



The longitudinal fibromuscular band of the anal canal

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Abstract

Objective There are many studies in the literature about the physiological and incontinence mechanisms of the anal region. However, there is a lack of information about the detailed anatomy and function of the longitudinal fibromuscular band. We have therefore studied the longitudinal fibromuscular band and its effect on the anal canal and the continence mechanism.

Materials and methods The anal canals of 12 pelvises of fixed cadavers abdominoperineal excision specimens were studied using a surgical microscope.

Results The longitudinal fibromuscular band terminates in three fibers extending downward. Medial fibers of the band reach the most inferior part of the circular fibers of the internal anal sphincter and end at the anocutaneous line. Lateral fibers run below the superficial parts of the external anal sphincter and terminate at the ischioanal fossa. Inferior fibers spread radially in and below the subcutaneous part of the external anal sphincter and terminate in the subcutaneous.

Conclusion The longitudinal fibromuscular band may play a role in incontinence because it supports the sphincter muscles in the anal canal from below. When the internal anal sphincter muscles relax, the longitudinal fibromuscular band located lateral to these muscles can assist with defecation. This will facilitate a better understanding of the mechanisms of incontinence. The anatomy of the anal canal is important in reducing the risk of recurrence in the surgical treatment of lower rectal tumors.

Keywords Anatomy · Anal canal · Longitudinal fibromuscular band · Defecation · Intersphincteric resection

1 Introduction

There are disagreements about the definition of the longitudinal fibromuscular band in classical textbooks and the literature. Its previous names included longitudinal band, longitudinal muscle, and conjoint longitudinal ligament [1–5]. We think that “longitudinal fibromuscular band” (LFMB) is a more appropriate name since this structure contains both smooth and striated muscle fibers and a thick aponeurosis.

The anal sphincter complex (ASC) surrounding the anal canal consists of the internal anal sphincter (IAS), external anal sphincter (EAS), and LFMB. The EAS is composed of striated muscle and has somatic innervation. Medial to the rectum, the smooth circular muscle fibers thicken in the anal canal to form the IAS. Longitudinal fibers located outside this muscle form the LFMB in the anal canal. This structure contains smooth and striated muscle. Medially, it is tightly attached to the IAS. The proximal portion of this band blends with the fibers of the puborectal muscle, which is part of the levator ani muscle. This muscle forms a U-shaped muscular sling (puborectal sling) that passes posterior to the anorectal junction [1, 2, 6, 7].

Many studies have been carried out to elucidate anal canal anatomy by endoanal ultrasound and magnetic resonance imaging. These studies have concentrated more on the physiology and physiopathology of the anal canal [8–11]. Different opinions about the anatomy of the LFMB have been considered [12]. Lunniss and Phillips dealt with this subject in detail, but they observed that knowledge of the anatomy and function of this structure was not sufficient [13]. The anatomy of the anorectal region must be known to avoid

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unwanted results in the repair of perineal injuries that occur during labor or during surgical treatments of anal fissures, fistulae and hemorrhoids [14–17]. As in all parts of the body, deep fascial leaves surround the muscle fibers in this region. The IAS consists of circular muscle rings, each of which is surrounded by a separate fascial leaf. While these rings are free in the lumen of the anal canal, the fascial leaves surrounding them are attached to the LFMB on the lateral side [18]. However, classical textbooks still depict these fascial leaves as part of the structure of the LFMB [6, 7]. The LFMB is located between the IAS and EAS and specifically supports the IAS like a skeleton. The detailed anatomy of the LFMB is important for understanding the mechanism of defecation [10, 13, 19, 20].

To minimize complications following intersphincteric resection of lower rectal tumors that compress the anal canal, a thorough understanding of the anatomy of the ASC is essential [21, 22].

Undoubtedly, the LFMB has been described in the colorectal literature and anatomy textbooks. However, some fibers passing through the sphincter muscles have also been indicated as supporting fibers. Nevertheless, the relationship of this structure with the IAS has not been comprehensively determined. Furthermore, the relationship between the IAS, EAS and LFMB, and its effect on the anal canal mechanism, has not been discussed in detail. We aimed to elucidate the anatomy and the function of the LFMB of the anal canal.

2 Materials and methods

The pelvis of 12 fixed cadavers (three female, nine male) were dissected. The cadavers were fixed with 10% formaldehyde. A surgical microscope ($\times 6$ – $\times 25$) was used for qualitative observation. The ages of the cadavers ranged from 60 to 85 years. To facilitate the dissections, the pelvises were removed from the torso at the level of the fifth lumbar vertebra and hip joints and then cut sagittally. The anatomy of the LFMB and its relationships with the neighboring structures were observed under a surgical microscope ($\times 6$ – $\times 25$ magnification). Specimens taken from the LFMB and structures around it were then fixed with formalin and blocked in paraffin (a representative subset of samples was taken). Four-micrometer sections were taken and stained with Mallory-Azan. The slides were photographed under an Olympus BH2 microscope. Special Mallory-Azan staining was performed to distinguish the fibrous connective tissue from the striated muscle fibers. Collagen fibers stained blue and the striated muscle fibers stained red (Fig. 1).

