Understanding the Fascial Supporting Network of the Breast: Key Ligamentous Structures in Breast Augmentation and a Proposed System of Nomenclature

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Background: The fascial system of the breast has, to date, only been described in general terms. This anatomical study has developed two distinct methods for better defining existing breast structures such as the inframammary fold, as well as defining previously unnamed ligamentous structures.

Methods: The authors harvested and examined 40 frozen, entire chest wall cadavers. Initially, 15 embalmed cadavers were studied with a combination of blunt and sharp dissection, which proved to be inaccurate. A further 20 fresh and five embalmed chest walls were harvested, frozen, and then sectioned with a bandsaw (3-cm slices) and knife (1.5- to 4-cm slices) depending on the area studied. Sagittal, horizontal, and oblique sections along the length of the ribs were created and then dissolved using either sodium hydroxide or alcohol dehydration followed by xylene immersion. Constant fascial connections between the breast parenchyma, superficial fascia, pectoralis muscle (deep) fascia, and bone were observed.

Results: Specimens clearly demonstrated internal structures responsible for the surface landmarks of the breast. The precise configuration of the inframammary fold was clearly visible, and new ligamentous structures were identified and named.

Conclusions: Knowing the location and interrelationship of these structures is particularly important in breast augmentation. Reappraisal of the anatomy in this area has enabled precise identification of ligamentous structures in the breast. Correlation of the findings in this article to specific clinical conditions or modes of treatment can be proven only by a clinical series that scientifically addresses the necessity and efficacy of preserving, releasing, or repositioning any of these structures. (*Plast. Reconstr. Surg.* 133: 273, 2014.)

Various methods have been used to study the ligamentous anatomy of the breast. Until now, many of these methods have produced conflicting results, possibly because of dissection artifact. With advancing breast implant technology and expansion of its role in the treatment of breast deformity, a concomitant need exists for a more detailed anatomical knowledge of the fascial and ligamentous structure of the breast. We describe two new methods to study the breast fascial system. These provide a more accurate assessment over existing techniques.

According to classic anatomic descriptions, the base of the nonptotic breast overlies the pectoralis major muscle between the second and sixth ribs.[1]

The breast overlies the fascia investing the chest wall musculature—most significantly, the pectoralis major muscle, the rectus abdominis muscle inferomedially, serratus anterior superolaterally, and a small portion of the external oblique inferolaterally.

The gland is anchored to the pectoralis major fascia by the suspensory ligaments first described by Astley Cooper in 1840.[2] These ligaments run

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throughout the breast tissue parenchyma from the deep fascia beneath the breast and attach to the dermis of the skin.

Overlying this is the superficial fascial system of the breast, first described by Scarpa[3] and Colles[4] and then further defined by Lockwood.[5] It is continuous with the superficial fascial system of the trunk and is best described as a connective tissue network extending from the subdermal plane to encase the fat and lobular tissues of the breast. This superficial fascial network has posterior extensions connecting it to the fascia overlying the muscles of the chest wall and, in certain regions, to the periosteum. Anteriorly, it has more numerous extensions, where it is inserted into the dermis.

While this superficial fascial system has been studied in the literature, there is a paucity of fine detail regarding its anatomical structure, particularly in the lower pole and inframammary fold. In addition, some of the studies directly conflict with each other, and some describe structures, such as the horizontal septum, that are not mentioned elsewhere.

We aimed to develop techniques that allow a more detailed study of the breast's fascial system. In particular, we aimed to provide specific information about the fascial structures that constitute the lower pole and inframammary fold and the interrelationship between these structures and other elements of the breast, particularly the suspensory ligaments of Astley Cooper and the superficial fascial system of Scarpa.

MATERIALS AND METHODS

We dissected 40 female cadavers using different approaches to define the ligamentous anatomy of the breast. All cadavers ranged in age from 58 to 95 years, with an average age of 83 years. We examined a broad range of breast sizes from those with hypoplasia or involution to overweight specimens with significant ptosis.

We initially studied 15 embalmed cadavers with a combination of blunt and sharp dissection to define key structures. This was, however, as previously stated, limited by dissection artifact.

A further 20 fresh and five embalmed female chest walls were harvested from whole cadavers from the midsternum to the posterior axillary line. The chest walls were then frozen and fixed with needles to maintain the correct position of the inframammary fold. Sections were obtained either with a bandsaw (3 cm wide) or a knife (1.5 to 4 cm wide, depending on the area studied, which allowed for greater precision).

