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RESEARCH ARTICLE
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STUDY OF DUPLICATION OF THE OPTIC CANAL IN DRY HUMAN SKULL BONES: AN OSTEOLOGICAL STUDY

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Abstract:
Introduction: The optic canal is medially located, one of the two round openings at the apex of a pyramidal-shaped orbit connecting the orbit with the middle cranial fossa, housing the optic nerve and ophthalmic artery. A duplicated optic canal is a rare variation.
Objective: To study the presence of unilateral or bilateral duplication of the optic canals and complete or partial duplication in human skull bones.
Material and method: A descriptive cross-sectional study was conducted on 50 dry human skull bones collected from Bhagwan Mahavir Institute of Medical Sciences, Pawapuri, Nalanda, Bihar, and ESIC Medical College, Bihta, Patna, from February 2023 to September 2024. Each skull was meticulously examined for the duplicated optic canal: partial or complete, unilateral or bilateral.
Results: A completely duplicated optic canal was found in only one human dry skull bone on the left side. A keyhole anomaly of the optic canal in the same skull bone on the right side was also found. In addition, one partially duplicated optic canal was observed in another skull bone on both the left and right sides.
Conclusion: This study provides further insights into the rare variation of the optic canal and highlights the fact that even though duplication of the optic canal is a rare finding, it has immense clinical significance, especially during surgical exploration of the orbit, access to the cavernous sinus, Sella tursica, and decompression of the optic nerve.

Keywords- duplicated optic canal, optic nerve, ophthalmic artery, skull bone.

Introduction:

The optic canal is a paired foramen of the skull bone connecting orbit with the middle cranial fossa. It lodges the optic nerve (nerve of vision) and ophthalmic artery placed superomedial and inferolateral in the foramen respectively [1]. The optic canal is an obliquely placed 4-10 mm long funnel-shaped passage between two roots of lesser wings of the sphenoid and the body of the sphenoid, divided into infraorbital, central, and intracranial parts. Its orbital opening is round whereas its cranial opening is transversely oval. The optic nerve (2nd cranial nerve), the main inhabitant of the optic canal is enclosed within meningeal sheaths unlike all other cranial nerves and one of the hypotheses behind duplicated optic canal is the thickening of this meningeal sheath leading to partition of the optic canal. [2] The optic nerve (aggregation of axons of ganglionic cells of the retina) carries a sense of vision from the retina to the visual cortex, present in the occipital lobes of cerebral hemispheres. The optic nerve frequently gets traumatized with severe head injuries and maxillofacial fractures.[3] Optic nerves also

suffer compression neuropathy due to mucocele, pseudotumor cerebri, fibrous dysplasia, optic nerve meningioma, and osteopetrosis. The optic nerve bears ischemic insult due to loss of blood supply in acute optic neuropathy following acute retinal necrosis syndrome.[4-6]
Knowledge of the optic canal variation is essential to dealing with the above-mentioned clinical scenarios. The ophthalmic artery is another inhabitant of the optic canal, a branch of the internal carotid artery that provides oxygenated blood and nutrients to the eye, face, orbit, meninges, and upper nose. It enters into orbit via the optic canal running inferolateral to the optic nerve but occupies the laterally placed accessory optic canal in case of a duplicated optic canal. In contrast, the main optic canal gives space to the optic nerve. The ophthalmic artery gained importance due to the anomalous origin of the middle meningeal artery as embryologically, the ophthalmic artery and middle meningeal artery derived from the stapedial artery.
The study of the optic canal is of great clinical significance, as any pathology of the optic nerve will lead to visual disturbances. The present study was aimed at finding the variations of the optic canal, which can be helpful for surgeons when approaching the optic canal for various invasive procedures.

Objective- To study the presence of duplication of the optic canal—unilateral or bilateral- and complete or partial duplication in human skull bones.

