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## Anatomical study of the breast superficial fascial system: the inframammary fold unit

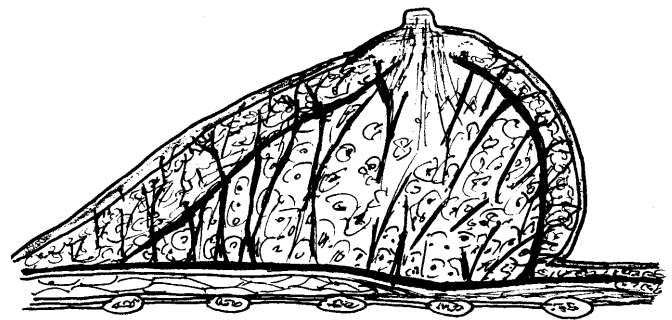
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**Abstract** The subcutaneous fascial system of the breast was investigated. The aim was to demonstrate splitting of the superficial fascia and the existence of an inframammary ligament. The inframammary region was studied in six cadavers (12 breast dissections) and in 21 patients during breast surgery (12 surgical and nine histological investigations). The superficial fascial system is related to sex, age, breast size, weight and adiposity. In females, the inframammary fold depends on the situation of the superficial fascia which, without true splitting, becomes deeper due to an absence of fat in the deep subcutaneous space, and on more adherence to the deep fascia through thickened retinaculum; there is a connective band, the anterior breast capsule, erroneously called “superficial layer of the superficial fascia,” and mistaken for “inframammary ligament”, which detaches from the superficial fascia. In males, there is a zone of adherence only at the inframammary midline. The microstructure of the breast fascial system at the inframammary region is demonstrated histologically. Surgical implications are suggested.

**Key words** Breast · Anatomy · Superficial fascial system · Inframammary fold

### Introduction

Preservation of the inframammary fold at the time of mastectomy and the reconstructive requirements prompted us to clarify the anatomy of this region through an improved knowledge of the fascial frame (Fig. 1). An accu-



**Fig. 1** Sagittal section of the breast

rate anatomical knowledge is a basic requirement for the improvement of plastic surgical results. The research presented is related to the verification of the subcutaneous fascial system in the context of the inframammary fold and its relationship to breast anatomy and aesthetics.

### Anatomy of the breast subcutaneous territory

The superficial fascia is exceptionally thick around the female breast. This fascia is as resistant as that of the subclavian area; both support the breast by means of their *retinaculum fibrosa* (Cooper's ligaments). It is separated from the muscular fascia through a thin, deep, subcutaneous layer where the connective retinacula are almost horizontal. They are joined by elastic septa which include adipose lobules. In thin women there are only few of these and they are small, and are fixed to the deeper muscular fascia.

The superficial fascia does not have two layers and is not to be considered the “deep layer” of the superficial fascia, even though this theory has been advanced by anatomists such as Charpy [4] and Sebileau [15]. The “superficial layer” was also described by Cooper [6], and more recently reported by surgeons [2], but it is only apparent due to the thickened retinaculum. These authors

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did not emphasize the age of the patient or the functional state of the breast. After Rieffel [14] and Chiarugi [5], Sterzi clarified the system in 1910, in his anatomical study on the subcutaneous breast tissue in babies, virgins, women at puberty, and aged women [16].

Fascial thickening takes place in puberty and in all phases of breast hypertrophy but, after pregnancy, the retinaculum lose their elasticity and remain firm, especially in fat women. This thickening of the retinaculum is greater in the infraclavicular area than in the mammary region, and resembles the presumed suspensory ligament of Giraldés [8] in the childbearing age.

Medially, the superficial fascia merges into the anterior membrane of the sternum and is composed of fibers coming from the tendinous apparatus of the sternocleidomastoid and pectoralis major muscles. The superficial layer is represented by a thin fibroareolar tissue with few adipose lobules.

### Anatomy of the inframammary fold

The inframammary fold is located at the fifth–sixth rib. The lowest portion extends to the sixth intercostal space. This fold has always been neglected by anatomists, perhaps because they did not believe it to be a distinct anatomical entity, even though it appears to have a constant position. In contrast, plastic surgeons have always recognized a true inframammary ligament [1,17].