We obtained a more accurate demonstration of the fascial network with sagittal (18), horizontal (five), and oblique (two specimens along the length of the ribs in the intercostal spaces) sectioning, and correlated the results from the different sections.

In 15 specimens, we used a gradual fat dissolution technique using four subsequent treatments with 10% sodium hydroxide and washing with water to demonstrate the fascial network. This gradual removal of fat maintains the fascial structure and allows for better definition of the ligaments of the breast. Constant fascial connections among the breast parenchyma, superficial fascia, pectoralis muscle (deep) fascia, and bone were examined.

In 10 specimens, we used a different dissolution technique. This involved using absolute ethanol baths with increasing concentrations of 50%, 75%, and 100% for 24 hours, followed by immersion in xylene for several days (the immersion time depended on the fat content of the specimen). This accurately demonstrated bony attachments of the ligamentous network.

RESULTS

Although the superficial fascial system varies according to age, degree of ptosis, and adiposity, we observed specific recurring ligamentous patterns in the cadavers we studied. As expected, fascial quality deteriorated with increasing age of the specimens; there was a greater degree of ptosis and ligaments were more lax and less dense in older specimens. However, the configuration of the structures was the same across all ages.

The anterior breast capsule (or superficial layer of the breast fascia) is well defined to the level of the fourth rib, after which it becomes obscured by glandular tissue and ducts as they form the nipple-areola complex. It is not visible inferior to the fourth intercostal space, because it gives way to direct dermal insertions, which fan out from the fifth rib and pectoral fascia superior to it. The posterior breast capsule creates a gliding plane between the pectoral fascia and breast, which is called the retromammary space (Fig. 1).

Commencing medially with the parasternal area, there are many dense transverse connections between the periosteum of the sternum and dermis, which firmly anchor the fused superficial and deep fascial system in this region. These medial sternal ligaments are short, run horizontally along the length of the sternum, and are stronger and thicker than in the remainder of the

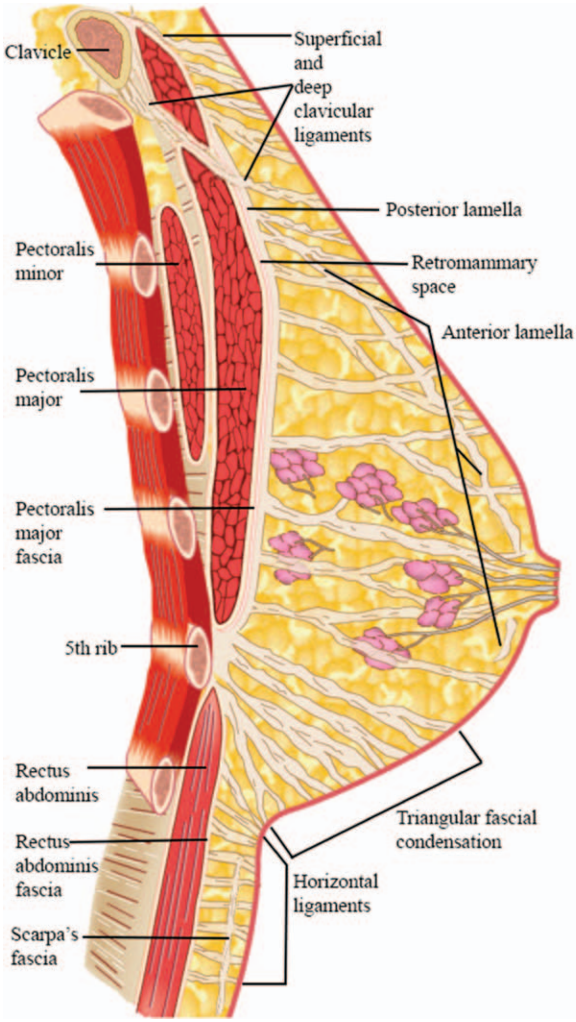

Fig. 1. Diagram of a sagittal section through the nipple, demonstrating the anterior and posterior breast capsule, ligaments, and triangular fascial condensation.

breast because there is little fat and no glandular tissue interspersed in this region. This creates a very firm zone of adherence medially (Fig. 2).

