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Review Article

Pharyngeal Fascia and its Relationship with Obstructive Sleep Apnea

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Abstract

Obstructive Sleep apnea is a highly prevalent sleep disorder among various sleep disorders. Various anatomical, physiological, and mechanical factors contribute to the reduction in patency of upper airways during sleep. Pharyngeal muscles play a significant role in preventing the collapsibility of upper airways. The pharyngobasilar fascia is a part of the middle layer of deep cervical fascia that surrounds the pharynx, along with the buccopharyngeal fascia. This study aimed to identify whether there is any relationship between pharyngeal fascia and obstructive sleep apnea. Articles relevant to pharyngeal fascia and sleep apnea were searched in Pubmed, Scopus and Google Scholar using the search terms pharyngeal fascia and sleep apnea. Based on the reviews, it is known that pharyngeal airway closure during sleep in patients with obstructive sleep apnea is generally felt to be due to the state-related loss of motor output to skeletal muscles surrounding the pharynx that dilate and stiffen this potentially collapsible upper airway segment and case series study concluded that the application of focused manipulation to the anterior fasciae, coupled with treatment of cranial connections, may improve the airway dynamics thereby reducing the severity of sleep-related conditions. A decrease in the quality of sleep which is a common symptom of Obstructive Sleep Apnea may also affect fascial function. From this it may be concluded that there is a significant relationship exists between the fascia and Obstructive Sleep Apnea and further studies are needed in this area.

Keywords: Pharyngeal Fascia; Obstructive Sleep; Apnea

Introduction

Obstructive sleep apnea (OSA) is recognized as a complex and heterogeneous disorder. Obstructive sleep apnea is characterized by loud snoring with a period of apnea and hypopnea more than five times per hour. [1]. The prevalence of obstructive sleep apnea (OSA) among the Indian population is 13.7% [2]. The prevalence of OSA is underestimated due to the absence of recognition of symptoms and also the lack of knowledge among the population at large as well as sectors of the medical profession [3]. Although alterations in neuromuscular and ventilatory control mechanisms can contribute to the reduced airway patency underlying OSA, Anatomical abnormalities play a key role in the development of OSA [4]. The Risk factors for obstructive sleep apnea are obesity, excess regional adipose tissue, enlarged upper airway soft tissues, and craniofacial abnormalities [5,6]. Based on previous studies it is well evident that the occurrence of OSA is multifactorial. The upper airway compromises the nasal cavity, oral cavity, pharynx, and larynx. The pharynx is further subdivided into the nasopharynx, oropharynx, and laryngopharynx. The primary dilator of the upper airway is the genioglossus muscle. Three pharyngeal constrictor muscles make up the outer layer of the wall and the inner layer is comprised of paired muscles. The three, superior, middle, and inferior pharyngeal constrictor muscles form a muscular sleeve that is lined by the pharyngobasilar fascia. Pharyngeal collapse commonly occurs during sleep when both the tongue and soft palate move posteriorly together pharyngeal collapse commonly occurs during sleep when both the tongue and soft palate move posteriorly together [7]. Fascia denotes the masses of connective tissue large enough to be visible to the naked eye. The pharyngobasilar fascia, part of the middle layer of deep cervical fascia surrounds the pharynx, along with the buccopharyngeal fascia. This fascial sheet completes the wall of the pharynx superiorly and continuous attachment to the base of the skull. The fascia becomes gradually thinner inferiorly, blending with the epimysium of the pharyngeal muscles [8]. There are various proposed reasons for the decrease in the patency of airways. Partial obstruction leads to snoring and complete obstruction may cause obstructive sleep apnea. The fascia invests and connects structures and its function is to provide the scaffolding that permits and enhances the transmission and absorption of forces. Changes in fascia will alter the function of muscles. The relationship between fascia and muscle or tendon has been studied for fascia like plantar fascia. The significance of pharyngeal fascia has not been evaluated yet. As pharyngeal muscles play a significant role in maintaining the patency of the upper airway, this study aims to examine the embryological and anatomical characteristics of pharyngeal fascia and the relationship between pharyngeal fascia on the patency of the upper airway.

Materials and Methods

A narrative review was conducted by two reviewers. The key words used for the search are upper airway, pharyngeal fascia and obstructive sleep apnea. Studies published in PubMed, Scopus and Google Scholar till February 2023 was included. The exclusion criteria were citations without abstracts and non-English articles. Total of 401 articles were identified and among that 191 articles were found to be relevant. Based on further detailed analysis, 11 articles met the eligibility criteria. The articles were reviewed for relevance by both authors.

