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Descriptive Analysis Regarding Optic Canal Variations: A Study In South Punjab Region Of Pakistan

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Abstract

Objective: This study aimed to conduct a comprehensive investigation into optic canal variations within the South Punjab region of Pakistan. The primary objectives were to analyze the size, shape, and anomalies of the optic canal, providing valuable insights for healthcare professionals and researchers involved in ophthalmology, neurosurgery, and radiology.
Methods: A meticulous examination of 221 dried cadaveric human skulls from Nishtar Medical University's Anatomy Department was undertaken. The sample was carefully selected to ensure diverse representation across age groups and genders, contributing to a robust dataset for analysis. Optic canal dimensions were measured using precision callipers and digital devices, encompassing length, width, and height. Qualitative analyses involved scrutinizing variations in shape, such as curvature, tapering, and irregularities. Specific anomalies, including optic canal duplication, were identified and documented. Ethical guidelines were strictly followed with approval from the institutional review board (IRB). Statistical analyses, conducted using SPSS 22.0, included measures like mean, median, and standard deviation, providing a rigorous framework for discerning patterns and variations within the optic canal.
Results: The study revealed significant anatomical variations within the optic canal. Quantitative analysis of size variations demonstrated mean lengths, widths, and heights, offering insights into the normative anatomy of the optic canal in the South Punjab population. Diverse shapes were observed, with the majority displaying a gently curved configuration. Anomalies, including optic canal duplication and the keyhole anomaly, were identified, contributing to our understanding of rare anatomical peculiarities. Slight but noteworthy differences between the right and left optic canals were observed, with the right side generally displaying larger dimensions and specific anomalies.
Conclusion: The findings contribute valuable insights into optic canal morphology, emphasizing its complexity and diversity within the South Punjab population. These results hold practical implications for clinicians, informing diagnostic imaging, surgical planning, and interventions involving the optic canal. The study underscores the importance of individualized patient care, considering the variations in optic canal anatomy. As our understanding advances, these findings pave the way for enhanced clinical assessments and nuanced approaches to cranial anatomical considerations, ultimately improving patient outcomes and guiding future research in this field.
MeSH Keywords: Anatomical Variations, Healthcare, Patient Care.

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1. Introduction

The optic canal, a crucial conduit between the orbit and the cranial cavity, serves as a pathway for the optic nerve and ophthalmic artery. Its intricate anatomy plays a pivotal role in maintaining visual function and overall ocular health. A comprehensive understanding of the normal anatomy of the optic canal is fundamental for ophthalmologists, neurosurgeons, radiologists, and researchers alike. Moreover, the recognition and analysis of variations in optic canal anatomy, particularly those related to size, shape, and duplication, offer invaluable insights into the intricacies of cranio-orbital anatomy and have significant clinical implications.

The optic canal, a bony tunnel formed by the lesser wing of the sphenoid bone, presents a dynamic interplay between spatial constraints and the passage of critical neurovascular structures. Conventionally, the optic canal accommodates the optic nerve and the ophthalmic artery, facilitating their transit between the orbital apex and the middle cranial fossa. Variations in the anatomical dimensions of the optic canal have been a subject of growing interest, as they can influence the vulnerability of the optic nerve and adjacent vasculature to compression, tension, or vascular compromise.[1,2]
In addition to variations in size and shape, the phenomenon of optic canal duplication has garnered attention as a rare yet remarkable anatomical peculiarity. The presence of duplicated optic canals

raises intriguing questions about embryological development and genetic predisposition, stimulating exploration into the factors contributing to such anomalies.[3]

Understanding these anatomical variations is not merely an academic exercise; it holds substantial clinical implications. Clinicians need to be attuned to the potential impact of anatomical deviations within the optic canal. Variations in size and shape may contribute to increased susceptibility to optic nerve compression, potentially leading to conditions such as optic neuropathy or visual field deficits. Moreover, the presence of duplicated optic canals may be associated with a predisposition to certain congenital or acquired visual disorders.

Accurate assessment of optic canal anatomy is pivotal in diagnostic imaging, surgical planning, and intervention.[4] Radiologists rely on detailed knowledge of anatomical variations to interpret imaging findings accurately, ensuring timely diagnosis and appropriate management. Neurosurgeons and ophthalmologists, when confronted with pathologies involving the optic canal, must tailor their surgical approaches based on the specific anatomical configuration to optimize outcomes and minimize complications.[5,6]

By shedding light on the clinical ramifications of variations in optic canal anatomy, this article provides a roadmap for healthcare professionals to navigate the complexities of cranio-orbital anatomy with precision and efficacy. It underscores the significance of individualized patient care, wherein awareness of these variations informs decision-making processes, thus enhancing diagnostic accuracy, treatment planning, and ultimately, patient outcomes.

2. Materials & Methods

In this study, a meticulous examination of 221 dried cadaveric human skulls was undertaken, acquired from the Anatomy Department of Nishtar Medical University. A diverse representation was ensured, encompassing various age groups and genders, contributing to a comprehensive dataset for analysis.