As the pectoralis major muscle takes its origin from the sternum and the first to fifth ribs, these ligaments extending from the pectoral fascia through to the anterior breast capsule and dermis gradually become longer, especially in the retroareolar portion of the ptotic, larger breast. This region has the greatest amount of glandular tissue and fat. The ratio of fat to glandular tissue varies greatly when comparing different breasts. With greater degrees of fatty infiltration in this area, the ligaments are more stretched, resulting in a greater degree of ptosis.

Superiorly, two direct bony anchor points to the clavicle were observed: one superior to its superficial aspect through the pectoral fascia (superficial clavicular ligament) and one to the deep inferior aspect of the clavicle through the fascial septum between the clavicular and sternal heads of the pectoralis major muscle (deep clavicular ligament). These are direct insertions between periosteum and dermis without intervening anterior breast capsule, which commences inferior to these attachments at the level of the second rib.

There is a fascial thickening between the pectoral fascia and superolateral breast at the lateral aspect of the pectoralis major as its fibers converge to form its tendinous insertion to the humerus, the lateral pectoralis major ligament (Fig. 3). This is a firm superolateral anchor point for the breast.

In the inferior pole of the breast, the ligaments run obliquely and inferiorly to insert directly into the dermis, with no intervening anterior breast capsule. At the level of the fifth rib, they fan out in a triangular fashion from a well-defined bony attachment where they are fused to the periosteum of the superior aspect of the fifth rib (the apex of the triangle) in the intermuscular septum between the rectus abdominis and pectoralis major. The most inferior of these fibers insert into the dermis of the inframammary fold. The remaining superior fibers insert into the inferior pole of the breast. This forms what we have named the *triangular fascial condensation* (Figs. 4 and 5).

In addition to the oblique fibers seen in sagittal sections, the condensation has radial fibers running perpendicular to these along the length of the fold. The amount and density of the criss-crossing insertions here create the degree of constriction of the lower pole, and also the degree of fold definition.

There are a few short horizontal ligaments inserting into inferior limit of the fold directly from the deep fascia overlying the rectus abdominis, with no intervening superficial fascial layer. The superficial fascial layer (Scarpa's fascia) is once again visible approximately 1 cm inferior to the fold. The fold is supported from below over the region of the sixth rib and superior portion of the seventh rib by very short horizontal ligaments connecting the deep fascia of the rectus abdominis to Scarpa's fascia, from which short ligaments run inserting into the dermis (Fig. 4).

The triangular fascial condensation is therefore a zone that forms a break in the continuity of the superficial fascial layer.

The inframammary fold lies at the level of the sixth rib or sixth/seventh rib depending on the degree of ptosis (and the length of these inferior ligaments).

The limit of the lateral third of the breast is defined by the fusion of the layers of fascia arising

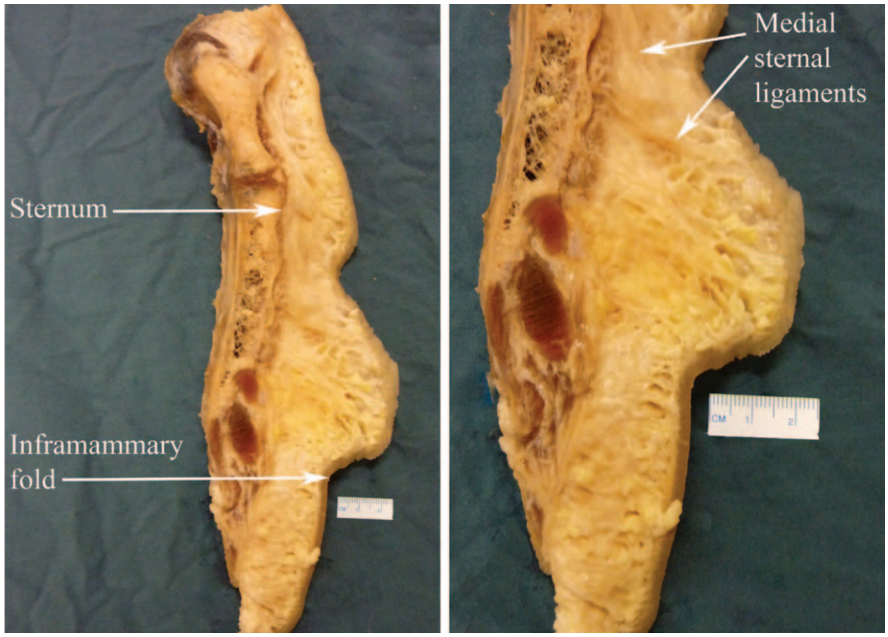

Fig. 2. Sagittal section through the sternum (*left*) with a close-up of the medial sternal ligaments (*right*). Sodium hydroxide dissolution.