Embryology of the fascial system

The fascial system is a link between the various body systems in humans. Knowledge of embryonic formation of the fascial system contributes to understanding the development of the whole body, helping to understand clinical phenomena. The formation of musculoskeletal fascia is from the somites and mesenchymal cells of the cranial neural crest. Differences in the formation of the head, neck, trunk, and limbs and their respective embryonic relationships are presented. The connective tissue that will originate the bones, muscles, and fascia of movement of the anterior region of the neck and face develops from the mesenchymal cells of the cranial neural crest. These cells are attracted to the anterior region through the development of pharyngeal arches. The development of the endoderm of the primitive gut tube releases gene factors responsible for this cranial mesenchymal cell migration [9].

Anatomy of pharyngeal fascia

The pharyngobasilar fascia provides structure to the lateral nasopharyngeal walls. It is attached to the basilar part of the occipital bone and temporal bone. Inferiorly its thickness reduces but is strengthened posteriorly by a fibrous band attached to the pharyngeal tuber of occipital bone which descends as the median pharyngeal raphe of constrictors. This fibrous layer is the internal epimysial covering of muscle and its aponeurotic attachment to the base of the skull. The thinner external part of the epimysium is the buccopharyngeal fascia, which covers the superior constrictor and passes forwards over the pterygoid mandibular raphe to cover Buccinator. It is a delicate, distensible layer of fascia that is the constrictor muscle of the pharynx and Buccinator muscle. Pharyngobasilar fascia closes the gap in the muscular wall of the pharynx.

The central fascial axis is composed of interpterygoid and pterygotemporomaxillary fasciae, and the palatine aponeurosis, which anchors it at the base of the skull. It continues into pharyngobasilar and buccopharyngeal fasciae which itself continues with the pericardium [8].

Histological studies

In a study on "Anatomical and histological study of the deep neck fasciae: does the alar fascia exist" by M. Gavid., *et al*, dissections of the neck of ten adult cadavers were performed, in the retropharyngeal region, layer by layer under a powered operating microscope. Detailed dissections helped to reveal the anatomical limits of the deep neck fasciae. Histological descriptions were also made on large tissue samples collected from three cervical dissections [10].

Palatal anatomy

B. Tucker Woodson conducted a study on palatal anatomy and phenotypes for the treatment of OSA to know the different patterns and airway configurations that may represent specific phenotypes. Further research is needed to find the association between phenotype and disease and treatment outcome [11].

Radiological studies

The normal anatomy of the nasopharynx and floor of the middle cranial fossa was analyzed with magnetic resonance (MR) imaging by L M Teresi., *et al*. In this study, magnetic resonance images from five healthy volunteers were correlated with whole organ cryo microtome sections from three cadavers [12].

The purpose of the study by Ning-Hung Chen is to identify pharyngeal distensibility during expiration as an independent predictor of the severity of obstructive sleep apnoea.

Simultaneously respiratory flow and airway caliber were measured using ultrafast CT for twenty-three patients with OSA and eight normal subjects. The change in a pharyngeal cross-sectional area divided by the change in concomitant flow was measured and compared with the different severities of obstructive sleep apnea [13].

Influence of gender and age

Ohad Ronen conducted a study to find the influence of gender and age on upper airway length during development [14].

Positional dependence

Stecco., *et al*. (2007) have demonstrated the presence of a variety of neural structures in the deep fascia – including Ruffini and Pacini corpuscles which proves that fascia helps in the perception of posture, as well as motion, tension, and position [15].

Hyoid bone

Relationship between the hyoid bone and pharyngeal airway cephalograms of 90 males and 90 females were divided into skeletal patterns such as class I, class II, and class III. The pharyngeal airway spaces such as SP, soft palate-related pharyngeal airway; BP, B point related pharyngeal airway; C2P, second cervical vertebra related pharyngeal airway; and LP, laryngopharyngeal airway were measured [16].

Osteopathic manipulation

A Case Series on osteopathic cranial manipulation and myofascial release of anterior fascia to improve respiratory dynamics in obstructive sleep apnea syndrome was done by Tores, which reviewed the relevant anatomy contributing to sleep-related breathing disorder and outlines an osteopathic treatment protocol to improve both the respiratory flow dynamics and sleep impediments of the disease [17].