Bayati and Seckel [1] reported the origin of the ligament to be from the periosteum medially, and to the fascia laterally. Other authors [7] have tried to describe it, using anatomical, histological, radiological, and ultrasonographic studies. Maillard and Garey [12] reported a crescent-shaped ligament which was situated between the skin and the anterior surface of the pectoralis major under the inframammary line. It is also true that no anatomy textbook has described such a ligament.

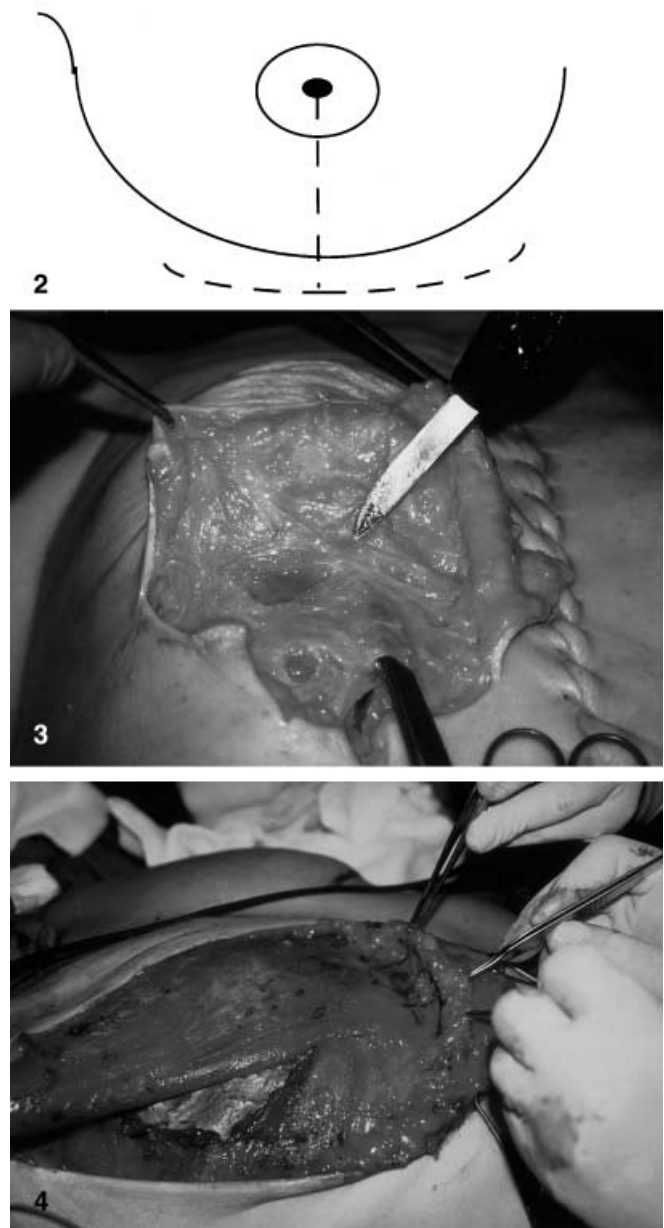
In the inframammary region there is the superficial fascia as a prolongation of the abdominal one, which extends to the retromammary space.

## Material and method

This study was performed on six cadavers and in 21 patients who had breast surgery. In 12 cases, the investigation was only surgical, and in nine, the investigation was only histological.