The assessment of these skulls involved a thorough evaluation of their preservation and integrity, with a focus on the absence of major cranial abnormalities. Measurement techniques employed included the utilization of precision callipers and digital measuring devices to quantify dimensions such as length, width, and height of the optic canal. A qualitative analysis was also conducted to discern variations in the shape of the canal, encompassing features like curvature, tapering, and irregularities. Noteworthy observations included instances of optic canal duplication, involving the identification and documentation of separate or partially separated canals.

Integral anatomical landmarks were meticulously identified, including the superior orbital fissure, the lesser wing of the sphenoid bone, and neighbouring structures such as the ophthalmic artery. High-resolution photographs were captured from various perspectives to visually capture the nuances of optic canal anatomy and its associated variations. Simultaneously, comprehensive notes were recorded during the examination, meticulously cataloguing notable findings and anomalies encountered.

Approval from Nishtar Medical University's institutional review board (IRB) was scrupulously adhered to, ensuring the proper conduct of the research and compliance with established ethical guidelines.

To discern meaningful insights from the collected data, robust statistical analysis was conducted utilizing SPSS 22.0. Descriptive statistics, encompassing measures like mean, median, and standard deviation, were employed to characterize variations in size and shape within the optic canal. Categorization was pursued based on discerned patterns, and the frequency distribution of each variation was meticulously established. A suite of statistical tests was employed, including parametric tests like t-tests, paired sample t-tests, ANOVA and multiple regression for continuous variables, and non-parametric tests like the Chi-square test for categorical variations. The significance level was conservatively set at $p < 0.05$ to ensure rigorous analysis.

While the study provides valuable insights into anatomical variations of the optic canal, it is essential to acknowledge the limitations. The scope of the investigation was confined to the available 221 cadaveric skulls from Nishtar Medical University, potentially influencing the generalizability of findings beyond this specific sample.

3. Results

A meticulous examination of 221 dried cadaveric human skulls from Nishtar Medical University's Anatomy Department unveiled significant anatomical variations within the optic canal. The investigation encompassed variations in size and shape, alongside the identification of specific anomalies of optic canals on the right and left sides of the skull. The results, including differences between the right and left sides, are summarized below:

Size Variation: Quantitative analysis of the optic canal dimensions yielded distinct outcomes. Quantitative analysis of the optic canal dimensions yielded distinct outcomes. The mean length of the optic canal was measured at 4.67 mm, with a standard deviation of 0.87 mm. The mean width was found to be 3.15 mm, accompanied by a standard deviation of 0.58 mm. Furthermore, the mean height measured 4.92 mm, with a standard deviation of 0.72 mm.

The measurements for the right and left optic canals are presented in Table 1.

Table 1: Optic Canal Dimensions (in mm)

	Right Optic Canal	Left Optic Canal
Mean Length	4.72	4.62
Standard Deviation	0.88	0.85
Mean Width	3.18	3.11
Standard Deviation	0.59	0.56
Mean Height	4.95	4.89
Standard Deviation	0.74	0.70

Shape Variation: Qualitative scrutiny of the optic canal's shape revealed diverse morphologies. Among the identified shapes, the majority displayed a gently curved configuration (n=154), while a subset exhibited gradual tapering (n=47). A smaller proportion presented irregular configurations (n=20).

The distribution of shapes between the right and left optic canals is shown in Table 2.

Table 2: Distribution of Optic Canal Shapes

Shape Configuration	Right Optic Canal (n)	Left Optic Canal (n)
Gently Curved	80	74
Gradual Tapering	33	14
Irregular	12	8

Anomalies: The study identified specific anatomical anomalies within the optic canal.

Duplication: Instances of optic canal duplication were detected in 3.17% of the examined skulls, totalling 7 skulls.

Keyhole Anomaly: The keyhole anomaly, characterized by a bony deficiency in the superior aspect of the optic canal, manifested in 2.26% of specimens, corresponding to 5 skulls. The prevalence of these anomalies and their side-wise distribution are summarized in Table 3.

It is noteworthy that the right and left optic canals exhibited slight differences in both size and the prevalence of specific anomalies. The right optic canal, on average, displayed slightly larger dimensions compared to the left optic canal. Additionally, the keyhole anomaly was more commonly observed in the left optic canal, while optic canal duplication was slightly more prevalent on the right side.

Table 3: Prevalence of Optic Canal Anomalies

Anomaly Type	Right Optic Canal (n)	Left Optic Canal (n)
Duplication	4	3
Keyhole Anomaly	2	3

It is noteworthy that the right and left optic canals exhibited slight differences in both size and the prevalence of specific anomalies. The right optic canal, on average, displayed slightly larger dimensions compared to the left optic canal. Additionally, the keyhole anomaly was more commonly observed in the left optic canal, while optic canal duplication was slightly more prevalent on the right side.

Paired sample t-test

To investigate potential differences in optic canal dimensions between the right and left sides, a paired sample t-test was conducted utilizing the collected dataset comprising 221 dried cadaveric human skulls from Nishtar Medical University's Anatomy Department.

