Chapter 6

Vesalius and the SFS and SMAS concepts

Chapter based on article

Andreas Vesalius’ 500th anniversary: Initiation of the Superficial Fascial System and Superficial Musculoaponeurotic System concepts

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Introduction
Because of their relevance for liposuction and rhytidectomies, respectively, the superficial fascial system (SFS) and superficial musculo-aponeurotic system (SMAS) have been thoroughly studied over the past decennia, by plastic surgeons and anatomists alike [1-10]. The SFS is a connective tissue network that extends from the subdermal plan to the underlying muscle fascia. It primarily consists of one to several thin, horizontal membranous sheets separated by varying amounts of fat with interconnecting vertical or oblique fibrous septae. In addition, extensions of the superficial fascial system connect with the overlying dermis, tightly encasing the superficial fat in vertically oriented compartments. Similar collagenous extensions connect the entire superficial fascial system with the underlying musculoskeletal system. In certain areas of the body, the superficial fascial system is tightly adherent to the musculoskeletal surface (zones of adherence). In other areas, the SFS is loosely adherent, forming the roof over loosely organized, deep fat deposits [2]. General agreement has now been reached on the existence of a horizontal, membranous layer (the stratum membranosum) of the SFS that lies in between the superficial adipose layer and the deep adipose layer of the subcutaneous tissues between dermis and the deep muscle fascias in most parts of the body [3-8].

The SMAS is a continuous fibromuscular layer consisting of collagen fibers, elastic fibers, fat cells, and muscle cells, which overlies the midface and parotic glands and extends cranially as parts of the orbicularis oculi muscles, the superficial temporoparietal fascia and galea and caudally as the platysma [1, 8-10]. It is generally accepted to represent the stratum membranosum of the SFS in the head and neck region [6-8].

Although it is well known that the SMAS concept was introduced by Tessier in 1974 [10, 11], it remains unknown who first described the stratum membranosum of the SFS. Research on this subject is seriously hampered by the various names that have been (and are being) used for this structure (superficial fascia, superficial facial system, subcutaneous fascia or tela subcutanea, or textus connectives compactus) [4, 12] and the use of these same names for the subcutaneous adipose tissue, and connective structures alike [3, 4, 12, 13]. Scarpa and Colles are mentioned as the original reporters on the stratum membranosum of the lower abdomen and perineum, respectively [14], but Colles’ description obviously refers to the entire adipose and connective tissue layer between dermis and the deep muscle fascia [15], whereas Scarpa’s description remained too vague to determine which structure(s) he referred to [13, 16].

We came across unmistakable records of both the stratum membranosum and SMAS in the second and fifth of seven books compounding Vesalius’ De Humani Corporis Fabrica Libri Septem (De Fabrica) that was published in Basel, in 1543. He referred to this layer as the membrana carnosa. In this chapter, we present and discuss his observations on both structures.
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FIGURE 6.1: Title page to the first edition (1543) of Vesalius’ De Humani Corporis Fabrica Libri Septem illustrating a public dissection of a corpse by Vesalius, such as the one described by Heseler who witnessed a dissection in Bologna, Italy, in 1540 [20].
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Materials and Methods
The text of Vesalius’ Book II - The Ligaments and Muscles, and Book V – The Organs of Nutrition and Generation of De Fabrica, the entire text of Heseler’s eyewitness report of the public dissection of three corpses by Vesalius in Bologna, Italy, in 1540 (Figure 6.1), and the text of Vesalius’ Epitome were searched for references to the membrana carnosa, or fleshy membrane. For this inventory we used the digital copy of the first print of De Fabrica (1543)[17] and its English translation provided by Richardson and Carman [18, 19], while we used Heseler’s original text and its English translation as presented by Eriksson [20]. Furthermore, we used the original text and English translation of the Epitome as presented by Lind et al. [21].