### Cadaver dissection and examination.

Bilateral dissections of the inferior breast were performed in six fresh cadavers (three females and three males). The mean age was 81 years for female cadavers (range 69–93 years), and 69 for males. One female was obese with large breasts, while the others were thin with small breasts. Two incisions were used: the first was transverse and parallel to the inframammary crease in the lower thorax, and the second was vertical, from the areola to the previous incision (Fig. 2). Through the transverse incision, a superficial dissection was carried out close to the superficial fascia of the lower thorax, until the inframammary fold was reached. The fascia and



**Fig. 2** The incision lines for cadaver investigation

**Fig. 3** Caudal view of breast dissection in a cadaver after skin débridement: the inferior instrument indicates the superficial fascia (thorax-abdominal portion), while the upper instrument shows the inframammary pseudoligament (Cooper's lamina), i.e., the lower part of the *fascia mammae* which envelopes breast gland. The point of the instrument precisely indicates the level of detachment from the superficial fascia level

**Fig. 4** Intraoperative lateral view after Patey mastectomy, sparing the inframammary fold, including the superficial fascial system. The line of conjunction between submammary lamina and superficial fascia. Methylene blue draws the location of the residual inframammary "pseudoligament", detaching from the residual superficial fascia

retinacula were then exposed, using blunt dissection. The retinacula were dissected from the inframammary skin by cutting their dermal attachments. Through the vertical incision, the breast was incised through its lower pole, revealing its sagittal section from the skin to the underlying deep fascia and muscles (Fig. 3).

## Dissection at the time of surgery

Twelve female patients underwent examination at surgery. None was obese, and all had medium-sized breasts, except three whose ages ranged from 38 to 54 (mean age: 47). Partial dissections of the submammary region were performed in seven immediate reconstructions, after radical mastectomy (Fig. 4); in one, delayed reconstruction using a prosthesis, in two, secondary mastoplasties, and in one other, elevation of a pectoralis major flap. In another patient, the visualization of the inframammary retinaculum was achieved through endoscopy ( $\times 50$ ), during secondary reconstruction.

In another nine patients undergoing radical mastectomy, the inframammary region was resected for histologic examination. The specimens obtained were fixed immediately in 10% buffered formalin and embedded in paraffin. Four micron thick sections were cut and stained with hematoxylin-eosin, and van Gieson's and Weigert's method for collagen and elastic fibers, respectively.

## Results

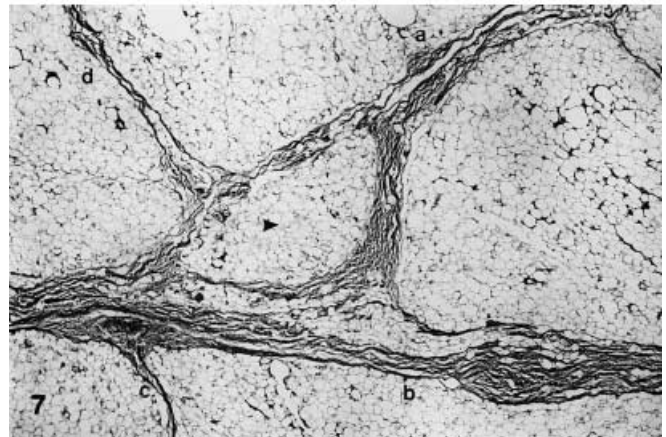
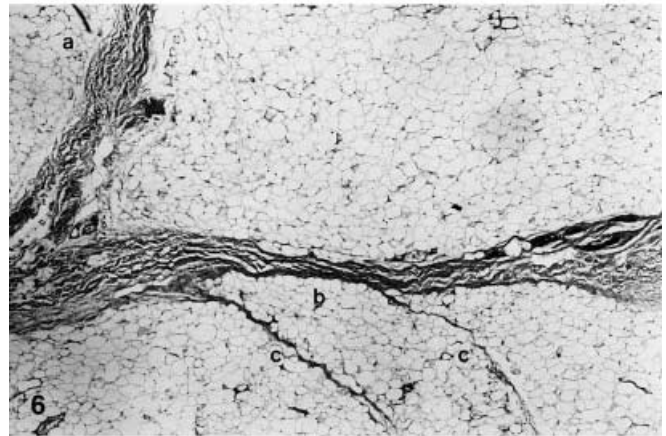
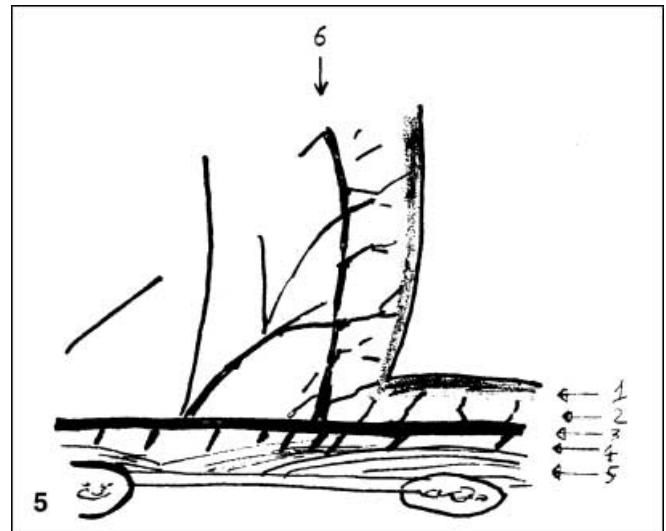
### Cadaver examination