Material and methods— A descriptive cross-sectional study was conducted on 50 dry human skull bones collected from Bhagwan Mahavir Institute of Medical Sciences, Pawapuri, Nalanda, Bihar, and ESIC Medical College, Bihta, Patna, from February 2023 to September 2024. Approval from the respective institutional ethical committee was obtained before the start of the study. Each skull was examined meticulously for duplicated optic canals--partial or complete, unilateral or bilateral. The compartment of the duplicated optic canal placed superomedially (which was somewhat larger compared to the compartment located inferolaterally) was considered the main optic canal. The narrower optic canal was considered an accessory canal. The patency of the main and accessory optic canals was checked using probes. The length of the main optic canal was measured using a marked needle. The length of the accessory optic canal and the thickness of the bony septum were not measured since it was too small to be measured with the needle.

Results- Out of 50 skull bones, a completely duplicated optic canal was found in only one human dry skull bone on the left side (Figures 1 and 3). A keyhole anomaly of the optic canal in the same skull bone was also on the right side (Figure 2). Additionally, one partially duplicated optic canal was also observed in another skull bone on both the left and right sides (Figures 4 and 5). Based on the cranial suture's closure patterns and prominent arachnoid granulation marking, it was estimated that the skulls bearing duplicated optic canals belonged to individuals above 40 years, justifying the reason for the thickening of the meningeal sheath of the optic nerve being one of the possibilities of duplicated optic canals .

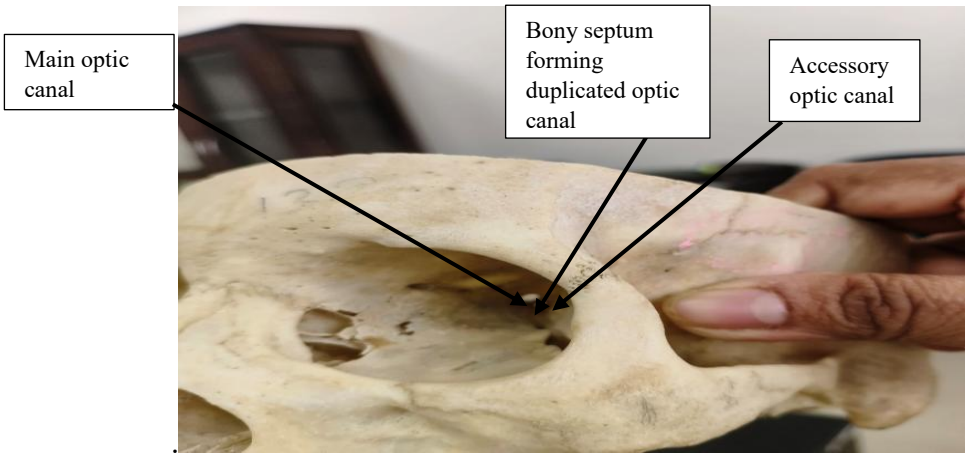

Figure 1. Showing a duplicated optic canal separated by a bony septum on the left side from the orbital side