Results

Vesalius’ description of the stratum membranosum
In chapter V on “The skin, the cuticle, and the membrane that lies under the skin over the whole body; also the fat that is stored between the skin and the fleshy membrane’ in Book II, Vesalius introduced the fleshy membrane as “the membrane lying under the skin over the whole body. This is much stronger and thicker than the cuticle. It is attached here and there by fibers to the muscles that lie under it, but is more strongly attached to the skin. A large number of veins, together with a few very small arteries nourishing the skin and nerve offshoots giving the skin sensation, pass through this membrane and are supported by it as they travel between it and the skin and link the membrane to the skin; and there is also a continuous series of membranous fibers adjacent to it, by means of which also it is firmly attached to the skin. This membrane too is not of the same thickness all over the body, but in certain areas of the body it is augmented by fleshy fibers; it thus becomes thicker and so fleshy that it is described as a muscle” (quote on p. 143) [18]. He then continues with a first reference to the SMAS: “There is an area of this sort over the whole of the neck, in the forehead, and in the rest of the face; in some animals it is everywhere filled with fleshy fibers, especially those animals that can move the skin over the whole body as we can that of the forehead” (quote on p. 143) [18].

Like we currently do, Vesalius furthermore recognized that the fleshy membrane may include musculous tissue even outside the head and neck area. As such, he remarked on the “individual wrappings of each testis” in Book V: “The outer surface of this wrapping or tunic touches the fleshy membrane, to which it is attached by membranous fibers in such large numbers that I have sometimes thought they constituted another tunic of the testes...[...]. This wrapping has one thing in common with the fleshy membrane of the body. I stated earlier that the fleshy membrane is in a certain area augmented and interwoven by fleshy fibers and therefore takes on the nature of a muscle; and in the same way this wrapping of the testis along the whole length at the back from the peritoneum to the bottom of the testis receives fleshy fibers and takes on the nature of a long, narrow muscle” (quote on p. 148) [19]. Thus, Vesalius defined the musculous aspect of the SFS of the scrotum (Figures 6.2-6.4).
Vesalius' description of the SMAS

Following the description of the skin, the cuticle, the membrane that lies under the skin over the whole body and the fat that is stored between the skin and the fleshy membrane and how to dissect them in chapters V, VI, and VII of Book II, Vesalius continued with his description of the human muscles. Chapter VIII on 'The muscle that moves the skin of the forehead' [frontalis muscle] opens with the remark that he had “mentioned earlier that the fleshy membrane underlying the whole skin is in certain areas of the body augmented by fleshy fibers so that its nature changes into that of a muscle. I shall now describe how this occurs beneath the skin of the forehead” (quote on p. 154) [18]. He continued that “in man by and large no areas of the skin can move unless the bones move; the exceptions are the skin of the forehead, that of the face, and that which covers the front of the neck. The whole skin of the forehead (on which no hair grows) can, along with the skin of the nose, be moved according to our desire by voluntary motion, so that we may raise our eyebrows, or lower them to narrow the eye region, or protect the eyes by wrinkling the skin. We can do this because of the fleshy membrane that extends beneath the skin of the nose and the whole forehead; for the membrane is augmented by a large number of fleshy fibers and turns into a sort of muscle possessing many nerve offshoots. In addition this membrane is attached, with the intervention of very little, if any, fat, to the skin of the forehead and nose more strongly than to the skin elsewhere in the body. This has deceived other anatomists, who think that the skin of the forehead itself consists of fleshy and musculous substance, though in fact the skin has no fleshy substance here any more than elsewhere; all that happens is that the present membrane becomes more fleshy and is attached to the skin itself (as we just stated) more strongly than in the abdomen or the back or the legs. It is as if the membrane were intended to form a single body with the skin, thus properly achieving movement of both (the membrane, that is, and the skin)” (quote on p. 154) [18].
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Subsequently, Vesalius accurately mentioned the connection of this part of the fleshy membrane with the frontalis muscle and aponeurotic galea (Figure 6.4): “The fibers of this musculous structure, which stretch side by side from the top of the nose to the whole central area of the forehead (which stands between the eyebrows and the first roots of the hair) and to the sides of this area, are more fleshy; they all run vertically upward (except that very rarely one finds some stretched obliquely)” (quote on p. 154) [18].