In the dissection of the female breasts in the frontal plane, the connective frame appeared band- or membrane-like after freeing the retinacula from the inframammary skin. It was evident that this band merged cranially with the *fascia mammae* (anterior breast capsule) as a whole. During the sagittal dissection, the examined band showed greatest thickening in the midline of the inframammary fold, at the point of its detachment from the superficial fascia. The superficial fascia was posterior to the mammary gland and easily distinguishable from the deep fascia (muscular fascia), by the interposition of a thin deep subcutaneous layer. The fascia of the male breast was thinner than that of the female breast, and there was thickening only in the retroareolar space. No ligament or fibrous band took origin from the superficial fascia at the inframammary line. The unique anatomical landmark was a prepectoralis adherence sited at 5 cm from the areola, which was recognized, since it provided major resistance to blunt dissection of the superficial fascia from the deep fascia in the central part of the presumed inframammary line at the sixth rib.

### Macroscopic and microscopic examination

The inframammary retinaculum were found intact and took origin from the superficial fascia in all the surgical dissections. The macroscopic structure was not homogeneous, but consisted of merging dense connective retinaculum. There were no detectable ligamentous structures between the superficial fascia, the myofascial layer, and the chest wall at the submammary fold. There was no ligamentous insertion running through the myofascial plane to the chest wall in the present investigation, as well as in routine surgical practice. There was, of course, fusion of the superficial fascia with the deeper fascia, but this was exclusively along the sternum.

The histological examinations confirmed the previous findings (Fig. 5). The inframammary region contained a



**Fig. 5** Details of the inframammary region, sagittal section: 1 skin, 2 superficial subcutaneous layer, 3 superficial fascia, 4 deep subcutaneous layer, with thickened retinacula fixed to the deep fascia, 5 deep fascia, 6 *fascia mammae* or breast envelope, otherwise named inframammary "ligament," breast envelope, improperly named anterior layer of the superficial fascia

**Fig. 6** Histological section of the inframammary region, showing: the origin of the *fascia mammae* (a) from the *fascia superficialis* (b), and fibers directed towards the deep fascia (c). (H&E,  $\times 25$ )

**Fig. 7** Histological section of the inframammary fold. The *fascia mammae* (a) appears irregular compared to the *fascia superficialis* (b) and includes an adipose lobule (arrow). Fibers directed towards the deep fascia (c) and the dermis (d) can be identified. (H&E,  $\times 25$ )

number of thick collagen fibers, stretched between superficial fascia and deep fascia. A true ligamentous structure connecting the fascia to the deep dermis was not observed, but a lamina detaching from the superficial fascia, was identified: this is the *fascia mammae*. The superficial fascia was made up of both collagen and elastic fibers. In contrast, the supportive tissue of the mammary gland appeared to be composed of collagen fibers, the *retinaculum fibrosa*, with no elastic fibers. The fascial microstructure at the inframammary fold was successfully demonstrated, as were the skin attachments, the insertion of the *fascia mammae* (inframammary ligament according to other authors), the superficial fascia, and the short retinaculum in the deep subcutaneous layer (Figs. 6, 7).