Results

Embryological study

The fascial system is formed mainly by mesodermal cells originating from a wide variety of tissues in the body. Formation of the fasciae of the face and the anterior region of the neck that is formed from the mesenchymal cells originating from the ectodermal cranial neural crest is the excretion in mammals. The development of the neural system is a major influencer and is influenced by this great fascial system, establishing an intimate relationship which is called the neuro-fascial system [8].

Anatomical studies

White DP, Malhotra A did a study to predict responses to upper airway surgery in obstructive sleep apnea using computational modeling and found that The pharyngeal airway is typically narrowest at the level of the velopharynx, although pharyngeal collapse commonly occurs during sleep when both the tongue and soft palate move posteriorly together [18].

Histological study

In the ten dissections, three layers of fascia were identified and dissected in the retropharyngeal region namely a visceral fascia, a prevertebral fascia, and an alar fascia. The alar fascia appeared like a connecting band derivative of the visceral fascia, between both vascular sheaths, and identified that it fused completely with the visceral fascia anteriorly at the level of T2 and with the prevertebral fascia posteriorly at the level of C1. There was no sagittal connection between the visceral fascia and the prevertebral fascia. The stained histological sections confirmed the presence of the visceral and prevertebral fasciae at the oropharyngeal level, with a third intermediate layer closely connected with the visceral fascia [10].

Radiological study

Study by L M Teresi., *et a*l. identified the anatomic connections existing between the para-nasopharyngeal spaces and the surface structures of the skull base. These anatomic connections include the close relationship between the eustachian tube and the pharyngobasilar fascia, the attachment of the muscles of mastication and deglutition to the skull base, and vascular and nervous structures in the foramina. The inherent contrast between the soft tissues of the nasopharynx and related structures and the bone of the floor of the middle cranial fossa allowed a clear view of these anatomic connections [12].

Influence of gender and age

The collapsible portion of the upper airway is longer in adult men than in women which may increase vulnerability to collapse during sleep. Many Important anatomic changes occur at puberty, which may be the reason males as a risk factor for pharyngeal collapse in adults [14].

Hyoid

The Results of the study done by Cheng, J., *et al.* showed that SP was significantly longer in class III (12.4 mm) than in class I (10.7 mm) and class II (9.5 mm), and BP was significantly greater in class III (16.3 mm) than in class II (12.4 mm). The hyoid bone had a significantly anterior location in class III compared to class II, there is no significant difference in vertical positions of the hyoid bone among the three skeletal patterns, and the horizontal position of the hyoid bone had a positive moderate, significant correlation with the C2P among female with a class III skeletal pattern, whereas, among male, this was not observed. They concluded that the location of the maxilla was not significantly correlated with the pharyngeal airway space. However, the more protruding the mandible is, the more anterior the hyoid bone and the pharyngeal airway will be longer [16].

Osteopathic manipulation

Several muscles in the anterior cervical fascia have a significant effect on the shape of the airway and can alter airflow dynamics with respiration. The alternating pattern of strains in the anterior cervical musculature can result in a wringing or narrowing of the airway, exacerbating sleep related breathing disorder phenomena. These muscles may also play a role in altering support for tongue movements and vocal cord function vital for latching, deglutition, and most of all speech production [17].

Discussion

Fascia is part of all the soft tissues of the body. It binds, packs, permeates, and protects envelopes and separates tissues. It is dynamic and active-participating in movement and stability. The anatomy trains myofascial meridians map the global lines of tension that traverse the body's muscular surface, acting to keep the skeleton in shape, guide the available tracks for movement, and coordinate global postural patterns [19].

That neurophysiology is a major feature of almost all dysfunction is not in question however, many clinically relevant effects are unrelated to neurophysiology and result directly from mechanically induced changes in cellular shape and so the emphasis is given to mechanotransduction [19].

From anatomical studies, it is evident that pharyngeal constrictors have a strong internal fascial lining, the pharyngobasilar fascia, and a thin external fascial lining, the buccopharyngeal fascia [20]. Buccopharyngeal fascia blends with the pretracheal layer of deep cervical fascia. The anterior cervical fascia incorporates many small muscles which define the upper airway including muscles connecting the sternum, clavicle, thyroid, pharynx, and hyoid. Concerted contractions of these structures allow for phonation required for speech, deglutition, and facilitation of breathing dynamics. The fibrous layer that supports the pharyngeal mucosa is thickened above the superior constrictor to form pharyngobasilar fascia. The histological studies confirmed the presence of visceral and prevertebral fascia at the oropharyngeal level with a third intermediate layer closely connected with the visceral fascia. The pharyngeal airway is typically narrowest at the level of the velopharynx, although pharyngeal collapse commonly occurs during sleep when both the tongue and soft palate move posteriorly together. Several muscles in the anterior cervical fascia have a significant effect on the shape of the airway and can alter airflow dynamics with respiration. The alternating pattern of strains in the anterior cervical musculature can result in a wringing or narrowing of the airway, exacerbating sleep-related breathing disorder phenomena. These muscles may also play a role in altering support for tongue movements and vocal cord function vital for latching, deglutition, and most of all speech production. The cranio visceral link (CVL) extends the bowstring concept to unite the pulmonary structures to the cranial concept, unifying primary and secondary respirations.