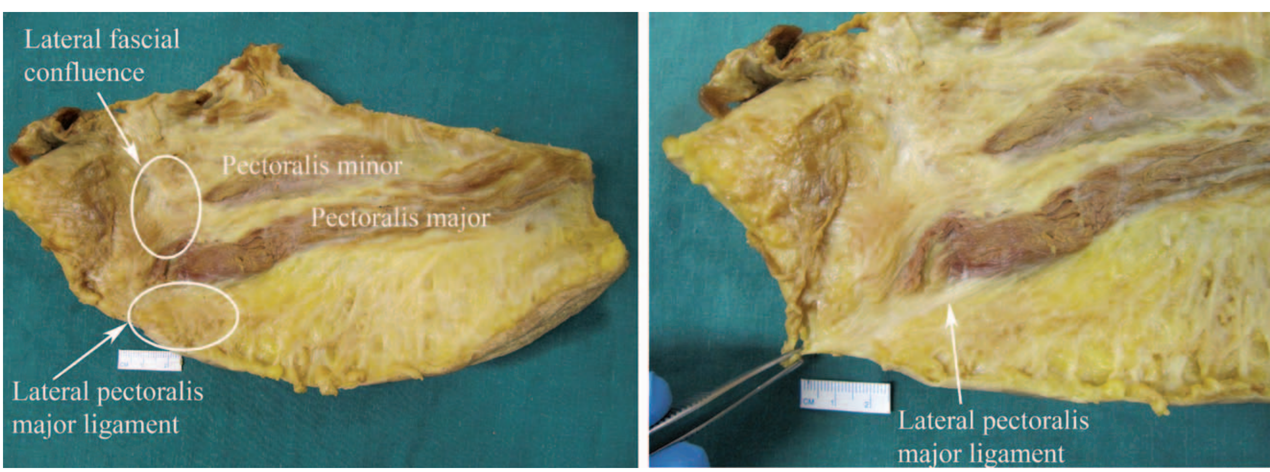

Fig. 3. General view of a horizontal section at the level of the second rib (*left*) and its close-up showing the lateral pectoralis major ligament (*right*). Xylene dissolution.

from fascia overlying the pectoralis major and minor muscles and the fascia overlying the serratus anterior, which has been named the *lateral fascial confluence*.

The fascia between the interdigitations of the serratus anterior anchors the breast directly to the fourth, fifth, and sixth ribs, and this creates the lateral continuation of the inframammary fold. The confluence of three fasciae (pectoralis major, pectoralis minor, and serratus anterior) creates the continuous curve of the inframammary fold as it merges laterally into the suspensory ligament of the axilla (an extension of the pectoralis minor fascia) (Fig. 6).

A dense fascial adhesion that is continuous with the fascia surrounding pectoralis minor (the clavipectoral fascia) attaches to the coracoid process, runs inferiorly, and emerges inferior and lateral to the pectoralis major muscle to fuse with its investing fascia and the fascia overlying the serratus anterior. Inferiorly, its fibers insert directly into the breast parenchyma approximately 4 cm lateral to the nipple and into the inferior pole of the breast, forming the pectoralis minor suspensory ligament (Fig. 7).

These fixed points create the surface topography known as the breast footprint, which varies in