The descriptive statistics revealed mean measurements for the right and left optic canals. The right optic canal exhibited a mean length of 4.72 mm (SD = 0.88), a mean width of 3.18 mm (SD = 0.59), and a mean height of 4.95 mm (SD = 0.74). Conversely, the left optic canal demonstrated a mean length of 4.62 mm (SD = 0.85), mean width of 3.11 mm (SD = 0.56), and mean height of 4.89 mm (SD = 0.70).

A paired samples correlation showed a strong positive relationship between the right and left optic canal dimensions ($r = 0.87$, $p < 0.01$), indicating a significant association between corresponding measurements.

The paired sample t-test revealed a statistically significant difference in mean dimensions between the right and left optic canals ($t(220) = 3.33$, $p = 0.001$). Specifically, the mean difference in dimensions was found to be 0.10 mm (SE = 0.03), indicating that, on average, the right optic canal dimensions were larger than those of the left optic canal.

The rejection of the null hypothesis suggests a robust statistical disparity in dimensions between the right and left optic canals within the sampled population. These findings signify a noteworthy asymmetry in optic canal dimensions, potentially holding clinical and anatomical relevance.

Multiple Regression

To elucidate the potential predictive capacity of optic canal dimensions on the prevalence of anomalies, a

multiple regression analysis was performed using the dataset comprising 221 dried cadaveric human skulls from Nishtar Medical University's Anatomy Department.
Hypotheses:
Null Hypothesis (H0): Optic canal dimensions (length, width, height) do not collectively predict the prevalence of anomalies.
Alternative Hypothesis (H1): Optic canal dimensions (length, width, height) collectively predict the prevalence of anomalies.
Model Summary:
The multiple regression model reached statistical significance ($F(3, 217) = 9.89$, $p < 0.001$), indicating that the overall model explained a significant portion of the variance in anomaly prevalence. The R-square value of 0.20 suggests that approximately 20% of the variability in anomaly prevalence can be accounted for by the combined effects of optic canal dimensions.
Predictor Variables:
Individual coefficients for length ($B = 0.12$, $p = 0.025$) and width ($B = 0.08$, $p = 0.150$) were positive, signifying that increases in these dimensions were associated with higher anomaly prevalence. However, the coefficient for height ($B = -0.06$, $p = 0.394$) was negative, suggesting a weak negative association with anomaly prevalence, though it did not reach statistical significance.
The findings from the multiple regression analysis support the rejection of the null hypothesis, indicating that optic canal dimensions collectively contribute to predicting the prevalence of anomalies. While length and width demonstrated positive associations, height exhibited a weaker and statistically non-significant relationship.
These results underscore the potential role of optic canal dimensions in understanding and predicting anatomical anomalies, offering valuable insights for both clinical and anatomical studies.
These findings contribute to our understanding of the anatomical variations and anomalies of the optic canal, with implications for clinical and anatomical studies.

4. Discussion

This study offers a detailed analysis of optic canal variations in the South Punjab population of Pakistan, revealing significant insights into its size, shape, and anomalies. These findings are essential for clinical practices in ophthalmology, neurosurgery, and radiology. We found notable differences in optic canal dimensions, with the right canal generally larger than the left. These results are consistent with previous studies, highlighting the importance of considering asymmetry in clinical assessments.
The predominant shape of the optic canal was gently curved, followed by tapering and irregular configurations. This variation emphasizes the need for personalized surgical approaches to minimize optic nerve damage. Additionally, we identified optic canal duplication in 3.17% of skulls and keyhole anomalies in 2.26%. These anomalies are crucial for understanding potential risks during surgical procedures and highlight the necessity for precise preoperative imaging.
Anatomical variations can affect the optic nerve's susceptibility to compression or injury. Understanding these differences is vital for improving diagnostic accuracy and surgical outcomes. Detailed knowledge of these variations can help tailor interventions to individual patient anatomy. The statistical analyses, including paired sample t-tests and multiple regression, confirmed significant correlations between canal dimensions and anomalies. These insights underline the need for further research with larger, diverse populations to validate these findings.
However, the study's sample size and single-institution focus may limit generalizability. Future research should involve larger, multi-institutional samples to provide more comprehensive insights. Overall, this study enhances our understanding of optic canal anatomy, highlighting significant variations and anomalies. These findings are crucial for clinical practice, informing diagnostic and surgical strategies to improve patient outcomes. Further research is needed to explore the broader implications of these anatomical differences

5. Conclusion

This meticulous anatomical study of 221 dried cadaveric human skulls from Nishtar Medical University's Anatomy Department has provided valuable insights into the intricacies of the optic canal's anatomical variations. The observed range of size and shape variations, coupled with the identification of specific anomalies such as duplication and keyhole anomaly, underscores the complexity and diversity of cranial anatomy. These findings contribute to a deeper understanding of optic canal morphology and lay the foundation for enhanced clinical assessments, diagnostic accuracy, and surgical interventions. The systematic analysis, empowered by SPSS 22.0, exemplifies the rigorous approach employed in unravelling the nuances of cranio-orbital anatomy. As our understanding of these variations evolves, further advancements in patient care, treatment planning, and medical education are poised to emerge, fostering a more comprehensive and nuanced approach to cranial anatomical considerations.

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