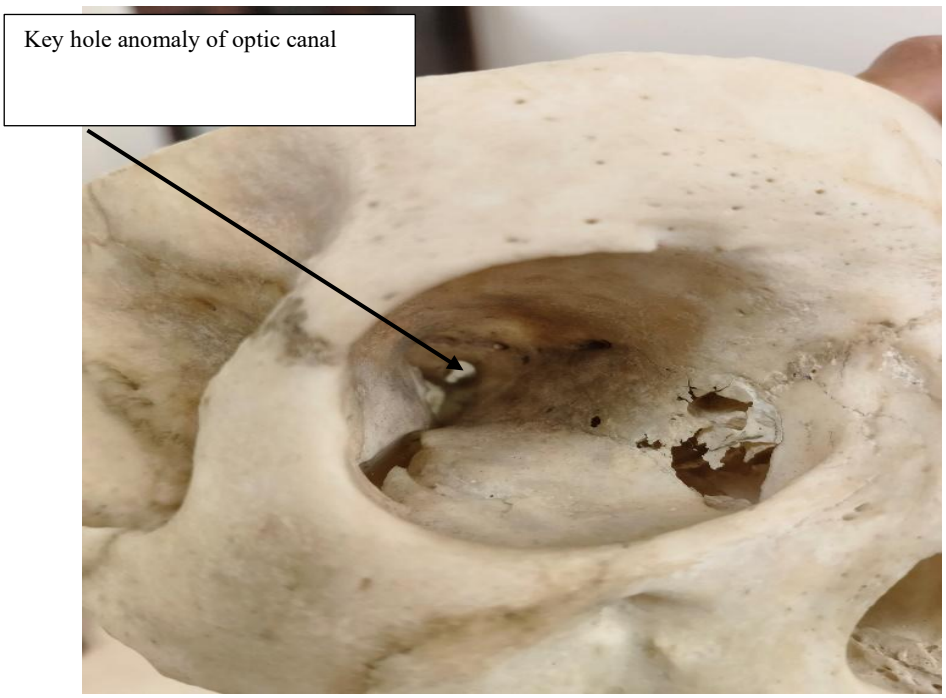

Figure 2. Showing keyhole anomaly of the optic canal on the right side from the orbital side

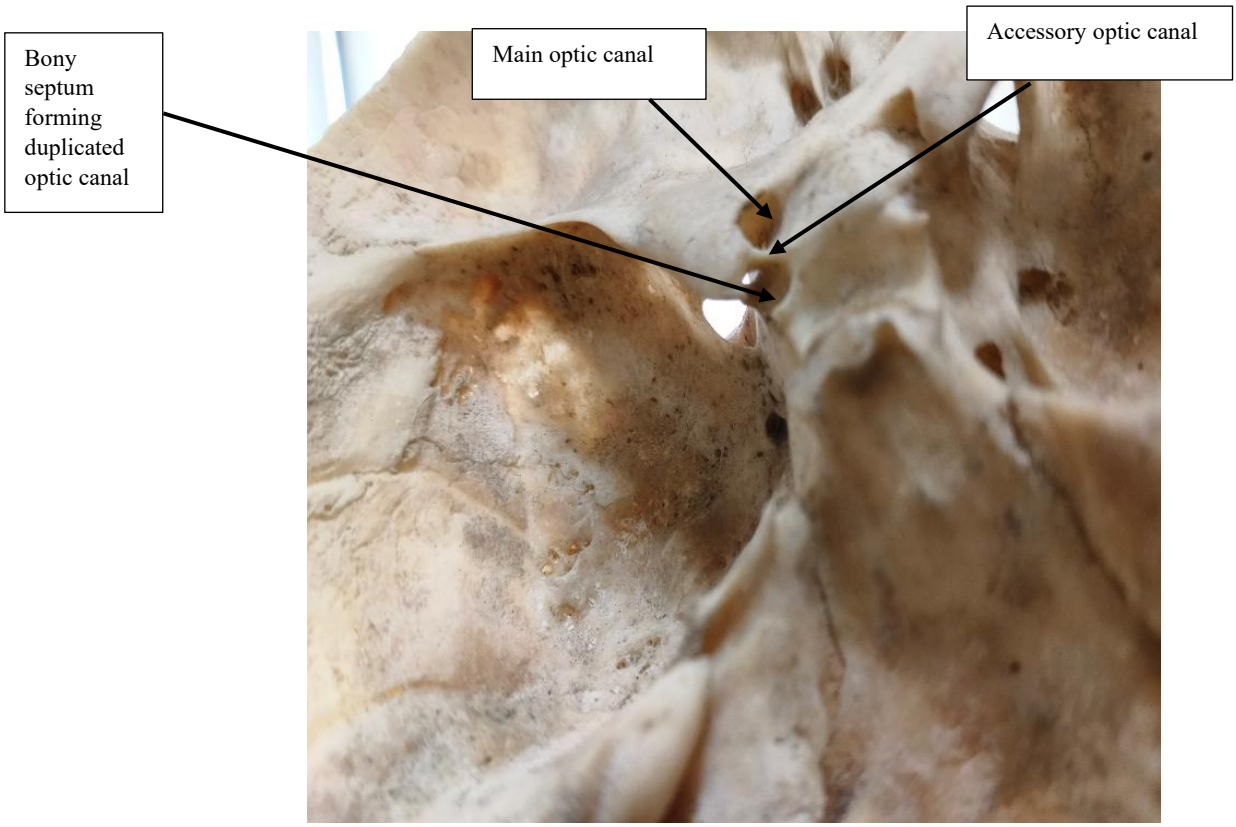

Figure 3. Showing a duplicated optic canal separated by a bony septum on the left side from the cranial side