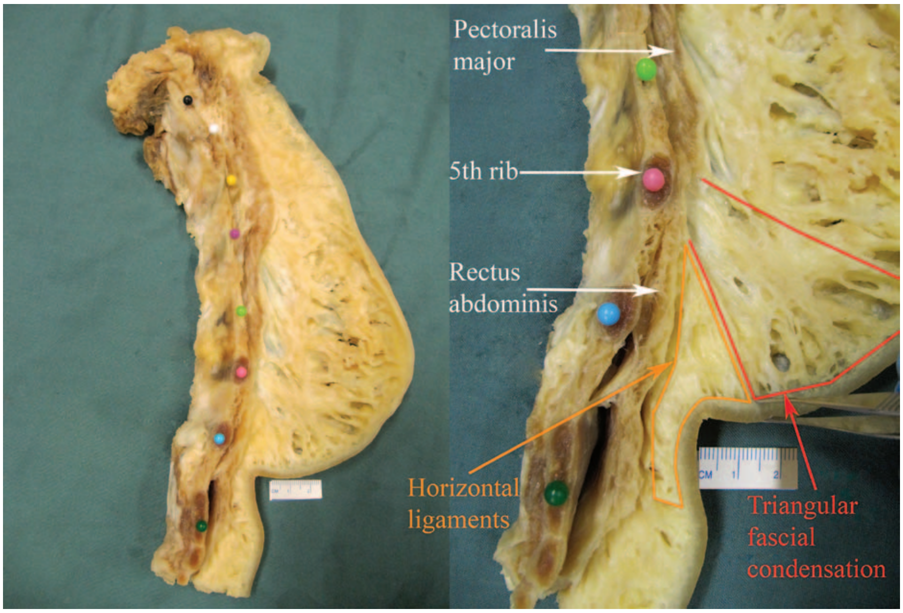

Fig. 4. General view of a sagittal section medial to the nipple (*left*) with a close-up of the attachment of the triangular fascial condensation to the fifth rib (*right*). Xylene dissolution.

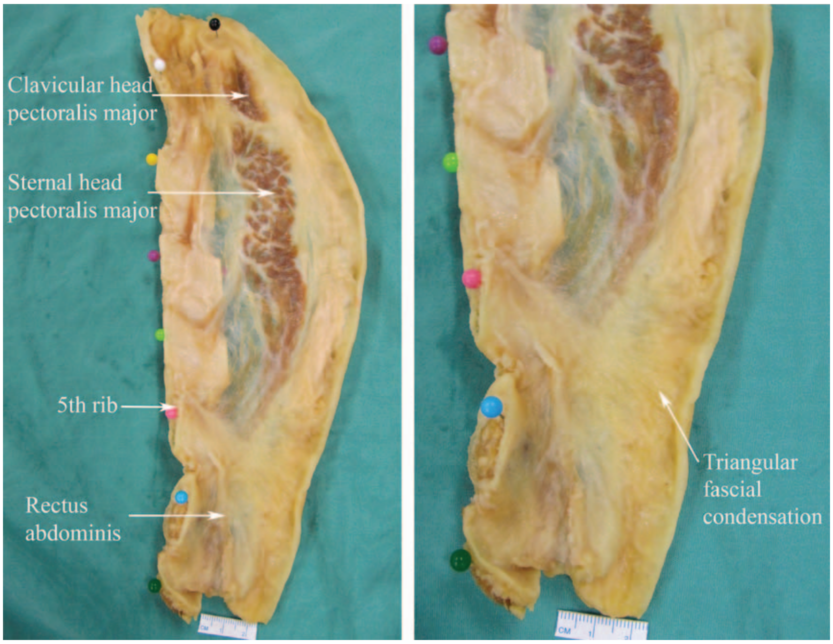

Fig. 5. General view of a sagittal section medial to nipple (*left*) with a close-up of the attachment of the triangular fascial condensation to the fifth rib (*right*). Xylene dissolution.

its position in each individual, depending on the length and laxity of these ligaments.

DISCUSSION

Knowledge of the fascial attachments of the breast is integral to understanding the aesthetic ramifications of breast surgery. Symmastia, the double bubble deformity, lateral implant migration, prolapse of a breast implant below the inframammary fold, and destruction of the inframammary fold following mastectomy are just some examples of surgery interfering with the breast's fascial network to produce unaesthetic surgical outcomes.

