Review Article
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The trochlea for the intermediate tendon of the digastric muscle: a review

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Abstract: This review explores the novel perspective that the intermediate tendon of the digastric muscle may function as an anatomical trochlear pulley system within the human body, challenging the traditional understanding of trochlear systems. While widely recognized trochlear units include structures like the medial part of the humerus and the superior oblique muscle of the orbit, the review focuses on the unique anatomical arrangement of the intermediate tendon of the digastric muscle in connection with the anterior and posterior bellies of the digastric muscles. Despite current debates within the anatomical community about labeling the digastric muscles as having a trochlea, this paper delves into the scientific definition of a trochlear pulley system, presenting the intermediate tendon of the digastric muscle as a potential trochlea.

Key words: Digastric muscles, Intermediate tendon, Trochlea, Anatomy, Fascia

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Introduction

The human body is composed of multiple complex processes where anatomical structures function to facilitate various physiological processes. Among these structures, trochlear systems play pivotal roles in the biomechanics of movement, particularly in the musculoskeletal system, by functioning as a pulley system. The trochlea is traditionally recognized as a smooth, grooved structure that guides the movement of tendons or muscles [1]. There are several widely recognized trochlear anatomical units in the human body, including the medial part at the distal end of the humerus, given its shape and the anatomical layout and function of the superior oblique as one of the extraocular muscles. However, providing a unique insight into a novel perspective that the intermediate tendon of the digastric muscle may function as an anatomical trochlear pulley system within the body can elevate our understanding of the muscle groups. This review delves into the anatomical definition of what constitutes an anatomical trochlear pulley system, exploring the role of the intermediate tendon of the digastric muscle as a potential trochlea. Understanding this unique anatomical arrangement has profound implications for comprehending the intricate mechanics governing several head and neck movements.

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Review

Structure and function

The digastric muscles comprise the anterior and posterior bellies connected by the intermediate tendon of the digastric muscle. These muscles contribute to the biomechanics of the mandible and play a crucial role in various orofacial functions, including mastication and speech [2]. The anterior belly of the digastric muscle originates from the digastric fossa of the mandible, while the posterior belly originates from the mastoid notch of the temporal bone. Both muscle bellies converge and attach to the intermediate tendon of the digastric muscle that inserts onto the body of the hyoid bone, forming a sling-like pulley structure [3, 4]. Together, these muscles facilitate coordinated and necessary orofacial movements, emphasizing elevating the hyoid bone during swallowing and assisting in the mandible opening.

Cadaveric studies have revealed the intermediate tendon of the digastric muscle's spatial relationships with adjacent structures, emphasizing its role as a dynamic connector between the mandible and hyoid bone [5, 6]. The intermediate tendon of the digastric muscle commonly runs through the stylohyoid muscle. It extends through a fibrous ring of deep cervical fascia attached to the hyoid bone (Fig. 1). However, there are variants [7] where the intermediate tendon runs medial or lateral to the stylohyoid muscle. Multimodal modeling and response studies have further contributed to visualizing the tendon's dynamics during movements of the mandible, offering insights into its biomechanical significance [8, 9].

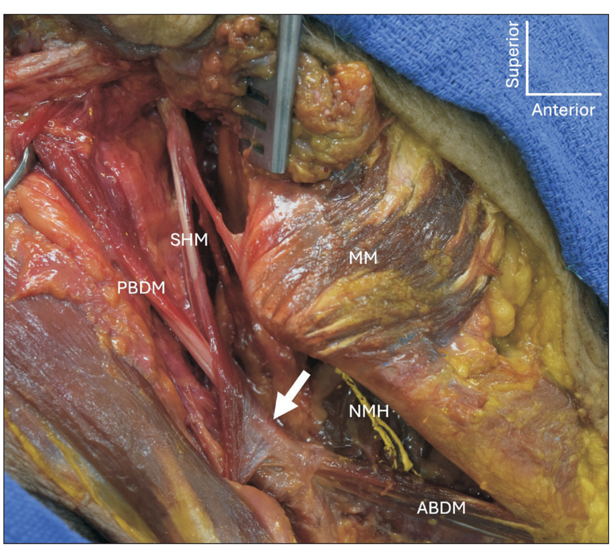

Fig. 1. Cadaveric dissection of the right neck. Note that the anterior belly (ABDM) and posterior belly (PBDM) of the digastric muscles are connected by the intermediate tendon (arrow), which is surrounded by the stylohyoid muscle (SHM) and its related fascia. MM, masseter muscle; NMH, nerve to mylohyoid muscle.