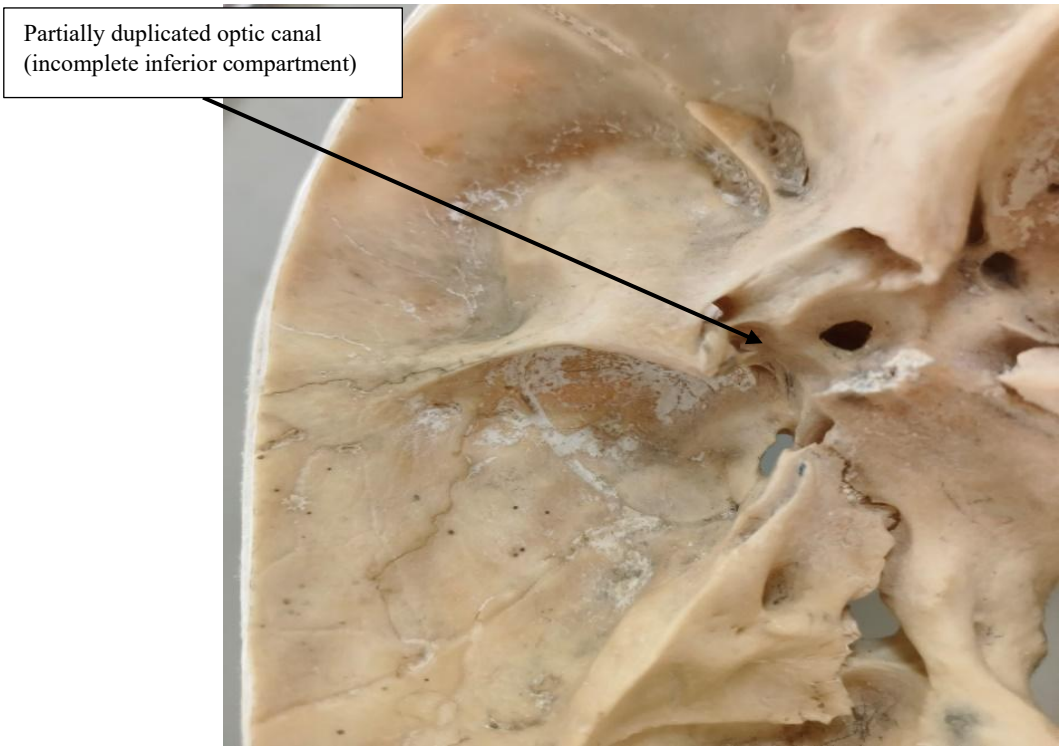

Figure 4. Showing a partially duplicated optic canal on the left side from the cranial side