The study of the breast's fascial network and supporting ligaments dates back to late eighteenth

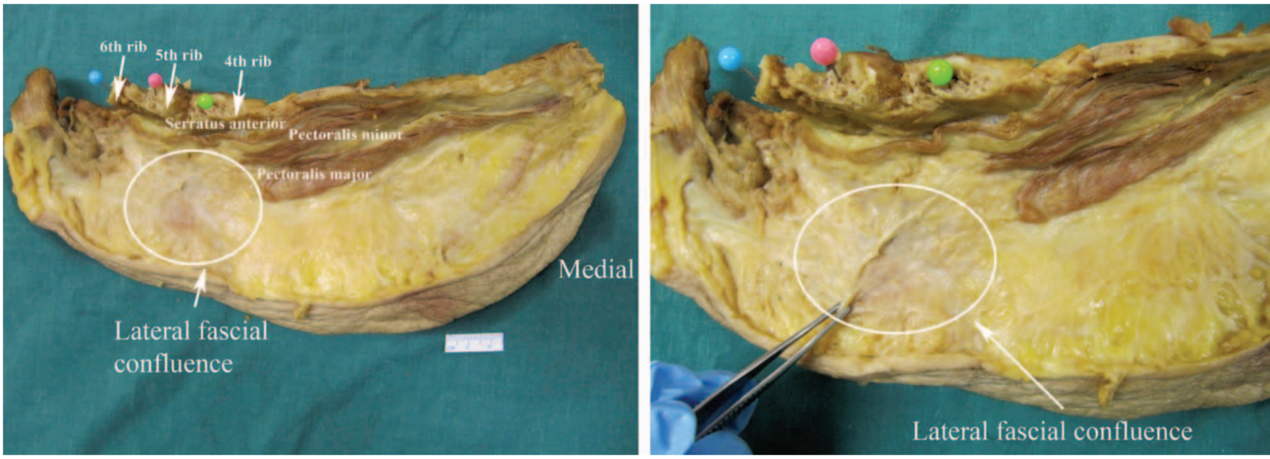

Fig. 6. General view of a horizontal section through the fifth (*pink pin*) and sixth (*blue pin*) ribs (*left*). Close-up of the area of fusion of the pectoralis major, pectoralis minor and serratus anterior forming the lateral fascial confluence (*right*). Xylene dissolution.

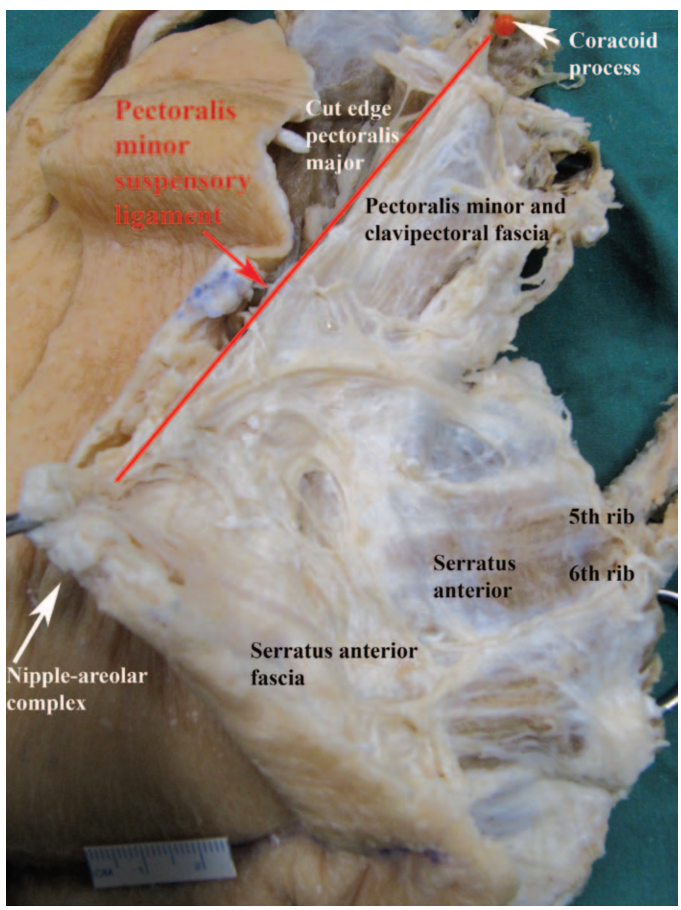

Fig. 7. Left breast oblique section through the lateral inframammary fold (sodium hydroxide dissolution). Pectoralis minor suspensory ligament is visible attaching to the coracoid process (*orange pin*) and running inferiorly to insert into the breast tissue.

century. As early as 1809, Scarpa[3] described the superficial fascia of the abdominal wall, and in 1811, Colles[4] described its continuation in the perineum. Perhaps Sir Astley Cooper should be recognized as the first to comprehensively and systematically describe and depict the fascial network of the breast, in 1840.[2] Astley Cooper described in detail the deep and superficial fascial system of the breast and the horizontal supporting ligaments that still bear his name today.