Embryology

Developmentally, the digastric muscle is a hybrid muscle with two distinct bellies originating from separate embryological sources during the Carnegie stages. The embryologic period after the first eight weeks is marked by the migration of neural crest cells, giving rise to the formation of the pharyngeal arches [7]. The anterior belly and the nerve to the mylohyoid muscle arise from the first pharyngeal arch (mandibular arch) and the posterior belly and the facial nerve originate from the second pharyngeal arch (hyoid arch) [10]. The anterior belly and posterior belly fuse together to form the intermediate tendon of the digastric muscle.

Anatomical variants

Many cadaveric studies have reported variations in the digastric muscles with findings on unilateral and bilateral variants of the digastric muscles, formation of accessory muscle bundles, and uncommon variations such as the intermediate tendon piercing the stylohyoid [3, 11-13]. The incidence of unilateral digastric muscle variants remains higher than bilateral variants. Across multiple studies, variations in cadaveric digastric muscles range from around 5% to 70% [7, 14], with several differences resulting from variant origins, insertions, or nerve innervations. Variations of the intermediate tendon of the digastric muscle are more likely to be a lateral or medial deviation from the stylohyoid muscle but rarely pierce it. Denk et al. [15] reported the absence of the fibrous slings. Thus, not only the digastric muscle but its associated structure can have variations. Although clinical problems arise infrequently from these variants, this information is vital for surgical evaluation of the floor of the mouth and during various head and neck surgeries [11, 16].

Clinical and surgical significance

Due to their anatomical complexity and functional implications, the digastric muscles are significant in surgical and clinical settings. Their location is a landmark used during surgical procedures involving the head and neck region [7, 17].

The digastric muscle bellies play a role in various functions, including mastication, speech, and swallowing. Dysfunction or abnormalities in these muscles can lead to difficulties in these functions, necessitating clinical evaluation and potential interventions. Additionally, knowledge of the embryological origins of the digastric muscles contributes to understanding developmental variations and anatomical anomalies that clinicians may encounter. Overall, the significance of the digastric muscles lies in their unique anatomy, functional roles, and relevance to various medical procedures and conditions in the head and neck.

Trochlear considerations

Several anatomical units in the human body are considered trochlear pulley systems, given their distinct function and activity. The most notable may be the superior oblique muscle of the eye, which passes through an annular ring (trochlea) and works to move the eye inferolateral upon contraction. Usually, no anatomical connection of muscle fibers exists between the trochlea and the superior oblique muscle, thus permitting the tendon to course easily through this fibrous band [18]. When discussing the pulley activity of the superior oblique muscle, the coordination of this muscle shifts force weight between the body of the sphenoid bone and the outer superoposterior quadrant of the eyeball posteriorly during contraction along the immobile annular loop [19].

When discussing a general anatomical pulley, it may be defined as a directional change in the pull of a muscle causing a bone or bony prominence to shift its position with little to no changes in the magnitude of the applied force when moved over a frictionless surface [20, 21].

With consideration of the digastric muscles, the anterior and posterior bellies connected by the intermediate tendon of the digastric muscle are important for depressing the mandible via the sliding action of the intermediate tendon of the digastric muscle along the U-shaped ring formed by a thickening of the deep cervical fascia anchored to the hyoid bone [22, 23]. However, the concept of "thickening of the fascia" is inconsistent with another concept "no anatomical connection of muscle fibers," as the fascia should to be attached to the muscles adjacent to it. Functionally, a fibrous sheath facilitates the sliding of the tendon tissue surrounding anatomical structures and prevents the loss of intrinsic muscle activity during muscle contraction. Therefore, the fibrous ring acts as a pulley, allowing the intermediate tendon to slide anteriorly and posteriorly freely.

Conclusion

Exploring the intermediate tendon of the digastric muscle as a potential anatomical trochlear pulley system presents a new outlook on the anatomical activity of specific head and neck movements. This review highlights shared characteristics by comparing them to well-established trochlear systems like the superior oblique muscle, emphasizing the validity of considering the intermediate tendon of the digastric muscle as a true trochlear. The detailed examination of its structure and function, along with other current anatomical considerations of pulley trochlear systems, offers valuable insights into the dynamic role of the intermediate tendon of the digastric muscle and its fibrous sheath that contributes to its biomechanical significance during jaw movements. This newfound understanding expands our anatomical knowledge and holds clinical implications, providing a foundation for further research on nerve and blood supply, clinical and surgical significance, embryology, and anatomical variants. Ultimately, this information enriches the anatomical and medical community's knowledge, fostering a more comprehensive and accurate framework for studying and addressing orofacial functions and related clinical conditions.

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Conceptualization: SI, JI, RST. Data acquisition: SI, JI, RST. Data analysis or interpretation: XP, YK, JJC. Drafting of the manuscript: XP, YK, JJC. Critical revision of the manuscript: YT, KCB, KR, SI, JI, RST. Approval of the final version of the manuscript: all authors.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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