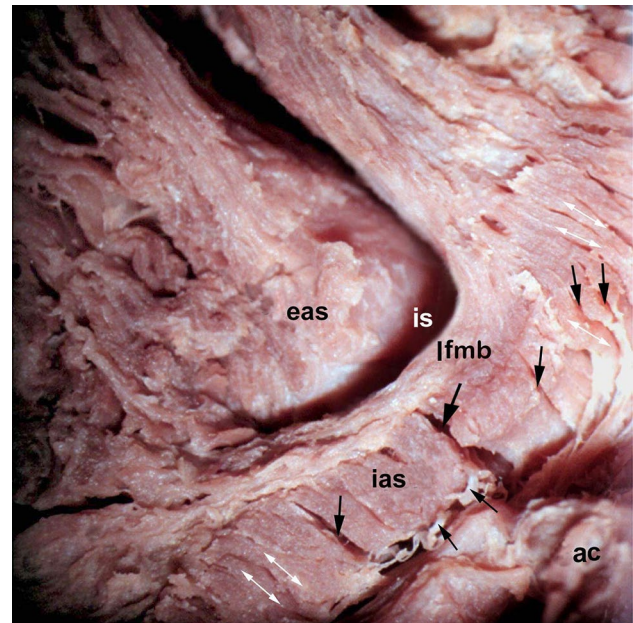


Fig. 1 Sagittal section from pelvis: eas, external anal sphincter; lfmb, longitudinal fibromuscular band; is, intersphincteric space; ias, internal anal sphincter; ac, anal canal; white arrows, rings of the internal anal sphincter; black arrows, fascia covering each leaf of the internal anal sphincter (rings are cut in cross section)

3 Results

The LFMB located outside the rectum formed a fibromuscular structure surrounding the anal canal. Our findings showed that two types of muscle fibers, smooth and striated, contributed to the structure of this band. The smooth muscle fibers constituted the main part of the band, which is located medially and strictly attached to the IAS. The striated fibers came from the levator ani muscle and ended at the anocutaneous line. Histological examination of this area revealed that the striated muscle fibers were located laterally in the fibrous connective tissue of the longitudinal fibromuscular band.

There is a space between the IAS and EAS in which the LFMB lies. The deep and superficial parts of the EAS are located lateral to the LFMB, and the IAS is located medial to it. A space can be formed easily by dissection between the parts of the EAS and the LFMB. This space is known as the intersphincteric space. In other words, the intersphincteric space is located between the LFMB and the parts of the EAS. The band appeared in this space as a thick aponeurotic structure (Figs. 2 and 3). It was connected strictly to the IAS. We observed no parts of this band among the s of this muscle. The characteristics of these fibers were detailed in our study on the anatomy of the IAS [11]. The LFMB separates the fibers as it extends

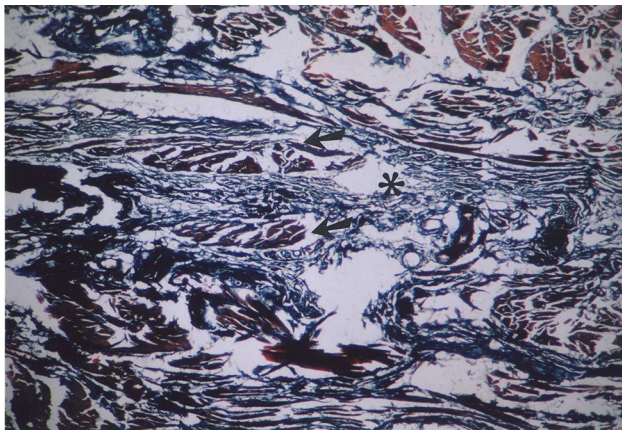


Fig. 2 Histological view of the longitudinal fibromuscular band. *, fibrous connective tissue; black arrows, striated muscle fibers in the fibrous connective tissue (Original magnification $\times 25$; stain: Mallory-Azan)