However, there are some structures described and illustrated by Sir Astley Cooper that we were unable to find, particularly the splitting of the fascial layers into anterior and posterior lamellae: "The gland of the breast is enclosed in a fibrous tissue, which as in the female, should be traced from the sternum outward ... when it reaches the breast it divides into two portions, an anterior and posterior layer. The anterior part passes upon the fore part of the gland and sends forth its ligamenta suspensoria to unite the breast to the inner part of the skin ... with which it becomes incorporated."[2]

This splitting of Scarpa's fascia into the anterior and posterior lamellae of the breast capsule has subsequently been accepted as fact in the literature. It has been described by others, and it is said to occur in the region of the inframammary fold.[6]

However, in our specimens using fat dissolution, no such division point was visible. Moreover, this is the region of a direct insertion point from both the periosteum of the fifth rib to the dermis of the inframammary fold and inferior pole (the triangular fascial condensation).

This is not the only anatomical structure described in the literature that we were unable to replicate. Würinger and colleagues described a thin horizontal fibrous septum originating from the pectoral fascia along the level of the fifth rib heading toward the nipple.[7,8] This fibrous septum is said to be mesentery-like and lies between a cranial and caudal vascular network, and is responsible for the blood supply of the nipple-areola complex. While there was a thin structure visible transmitting neurovascular supply to the breast in the specimens, there was no distinct septum dividing the breast superiorly and inferiorly.

The inframammary fold has also been subject to several conflicting descriptions. Maillard and Garey described a crescent-shaped ligament stretching between the superficial aspect of the pectoralis muscle and skin just inferior to the inframammary fold.[9] Bayati and Seckel's results corresponded closely to our findings (however, excluding the lateral extent of the fold).[10] The ligament was described as originating from the fifth rib and inserting into the deep dermis of the skin.

Muntan et al.[11] described the fascia of the fold as having different configurations; the deep fascia being fused with the superficial fascia at the fold level or alternatively, bundles of fibers arising from the superficial fascial layer and inserting into dermis. Boutros et al.[12] in a later study said that there was no evidence of a ligamentous structure in the area of the inframammary fold and that it is an intrinsic dermal structure consisting of regular arrays of collagen held in place by a zone of adherence that is a specialized area of the superficial fascial system.

In a more recent study of the pectoral fascia, Jinde and colleagues[13] described a dense connective tissue structure at the level of the inframammary crease connecting it to the underlying pectoral fascia.

The structural anatomy of the breast is affected by skin quality, fat, glandular tissue connections to underlying musculature (pectoralis major, pectoralis minor, serratus anterior, and rectus abdominis), and the fascial architecture.

Our study shows that the fascial architecture of the breast forms a ring around the breast, and between this fixed framework are attachments between deep muscle fascia and anterior breast capsule. The concept of such zones of adhesion has been well described by Lockwood,[5] particularly the medial sternal adhesion zone.

This ring is formed (summarized in Fig. 8):

1. Superiorly by the superficial clavicular ligament and deep clavicular ligament
2. Medially by the medial sternal ligaments
3. Laterally by the pectoralis minor suspensory ligament and lateral fascial confluence
4. Inferiorly by the triangular fascial condensation

All of these structures affect support; however, the strongest are fixed areas of bony attachment. These form the breast footprint, and it is also around these fixed points that ptosis occurs.

The neurovascular supply of the breast has previously been studied and found to cross tissue planes in the aforementioned fixed areas, which correlates with the principles stated by Taylor and Palmer that vessels do not cross mobile tissue planes but rather radiate from fixed to mobile areas.[14]

Breast procedures such as breast augmentation, breast reduction, mastopexy and mastectomy, and reconstruction can disrupt these internal support structures.

When performing breast augmentation, overdissection medially, laterally, or inferiorly of any of these ring structures can lead to implant malposition.