In conclusion, it could be shown that there was one superficial fascia over the muscular plane in the inframammary and retromammary regions. Although a true splitting of the superficial fascia was not present, there was a transverse fibrous lamella that came off the fascia almost at the 6th rib, and extended the full length of the inframammary crease. Such a structure had a different texture and a denser consistency from that of the superficial fascia. It appeared to be a thickening of the *retinaculum fibrosa* that made it look like a ligament. Histology confirmed the different stroma, i.e., elastic fibers, were only detected in the superficial fascia.

Furthermore, this structure was connected with the skin through several short connective retinaculum. The merging of the inframammary retinaculum increased with aging. It was found to be thicker in those people who, in addition to being older, had bigger breast mounds and had fibrocystic disease.

Between the superficial and deep fascia, there was a layer consisting of fibroareolar tissue and occasionally fibrofatty tissue. Strangely enough, at the submammary area, the tissue appeared to be more fibrous at the sixth rib–sixth intercostal space and, therefore, the superficial fascia appeared to be adherent to the deep plane (muscular fascia) and more resistant to traction. The adherence was histologically made up of multiple, short, fibrous connections which did not pass through the fibromuscular plane. This was also present in male cadavers, but only above the sixth rib in the central portion of the inframammary crease.

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## Discussion

A pseudoligamentous band envelopes the female breast gland externally. It is not constantly and homogeneously present or firmly adherent to the anterior surface of the gland on the submammary fold. It is not present at the posterior surface of the gland, which is, on the other hand, covered by the superficial fascia. This band represents the breast capsule and, as opposed to the superficial fascia, it has the features of thickness, whiteness, and strength, very similar to those of the Cooper's ligaments. It was erroneously believed to be the "superficial layer

of the *fascia superficialis*", but it is not as constant as the superficial fascia which is present in both female and male anatomy. The male breast has neither a "superficial layer of the fascia" nor an inframammary ligamentous structure, but, on the contrary, has a small fibrous band in the retroareolar space that should be emphasized, because it appears to be related to the atrophic breast gland and comparable to the band which we have studied. To sum up, it could be suggested that this band depends on the breast gland rather than the superficial fascia, as is true for Cooper's ligaments.

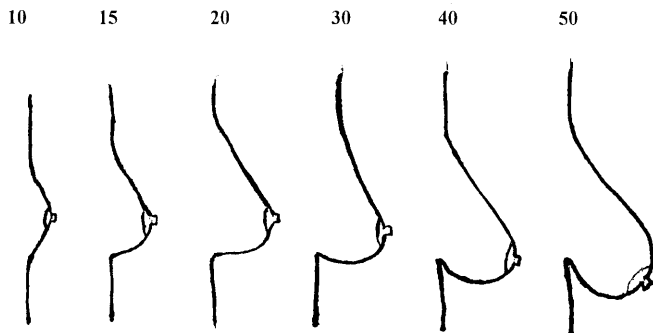
The position of this fold results from the insertion line of the aforementioned fibrous band into the superficial fascia. It is a fixed entity. Its destruction causes the loss of the inframammary crease. We did not confirm the muscular and periosteal origins of the inframammary ligament [1,12], but we can state that the superficial fascia connects with the deeper muscular fascia by means of thicker retinaculum at the deep inframammary subcutaneous layer, as suggested by Garnier et al. [7]. Indeed, although there was no submammary band in male cadavers, we noticed that some resistant adherence and thickening of the retinacula of the deep layer was present at 5 cm from the areola (fifth space–sixth rib).

Maillard and Garey [12] describe a crescent-shaped ligament between the skin and pectoralis major muscle, even if the fine curvilinear contour of the crease appears to be so far from the linear, oblique free border of the pectoralis major, and is not related to muscular movements. It would also be unusual to compare the presumed skin insertion of the pectoralis major with the zygomaticus major muscle insertion in the nasolabial fold, whereas one skin-mimic muscle insertion could have probably been compared to the skin-superficial fascia one, due to their common histogenesis. We agree with the accepted anatomical and surgical importance of that band as support for the inframammary fold, but do not believe that it derives from the pectoralis major. On the other hand, we suggest that the band is an oblique fibrous projection of the superficial fascia, i.e., the most inferior portion of Cooper's ligament, which really defines and supports the inframammary fold.

