major neurovascular structures, supporting its suitability as the preferred intramuscular injection site. These findings are in agreement with the cadaveric study by Coskun et al., who reported that the ventrogluteal site was consistently farther from the sciatic nerve and major gluteal vessels than the dorsogluteal site, thereby reducing the likelihood of iatrogenic injury [4]. Similarly, Small, in a comprehensive literature review, concluded that the ventrogluteal region provides the safest anatomical location for gluteal intramuscular injections owing to its greater distance from the sciatic nerve and major blood vessels [10]. Mishra and Stringer also highlighted that sciatic nerve injury remains a preventable complication when appropriate injection sites are selected based on sound anatomical knowledge [11].

An important observation in the present study was the higher frequency of major neurovascular structures within the potential risk zone of the dorsogluteal region, particularly the sciatic nerve, which was identified within 5 cm of the injection site in 18% of specimens, whereas no such occurrence was observed at the ventrogluteal site. These findings reinforce concerns regarding the continued routine use of the dorsogluteal region for intramuscular injections. Comparable results were reported by Nakajima Y et al., who demonstrated that the dorsogluteal site carries a greater risk of injury to the sciatic nerve and superior gluteal artery because of their close anatomical relationship, whereas the ventrogluteal site is relatively devoid of critical neurovascular structures [8]. Similarly, Soliman emphasized that improper site selection remains a major contributor to injection failure and neurological complications, advocating the ventrogluteal region as the preferred site for safe and effective drug delivery [2].

Sex-based analysis in the present study revealed significantly greater gluteus medius muscle thickness in males, whereas females exhibited significantly greater subcutaneous fat thickness. These anatomical differences may influence needle selection and the likelihood of successful intramuscular drug deposition. Similar findings have been reported by Elgellaie et al., who demonstrated that variations in muscle and subcutaneous tissue thickness significantly affect the efficacy of gluteal intramuscular injections and should be considered during clinical practice [12]. Collectively, the present findings, together with previous cadaveric and anatomical studies, provide further evidence supporting the ventrogluteal region as the safest and most anatomically reliable site for gluteal intramuscular injections while emphasizing the importance of adequate anatomical training to minimize preventable injection-related complications.

Conclusion

The present cadaveric study demonstrated that the ventrogluteal region provides a larger and more anatomically consistent safe zone for intramuscular injections compared to the dorsogluteal region, with significantly fewer major neurovascular structures at risk of injury. The observed morphometric relationships and symmetrical anatomical landmarks further support the reliability of landmark-based identification of the ventrogluteal site. Additionally, sex-related differences in muscle and subcutaneous tissue thickness highlight the need for individualized consideration during needle selection and injection technique. These findings reinforce the importance of anatomical knowledge in clinical practice and support the preferential use of the ventrogluteal region to enhance the safety and effectiveness of gluteal intramuscular injections while minimizing preventable injection-related complications.

Acknowledgement: None
Funding: None
Conflict of Interest: None

References

1. Ayinde O, Hayward RS, Ross JDC. The effect of intramuscular injection technique on injection associated pain; a systematic review and meta-analysis. PLoS One. 2021;16(5):e0250883.
2. Soliman E, Ranjan S, Xu T, Gee C, Harker A, Barrera A, Geddes J. A narrative review of the success of intramuscular gluteal injections and its impact in psychiatry. Biodes Manuf. 2018;1(3):161-170.
3. Park CW, Cho WC, Son BC. Iatrogenic Injury to the Sciatic Nerve due to Intramuscular Injection: A Case Report. Korean J Neurotrauma. 2019;15(1):61-66.
4. Coskun H, Kilic C, Senture C. The evaluation of dorsogluteal and ventrogluteal injection sites: a cadaver study. J Clin Nurs. 2016;25(7-8):1112-9.
5. Arslan GG, Özden D. Creating a change in the use of ventrogluteal site for intramuscular injection. Patient Prefer Adherence. 2018;12:1749-1756.
6. Cornwall J. Are nursing students safe when choosing gluteal intramuscular injection locations? Australas Med J. 2011;4(6):315-21.
7. Larkin TA, Ashcroft E, Hickey BA, Elgellaie A. Influence of gender, BMI and body shape on theoretical injection outcome at the ventrogluteal and dorsogluteal sites. J Clin Nurs. 2018;27(1-2):e242-e250.
8. Nakajima Y, Fujii T, Mukai K, Ishida A, Kato M, Takahashi M, Tsuda M, Hashiba N, Mori N, Yamanaka A, Ozaki N, Nakatani T. Anatomically safe sites for intramuscular injections: a cross-sectional study on young adults and cadavers with a focus on the thigh. Hum Vaccin Immunother. 2020;16(1):189-196.
9. Gyawali S, Rathore DS, Shankar PR, Kc VK, Jha N, Sharma D. Knowledge and Practice on Injection Safety among Primary Health Care Workers in Kaski District, Western Nepal. Malays J Med Sci. 2016;23(1):44-55.
10. Small SP. Preventing sciatic nerve injury from intramuscular injections: literature review. J Adv Nurs. 2004;47(3):287-96.
11. Mishra P, Stringer MD. Sciatic nerve injury from intramuscular injection: a persistent and global problem. Int J Clin Pract. 2010;64(11):1573-1579.
12. Elgellaie A, Ashcroft E, Larkin TA. Effects of thickness of muscle and subcutaneous fat on efficacy of gluteal intramuscular injection sites. Br J Nurs. 2018;27(6):300-305