The inframammary approach to breast augmentation will disrupt the fibers of the triangular fascial condensation along the length of the

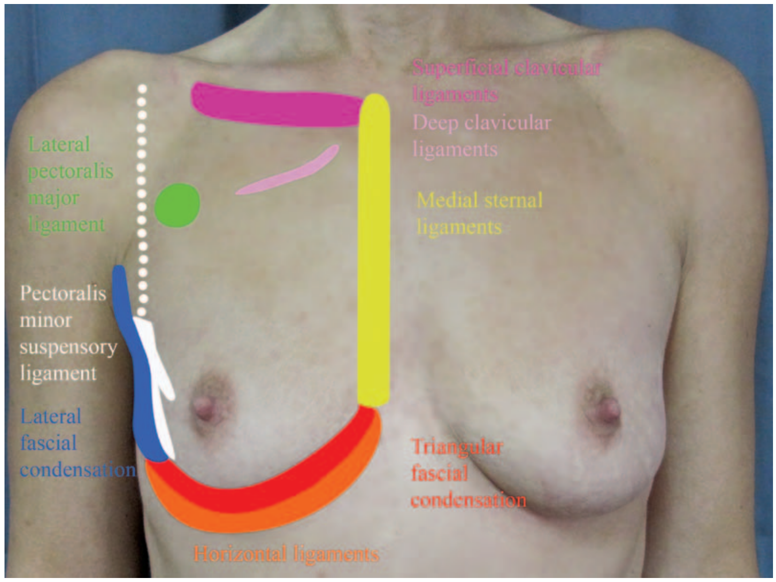

Fig. 8. The surface anatomical landmarks created by the ring of fascial attachments of the breast.

skin incision. Angling the incision superiorly will divide the condensation through its midpoint and will preserve some of the inferior horizontal ligaments arising from the rectus abdominis fascia; however, access to either the subglandular, subfascial, or submuscular plane necessitates the release of its attachment to the periosteum of the fifth rib (the apex of the triangle).

Repositioning the inframammary fold more than approximately 1 cm inferiorly will result in division of the triangular fascial condensation and destruction of the horizontal supporting ligaments beneath the triangular fascial condensation that run from the deep fascia overlying the rectus abdominis to the dermis. Unless this attachment is formally repaired, there may be less support for the implant and a higher risk of inferior implant malposition.

In more routine breast augmentation where the inframammary fold is not lowered beyond the extent of the triangular fascial condensation, reconstituting the fold by anchoring the released triangular fascial condensation to the deep muscle fascia or the periosteum of the rib may more accurately maintain fold position and provide more predictable implant support. In this way, the triangular fascial condensation can be anchored below the implant and is likely to act as a firm sling and provide the surgeon with greater control in precisely positioning the new inframammary fold. The consistency with which the triangular fascial condensation was observed in the cadaveric studies suggests that it is a strong and extensive structure that may be sutured and can potentially be used to gain greater surgical control of the inframammary fold.

Release of the lateral fascial confluence needs to be performed in order to accommodate the implant to continue the smooth curve of the inframammary fold laterally. This is especially important inferolaterally at the transition point between the pectoralis major and the serratus anterior (where the fold is formed from the insertion of the serratus anterior fascia and is firmly attached to the ribs). Inadequate release can lead to compression and distortion of the implant in this region. However, care should be taken when dissecting in this region because the nerve supply to the breast is transmitted through this condensation. Dissection beyond this confluence in its inferolateral aspect should be undertaken with care; while being a denser structure more superiorly, it is formed only by serratus fascia inferiorly. Once in this space, implants are therefore likely to migrate inferolaterally in an uncontrolled manner unless the superficial fascia is firmly anchored to the periosteum and the lateral extent of the implant pocket is defined.

CONCLUSIONS

Various methods have previously been used to study the ligamentous anatomy of the breast. Many of these attempts have produced conflicting results because of dissection artifact, which also created similar problems in the initial stages of this study. This necessitated the development of two new techniques that have enabled a more accurate study of the superficial fascial anatomy of the breast.

Knowledge of the specific connections of the breast to the pectoralis muscle, ribs, deep fascia, and dermis is critical to understanding the effects of surgical approaches in this region.

Certain recurring ligamentous patterns have been observed, and a system of naming these newly defined structures has been proposed. The insertion of these ligamentous attachments contributes to the surface landmarks of the breast. Being aware of their precise attachments and internal structure is likely to be important when planning breast augmentation; however, this needs to be validated in further clinical studies. Respecting their attachments and considering their reconstitution may be a factor in preventing implant malposition, particularly in an inferior direction when the triangular fascial condensation is completely divided.

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