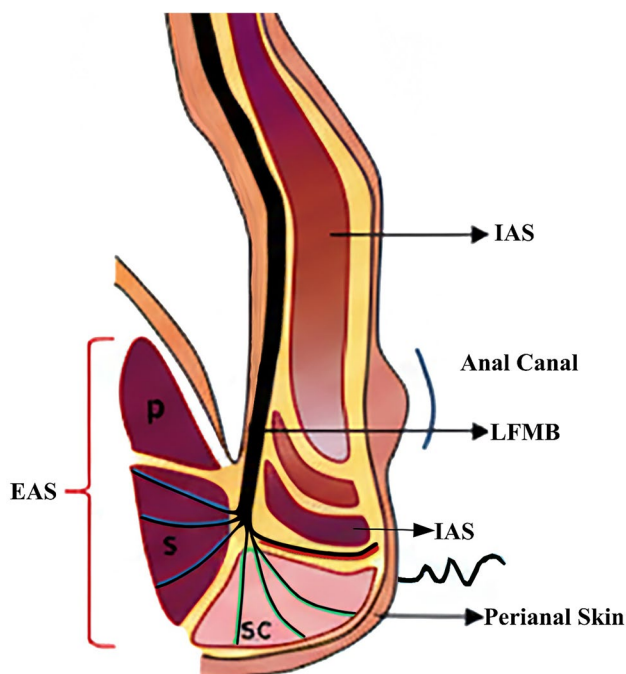


Fig. 3 Schematic drawing. IAS, internal anal sphincter; LFMB, longitudinal fibromuscular band; EAS, external anal sphincter; p, deep part of the external anal sphincter; s, superficial part of the external anal sphincter; sc, subcutaneous part of the external anal sphincter; red line, medial fibers of the longitudinal fibromuscular band; green lines, inferior fibers of the longitudinal fibromuscular band; blue lines, lateral fibers of the longitudinal fibromuscular band

(Fig. 3): (1) Medial fibers of the band reach the most inferior part of the circular fibers of the IAS and end at the anocutaneous line. (2) Lateral fibers run below the superficial parts of the EAS and terminate at the ischioanal fossa. (3) Inferior (middle-median) fibers spread radially in and

below the subcutaneous part of the EAS and terminate in the subcutaneous connective tissue.

4 Discussion

Fecal incontinence is a serious condition. It arises from a variety of causes [1]. The most common causes are childbirth and anorectal surgery, which can damage the external anal sphincter and pudendal nerve. Therefore, the structure and mechanism of the ASC must be well understood. The primary function of the anal canal is to ensure continence. In the normal resting state, this is achieved by the angle formed by the puborectal muscle and the tone the IAS and ESA. The IAS, which is innervated by the autonomic nervous system, plays the most significant role here. The EAS plays a role in voluntarily closing the anal canal. During defecation, the intestinal contents create pressure in the rectum. Consequently, the IAS relaxes. Due to this relaxation, some of the contents enter the anal canal and come into contact with the mucosa. Thus, the separation of gas and stool occurs. If conditions are not suitable, the puborectal muscle (the anorectal angle flattens) and the m. sphincter ani externus contract to keep the anal canal closed (continence). When conditions are suitable, these two muscles relax to allow defecation. After this function is completed, the relaxed muscles contract to close the anal canal [1, 2, 4, 21, 22].

Many researchers have explained the function and structure of the anal canal using different imaging techniques [25–28]. Aronson et al. examined five anal continent nulliparous women of reproductive age using magnetic resonance imaging. The muscular structures surrounding the anal canal were demonstrated. Understanding the anatomy of this region, including the LFMB, is crucial for anal incontinence surgery and primary repair of sphincter tears [25]. Petrous et al. reported that although different imaging techniques were used in patients with constipation and fecal incontinence, the same movements occurred during defecation [28]. Peschers et al. demonstrated detailed visualization of the anal sphincter structure in six cadavers using magnetic resonance imaging (MRI) and ultrasound cross-sectional images. However, they noted that the LFMB was not clearly visible [27]. Dobben et al. recommend MRI for patients before surgical procedures. They stated that endoanal sonography should be preferred for postoperative evaluation. They stated that even with widespread atrophy of the sphincter muscles, endoanal MRI can be performed with sufficient experience [26]. T J O'Kelly et al. stated that in vitro studies showed it formed in the internal anal sphincter and LFMB smooth muscle fibers. However, they stated that the LFMB contained fewer smooth muscle fibers. [29].

The low anterior resection and manually sutured coloanal anastomosis defined by Parks has been widely used as an

excellent procedure for preserving the anus in lower rectal cancer [30]. However, permanent colostomy has not been readily accepted by patients. Therefore, many techniques have been described since then [31]. In recent years, intersphincteric resection preserving the ASC has come to the fore in lower rectal cancers. Kraima et al. emphasized that selecting appropriate surgical planes and performing resection to tumor-free areas are important for reducing local recurrence in rectal cancer surgery. They stressed the importance of detailed knowledge of the anatomy of the ASC during this resection [22].