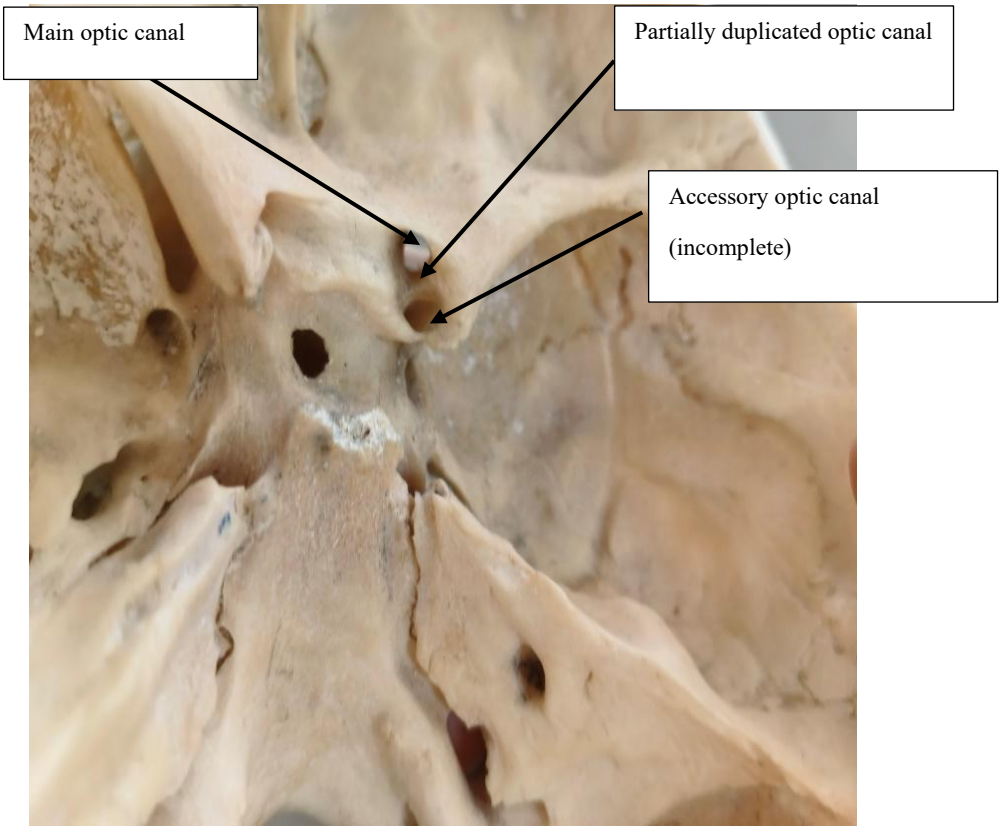

Figure 5. Showing a partially duplicated optic canal on the right side from the cranial side

Discussion: There are many schools of thought regarding the genesis of the duplication of the optic canal: -Duplication of the optic canal is the result of the thickening of the dura mater lies in between the optic nerve and ophthalmic artery according to the hypothesis supported by Calori (1891) [14] and Le Double (1903) [15].

Leon (1996) [16] and Scheuer (2000) [17] believed that the resultant of anomalous growth of optic strut or sphenoidal strut that forms the inferolateral wall of the optic canal, separating it from the superior orbital fissure and its content-optic canal duplication is due to the persistence of "le trou metoptique", a foramen frequently present in the fetal skull giving passage to aberrant ophthalmic vein -Augier (1931) [18]

Keyes (1935) [19] suggested that a bony projection on the inferolateral wall of the optic canal, when it gets enlarged, divides the optic canal, resulting in the formation of a small accessory canal.

Duplication of the optic canal has drawn the attention of many researchers from time to time. The works of various researchers on the duplication of optical canals are compared in Table 1 below.

Name of researcher	Sample size	Duplicated optic canal was found unilaterally	Duplicated optic canal was found bilaterally
Ghai et. al. (2012) [7]	194	2	3
Sweta and Kumar (2014) [8]	67	2	1
Patil et.al. (2011) [9]	400	8	3
Singh et. al. (2005) [10]	435	6	7
Shindhe et.al (2013) [11]	100	1	None
Choudhary et al. (1988) [12]	Case report	1	2
Gyanranjan et. al. (2016) [13]	100	1	2
Present study (2025)	50	1	None

Conclusion- A completely duplicated optic canal was found in only one human dry skull bone on the left side. A keyhole anomaly of the optic canal in the same skull bone was also on the right side. Additionally, one partially duplicated optic canal was also observed in another skull bone on both the left and right sides. This study provides further insights into the rare variation of the optical canal and highlights the fact that even though duplication of the optic canal is a rare finding, it has immense clinical significance, especially during surgical exploration of the orbit, access to the cavernous sinus, Sella tursica, and decompression of the optic nerve. Likewise, knowledge of the variation of the optic canal is of immense importance for radiologists and surgeons performing head and neck surgery.

Conflict of interest: None

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