Distensibility or collapsibility is the reason for the apnoea–hypopnoea index in regression modeling and found that age, gender, and body mass index were not significant independent predictors for partial or complete obstruction. According to Purslow, age-related changes also affect muscle fascia, with endomysial and perimysial tissues developing tangled cross-linkages – which has clear health implications, as these structures act as pathways for myofascial force transmission and reduced soft tissue mobility is the result which may affect the muscle function. This may also contribute to age as a risk factor for obstructive sleep apnea.

Hyoid bone takes part in the function of speech, respiration, mastication, and swallowing, as well as maintaining the patency of the airway between the oropharynx and the tracheal rings. Knowledge of the anatomy and physiology of the hyoid is necessary for the recognition of the clinical presentation of related disorders and syndromes. An imbalance between the suprahyoid and infrahyoid muscles may lead to an alteration in the position of the hyoid, thus affecting airway patency and causing more pharyngeal collapsibility [21]. The hyoid is attached to the cervical spine posteriorly via the cervical fascia. This could explain the relationship between fascia, hyoid, and obstruction during sleep.

In 2015, Paolo Tozzi presented the Neurofasciogenic Model to the world, which highlights the relationship between the fascial and neural systems with the functioning of all the systems in the body. He considers this neuro-fascial interaction as key in the complex interactions between the various tissues and organs of the body. Fascia invests and connects structures, providing the scaffolding that permits and enhances the transmission and absorption of forces.

In the presence of somatic dysfunction, limitations in motion affecting these muscles may create areas of dysfunctional stenosis, lowering the threshold for apneas and hypopneas to occur. For instance, asymmetric contraction of the thyrohyoid will result in asymmetric elevation of the larynx with depression of the hyoid, creating an airway profile with a smaller cross-sectional area potentially limiting air movement. As such, dysfunctions of these muscles may play a role in the pathophysiology of sleep disturbances.

The result of the radiological studies states that anatomic connections including the intimate relationship between the Eustachian tube and pharyngobasilar fascia exist between para nasopharyngeal spaces and the surface structure of the skull. This gives a visualisation of the role of fascia in pharyngeal space.

Obstruction of the airway during sleep in patients with obstructive sleep apnea (OSA) is generally felt to be due to the state-related loss of motor output to skeletal muscles surrounding the pharynx that help to maintain the diameter of the collapsible upper-airway segment [18].

The conclusion made by the result of the case series by Torres, J. W. “The application of focused manipulation to the anterior fasciae, coupled with treatment of cranial connections, may improve the airway dynamics, while also addressing the relationship between primary and secondary respiration, thereby reducing sleep disordered breathing episodes, improving sleep quality, and reducing the severity of sleep-related conditions” [17]. Finally, these findings suggest the relationship between pharyngeal fascia and obstructive sleep apnea however more studies can be done to know the structural and functional relationship between pharyngeal fascia and obstructive sleep apnea.

On the other hand, fascial dysfunction may occur in people with obstructive sleep apnea. The clinical features of obstructive sleep apnea are loud snoring, disturbed sleep, and decreased attentiveness, etc., Sleep disturbance will increase mental stress. Poor sleep quality as well as mental stress will affect the function of fascia. So the symptoms of Obstructive Sleep Apnea may worsen the function of fascia, including pharyngeal fascia. Future studies are needed to check the fascial dysfunction of people with obstructive sleep apnea.

Conclusion

Based on the narrative review it is evident that muscles in the pharyngeal fascia is related with respiratory mechanics and alternating pattern of strain may decrease the diameter of airway which predisposes to change in breathing pattern. Hence there is a significant relationship exists between the pharyngeal fascia and obstructive sleep apnea and further studies are needed to explore more details in this area.

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Conflict of Interest

We declare that there is no conflict of Interest.

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