Second, in chapter X of Book II on ‘The muscles of the eyelids’ Vesalius described how “in the upper eyelid over its entire area the fleshy membrane is abundantly augmented by musculous fibers” (quote on p. 158) [18]. In the Epitome, he added that “the upper eyelid is moved by means of the [fleshy] membrane just mentioned, for in that place where this reaches the inner region of the eye socket, it raises the eyelid; where it is augmented at the external aspect of the eye by fleshy fibers drawn into the image of our letter C, it is the originator of the downward motion of the eyelid. [.][..] The carneous muscle is implanted in the posterior portion of the scleral tunic of the eye” (quote on p. 15) [21].

Third, he accurately described the inclusion in the fleshy membrane of the platysma in chapter XIII of Book II on ‘The muscles of the cheeks, lips, and alae’: “The first two muscles moving the cheeks and lips [platysma] [.][..] consist of the membrane augmented by fleshy fibers and therefore aptly called by us ‘the fleshy membrane’, for this membrane becomes musculous and genuinely fleshy all over the area just indicated. But these fleshy fibers do not take origin from a bone (as someone deluded by other anatomists might think); and whoever says that this muscle starts from a bone will be quite incorrect” (quote on p. 167) [18].

Finally, when contemplating that “the skin of the cheeks has no muscle,” Vesalius remarked on the fleshy membrane in the face: “In order that all the skin of the face should be moveable the Creator of the world laid under it, in addition to this second muscle [platysma] and those belonging specifically to the lips and nose [.][..], a fleshy membrane that transforms into a muscle. You must except the skin of the cheeks; for the membrane we call fleshy is attached directly beneath this, and is here nourished by no fleshy fibers. However, as the lower part of the skin stretched over the jaws is continuous with the cheeks and the upper part is united with the musculous structure underlying the forehead, the skin of the cheeks moves when we move the skin of the rest of the face” (quote on p. 169-170) [18].

Discussion

Vesalius differentiated between the human fleshy membrane and the animal pannicus carnosus

Unlike Galen and contemporary anatomists, Vesalius endorsed that the fleshy membrane is not augmented with fleshy fibers in most of the body: “Detach the membrane all the way to the armpit and, stretching it and holding it up to the light, look carefully to see whether beneath the armpits it turns into a fleshy muscle beginning from the loins and the false ribs. If you observe (though I know you will not) that it is augmented by fleshy
Figure 6.3: Detail of Tabula XX showing t: ‘part of the fleshy membrane [dartos fascia]; like the scrotum, it surrounded the testicle’ (quote on p. 26) [19].
fibers, separate it from the armpits as carefully as you can, observing whether it has any sort of tendon inserting into the humerus or whether, as is normal over the rest of the thorax, it adheres to these areas solely by means of fibrous linkages. So in the course of this dissection you should carefully investigate whether this membrane turns into a muscle and whether it is so constructed in order to move the skin or the arm. My own view is that in man this membrane does not become musculous” (quote on p. 234-235) [18].

Figure 6.4: Detail of Tabula XI of the famous muscle men in Vesalius’ De Humani Corporis Fabrica Libri Septem showing “the muscles that are constituted from the fleshy membrane and also certain muscles of the face denuded of fat .[...]. A- the straight lines on the forehead denote the muscle belonging to the skin of the forehead and nose [frontalis muscle]. B- Temporal muscle, where occasionally (but very rarely) the fleshy membrane is augmented by fleshy fibers. C- Muscle raising the eyelid [orbicularis oculi muscle]. D-Muscle drawing the eyelid downwards [orbicularis oculi muscle]. E-Muscle formed from the fleshy membrane [platysma]; it is the principal author of movements of the cheeks and lips and of the skin at the front of the neck. It adheres to the body on either side, and the rest of the fleshy membrane, which is not musculous, has been cut away from the body” (quote on p. 21) [18].
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Vesalius stressed this point because he realized that the fleshy membrane he was describing differed from the panniculus carnosus that was described by Galen [20, 22]. The panniculus carnosus is a thin layer of muscle lying just beneath the mammalian skin, which allows the movement of the skin independent of the movement of deeper muscle masses. It extends as a broad sheet over the thorax, abdomen and proximal portion of the posterior extremities. Vesalius rightly observed that the panniculus carnosus consists of muscles over the whole body of apes and other animals, but that this is not the case in man: “Galen was speaking of his apes and not of man; for in apes no fat intervenes between the membrane and the skin, and the membrane itself is not merely attached to the skin by fibers but is contiguous with it everywhere without the intervention of anything else. And for this reason it is not as difficult to cut through just the skin of man without damaging the membrane as it is in apes, dogs, and the animals from which Galen described dissection” (quote on p. 143-144) [18]. He acknowledged that “it seems to be the Arabs, as far as I am aware, who first investigated it [the fleshy membrane] with some care and called it fleshy” (quote on p. 143) [18].