This "ligament" should leave the superficial fascia at a level where the whole fascia changes plane and deepens to run close to the muscular fascia. The adipose subcutaneous layer becomes thinner as the fascia is pushed back by the mammary gland. Such a concept, which was already reported by Laldrie and Jouglard [9], explains why liposuction at the appropriate level can improve the fold definition.

We believe that a thin retinaculum or fibers of the deep layer, i.e., between superficial fascia and pectoral fascia, can thicken in the inframammary region, as happens in the infraclavicular region between superficial fascia and clavicle periosteum.

These observations are in contrast with the demonstration by Bayati and Seckel of such a rare combined "ligament," either between bone and skin or between deep fascia and skin[1]. It is unusual that no anatomy

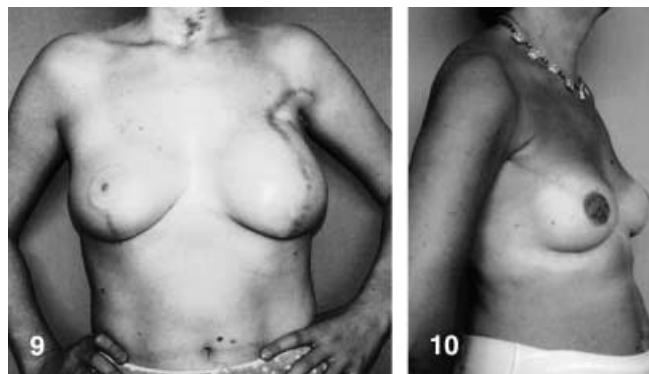


**Fig. 8** The frequent modifications undergone by a medium-sized breast at various stages of maturity, excluding the changes after pregnancy. Laxity of the superficial fascial system progressively displaces the breast balance against gravity. In time, the inframammary profile changes from obtuse to acute. If the fascial system were not fixed, the profile would maintain an obtuse angle

textbook has ever considered such a macroscopic ligament. We still consider the validity of a continuous strong plane, which runs over the lower insertions of the pectoralis major muscle, the inferior part of serratus major, the rectus abdominis sheath, and the external oblique aponeurosis. It seems unlikely that the deep fascia can be interrupted by that ligament. It was not found between superficial fascia, deep fascia, and chest wall. As suggested by the histological findings, we consider it to be an apparent connection between myofascial layer, superficial fascia, and dermis-fascia retinaculum, made of a fine fibrous microstructure, which usually thickens after pregnancy, breast hypertrophy, obesity, or aging. Bayati and Seckel, who did not report the age and breast status of their female cadavers, have probably made the same mistake as many other anatomists made nearly a century ago, in relation to the presumed suspensory ligament of Giralde's. Furthermore, we think the fall of the breast depends much more on breast shape and Cooper's ligament laxity than on the supposed different position of the inframammary ligament.

After all, according to the concept of the skin-superficial, fat-superficial fascial system functional unit, as described by Lockwood [10], the inframammary fold represents a zone of subcutaneous adherence, made of contiguous connective structures of both superficial and deep subcutaneous layers. A similar point of view has recently been supported by Boutros et al., who observed a condensation of the superficial fascial system, without evidence of any ligament [3].

This system can change its fibrous frame after aging and due to the force of gravity (Fig. 8). Lockwood states that breast ptosis is always related to the laxity of skin and the superficial fascial system. We agree that the entire dermal and fascial frame of the breast relaxes as a result of gravity and aging factors, with the exception of the inframammary zone. At this site, as we observed, the same forces cause thickening of the superficial fascial system, as a result of the traction on the fixed zone of adherence that is the fold. As is well known, new connective production is stimulated by tension forces. Although



**Fig. 9** Patient with left breast reconstruction, using bidimensional expander and contralateral mastopexy, before expander change with permanent implant. The appropriate location of the expander at the inframammary fold, when preserved, can obtain fine contouring of the lower pole