Koda et al. stated that factors affecting the occurrence of “low anterior resection syndrome” after rectal surgery do not include resection of a large portion of the rectum. However, they noted that it can also be seen as a result of damage to the muscle structures surrounding the rectum [21]. Some studies have shown that the LFMB is (partially) absent in some areas and that the area between the IAS and EAS is (mostly) filled with adipose tissue. Sometimes, the LFMB has been reported to cover the entire area between the IAS and EAS, closing the intersphincteric space. Therefore, they have stated that the use of the term “inter-sphincter space” is misleading [12]. Our study included the intersphincteric space and the LFMB. However, since we did not examine the thickness of the LFMB, we cannot comment on age-related atrophy. We believe the reason for the presence of the intersphincteric space is that the fatty tissue located here in cadavers has become a space over time. Although using the intersphincteric space may be misleading, we believe that entering from this area is safer surgically.

Studies on the anococcygeal ligaments have shown that the thick ventral portion of this ligament contributes to the structure of the LFMB [23, 24]. In our study, the LFMB was not traced proximally, and its characteristics at this location were not examined histologically.

The detailed anatomy of the LFMB is important for understanding the mechanism of defecation [10, 13, 19, 20]. According to Geredes et al., it is formed by the smooth muscle fibers of the rectum and the striated muscle fibers of the levator ani muscle [19]. Some authors have also mentioned that the medial parts of the LFMB band pass through the fibers of the IAS and end on the submucosa of the anal canal [13, 19]. The LFMB is composed of smooth muscle fibers of the rectum and striated fibers coming from the levator ani muscle. A thick aponeurotic band is strictly attached to the IAS. There are no divisions of the LFMB passing beneath the IAS. These divisions belong to the IAS itself, as mentioned in our previous study (Fig. 2) [18]. They are formed by the fascia covering each muscle leaflet of the IAS and attach laterally to the LFMB. According to our anatomical dissection, no part of the LFMB passes through the internal anal sphincter. However, part of the band passing under the IAS attaches to the skin of the anocutaneous line. A

similar structure passes under the superficial part of the EAS and supports the muscles from below. These structures are band-like, as if supporting these muscles from below. The LFMB fibers passing through the IAS and the fibers passing outside the superficial part of the EAS are of the same shape and are thicker than the suspensory bands supporting these muscles from below. While the peripherally spreading LFMB fibers attach to fixed structures, the medially extending fibers attach to the skin below the anocutaneous line.

According to our anatomical observations, there is a strong connection between the internal anal sphincter and the LFMB. This band supports this muscle laterally. The fascia covering each muscle fiber of the internal anal sphincter originates from the LFMB, that is connection with the internal anal sphincter supports this muscle. Additionally, the distal fibers of this band may influence the sepsis spread mechanism.

5 Limitation

The small number of female cadavers prevented us from revealing differences in this regard. The structural characteristics of anatomical organs located in the pelvic cavity may differ between females and males. Furthermore, due to the use of fixed cadaver tissue, no quantitative morphometric data regarding the thickness of the LFMB was presented. If quantitative data had been provided, it would have been necessary to distinguish between female and male differences. However, the small number of female cadavers could have caused difficulties in interpretation. Additionally, differences in muscle tone between cadavers and living tissue could cause difficulties in the evaluation of quantitative morphometric data. Histological samples were taken from a representative subset. This study was performed on cadaver tissues that lacked elasticity and muscle contraction. The anal canal was not compared with *in vivo* studies using endoanal ultrasound or nuclear magnetic resonance imaging.

6 Conclusion

The LFMB consists of smooth and striated muscle fibers. It is tightly attached to the internal anal sphincter. It does not send branches to the IAS. It is located between the two sphincter muscles and, due to its anatomical position, may play a role in the defecation process. For this reason, during defecation, the proximal part of the LFMB may pull the anal canal upward, while the upper part of the canal relaxes and allows stool to enter the canal.

During this upward elongation of the LFMB, we assume that the medial fibers can widen the lower part of the anal canal by pulling the skin to which they are attached outward

and upward; the medial fibers attach to mobile skin, but the fibers extending to the ischioanal fossa attach to immobile structures. Because of these features, we can think that the part of the anal canal below the anocutaneous line can open and the anal canal can widen. Since the fascial structures covering each muscle leaflet of the IAS originate from the LFMB, disruption of the LFMB's structure may affect the function of this muscle.

The most important criterion for intersphincteric resection in lower rectal tumors is to minimize recurrence. This requires excellent anatomical knowledge.

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Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Aysun Uz and R. Shane Tubbs. The first draft of the manuscript was written by Aysun Uz and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no competing interests.

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