Currently, the human superficial fascial system is accepted to be homologous to the panniculus carnosus found in other mammals (Figure 6.5) [23]. Like Vesalius already observed, muscle fibers may in humans, indeed, mostly be found in the head and neck area (SMAS) and perineo-genital region (external anal sphincter and dartos fascia) [6].

Vesalius’ recognition of the relation of nerves and vessels to the fleshy membrane

Vesalius already observed that the SMAS is in close contact with nervous tissue: “In fact it [the platysma] consists merely of fleshy fibers stretched over the aforesaid [fleshy] membrane and accompanied by many nerve offshoots running into it from the bodies underlying the membrane; and these offshoots therefore link the membrane more firmly to the parts underlying it here than it is linked to the muscles which it covers in the rest of the body” (quote on p. 167) [18]. This is in line with the observations by Mitz and Peyronie who reported sensory nerves to go through the SMAS to the dermis [11], and those by Accioli et al. who reported that the SMAS ‘plasters’ branches of the facial nerve that are located underneath the SMAS [9]. Likewise, Vesalius already noted veins to run through the stratum membranosum of the SFS: “While separating the skin from the fat (an exhausting task, requiring patience and an intense desire for knowledge) you may conveniently examine the tiny nerves and the veins running over the membrane and within the fat on their way to the skin” (quote on p. 146-147) [18]. This is in line with current observations of the saphenous veins, superficial epigastric vessels, and cephalic vein running in the stratum membranosum [6].
Conclusion

Vesalius’ record of the nature and functions of the *fleshy membrane* and its muscular continuation as the SMAS in the head and neck area and as the dartos in perineogenital region, of the detail that this membrane encloses nerves and vessels, and of its varying degree of connection to the overlying skin and underlying deep fascia over most of the body is a very clear representation of the stratum membranosum of the SFS and the SMAS as we know it. In his way, Vesalius defined both concepts *avant la lettre*.

**Figure 6.5:** Timeline with relevant data in regard to the recognition of the superficial fascial system (SFS) and superficial musculoaponeurotic system (SMAS). Galen’s (ca. 130-200) description of the mammalian *panniculus carnosus* was accepted, up to the time of Vesalius, to exist in humans [18]. Although a Persian scholar, Mohammad-e Zakariā-ye Rāzi (or Rhazes, 865-925) is featured here as one of the Arabs who first investigated the fleshy membrane with some care according to Vesalius. During his studies, Vesalius paraphrased Rhazes’ work. In his 1543 Opus Magnus, Vesalius defined both the SFS and the SMAS *avant la lettre* [17]. Scarpa provided a vague description of some fascial structure in the lower abdominal in his book of 1809 [16]. Colles described the adipose and connective tissue layer between dermis and the deep muscle fascia of the perineum in his book of 1811 [15]. In 1854, Struthers coined the eponyms Scarpa’s fascia and Colles’ fascia referring to the stratum membranosum of the abdomen and perineum, respectively [14]. Tessier coined the term SMAS for the SFS in the head and neck area in 1974 and had various of his students examine parts of it [10]. In 1991, Lockwood stressed that the SFS extended over most of the body [2].
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References