**Fig. 10** Patient with right post-mastectomy reconstruction, using anatomic prosthesis. At the second stage (expander change), the inframammary fold was restored, using the authors' special technique

the differences related to breast size, number of pregnancies, weight, and age are not statistically significant, they are however, indicative. This is confirmed by clinical observation of healthy women. Fibrous modification of the fascial frame is commonly detectable during breast examination in most women aged over 35. We have found a certain degree of palpable hardening at the submammary region, up to 1–2 cm above the crease in pluriparous women aged over 35, and with ptosis of medium-large breasts. In contrast, the submammary region maintains the same skin texture and subcutaneous density of the resting breast in all small breasts, either with or without ptosis, in women aged over 35.

## Conclusion

The superficial fascia is constantly present at the under-surface of the breast. In the abdomen, this fascia is separated from the deep fascia by a fatty layer (deep subcutaneous layer). In the thoracomammary region, this layer becomes more fibroareolar than fatty and, hence, thinner, and the superficial fascia can therefore be very close to the deep fascia. Such changes occur at the inframammary fold. Furthermore, as we also observed in male cadavers, the superficial fascia is more resistant to digital undermining in the deep layer, at the middle inframammary transverse line; that is due to thickened retinaculum between the superficial and deep fascia (zone of adherence). The aforementioned superficial changes can produce an anatomical fold by themselves. It is suggestive that the sternal depression, similarly due to the absence of fat in the deep layer and the presence of adherent retinacula, can become a true fold in obese people, both male and female.

Cooper's ligaments detach from the superficial fascia and reach the skin. The same behavior can be observed

in the capsule or *fascia mammae*. The similarity suggests that this fascia is better termed as “Cooper’s lamina”. This envelope is a fascial layer covering the anterior surface of the mammary gland. Such a fibrous band is made of thickened and merging retinaculum or fibers, more apparent at the submammary fold than at its site of detachment from the superficial fascia. This is the fibrous membrane that many authors have confused with the inframammary ligament: it is interconnected to the muscular fascia through the superficial fascia; it is joined to the presternal fascia at its medial edge, and the orientation follows the breast shape instead of the inferior pectoral border; and, in contrast to the superficial fascia’s constant behavior, its density and thickness are related to age, breast size, and, hence, weight. It is not a true ligament but, in fact, the capsule of a gland which has an ectodermal origin.

Formation and appearance of the inframammary fold are due to breast development and growth as well as to its biological changes, including breast aging, which influences the superficial connective frame. We prefer to think, as a result of this study, that the harmony and roundness of the female breast, and also the fine inframammary contouring, are related to the superficial subcutaneous structures, rather than resulting from being anchored to the deeper planes.

The cosmetic relevance must be considered by breast surgeons. The inframammary fold should be respected in at least three situations, i.e., immediate reconstruction, expander change with permanent implant, and reduction mammoplasty. The preservation of the fold unit is mandatory during mastectomy, because it is oncologically safe. The inframammary line is made of fibrofatty tissues which rarely contain breast parenchyma; resection can be justified only when the cancer site lies at the inferior quadrants. The inframammary fold should be preserved and not detached from the deep fascia. This maneuver allows for better placement of the implant at the inframammary crease and trimming of the lower insertions of the serratus anterior muscle without intrusion into the upper mastectomy site. These refinements can radically improve expansion of the lower pole of the new breast (Fig. 9), but sometimes they are not sufficient to establish a new inframammary fold.

At the second stage of breast reconstruction, the inframammary fold must be reconstructed when absent. New techniques allow us to create excellent breast symmetry and ptosis [13]. The fascial system is exposed at the same level as the contralateral fold, then resected, and

the inferior edge is fixed to the deep fascia at the appropriate level, using #1–0 absorbable running suture (Fig. 10). The superficial fascial suspensory system finds further application in reduction mammoplasty and mastopexy [11]. This can provide the primary support instead of the dermal suspension, with finer scarring, and it anchors the poorly fixed inframammary folds. A natural suspension of the superficial fascial system is able to provide more predictable and stable breast contours. The success of these procedures relies on comprehension of the superficial fascial system, and particularly, of the inframammary frame.

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