



# Management of the Inframammary Fold

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## 1 How to Reduce Complications and Malpositions with Accurate Preoperative Planning and Impeccable Surgical Technique

A scientific and rigorous approach towards breast augmentation is mandatory to reduce complication rates and to obtain high patient satisfaction level.

A rigorous approach starts with an accurate first consultation, analyzing the characteristics of the patient's skin and soft tissues, evaluating the size of the breast, the chest wall width and symmetry, assessing the breast shape and listening to patients' wishes, always remembering that if you fail to plan, you plan to fail.

After accurate planning and shared decision-making, a properly performed surgical procedure, with a complete knowledge of the devices you are using, and a correct and standardized follow-up are the other factors contributing to the best outcomes and the reduction of complications in breast augmentation.

Balancing the wishes of the patient with her tissue characteristics, identifying potential mismatches between the desired results and soft tissue characteristics are the first steps towards a successful breast augmentation. We must keep in mind that some choices in breast augmentation are not negotiable: the incision must always be preferred at the inframammary fold, chest width and cleavage will determine the choice of implant maximum width, the need of mastopexy could be not overcome with a larger volume implant. When the patient's wishes are not achievable, further consultation and patient education are mandatory. The more clearly the patient's

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expectations are defined and the better her wishes are communicated, the more likely our goals can be achieved.

The final breast shape will depend on the characteristics of the coverage tissue (breast skin, glandular parenchyma and fat) and implants. Only after an objective assessment of specific patients' parameters (chest wall width, base width of the existing breast, nipple-to-inframammary fold distance under maximal gentle stretch, medial, lateral, superior, and central pinch thickness of the existing tissue, cleavage, and sternal notch to nipple distance) (Fig. 1), the surgeon can choose the best width, height, and projection of the implant.

We developed a planning method to guide the decisional process in breast augmentation based on skin and soft tissue characteristics, breast and chest wall size, breast shape and patient's wishes.

When planning a breast augmentation, the surgeon will assess implant size, implant type, implant pocket position, and incision location and each decision will strongly impact on final outcomes.

We must pursue evidence-based surgery, and to achieve predictable outcomes with low re-operation rates, we have to build our results on objective data.

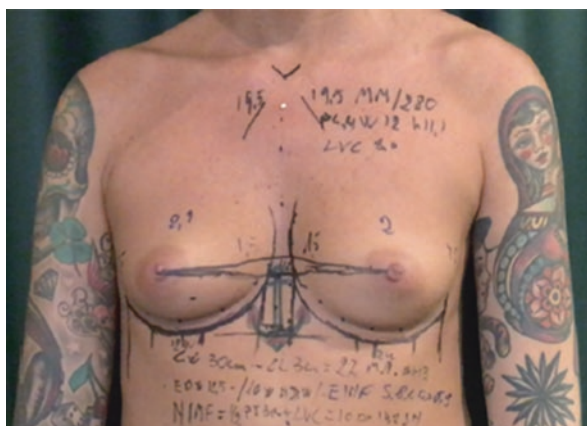
Our decisional process in breast augmentation is summarized in the breast augmentation flow diagram (Fig. 2).

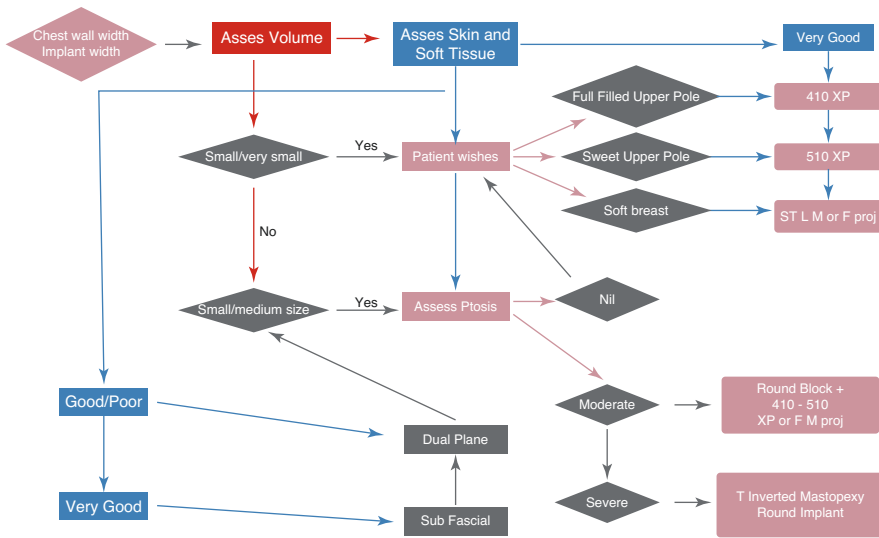
Potential surgical complications in breast implant surgery could be classified in preoperative and intraoperative complications and early and late postoperative complications (Fig. 3).

Preoperative complications essentially derive from poor planning (wrong choice of the surgical access, inaccurate measurements); intraoperative complications are associated to poor surgical technique. Early and late postoperative complications derive from all steps and even from poor management following the surgical procedure.

According to this classification, accurate preoperative planning could be viewed as the first step to reduce inframammary fold (IMF) violations.

**Fig. 1** Preoperative planning of breast augmentation. Key measurements: existing inframammary fold (e-IMF); new inframammary fold (N-IMF); breast parenchymal thickness; existing chest width; existing breast width; cleavage; lateral and medial pinch thickness; sternal notch to nipple distance (SN-N)





**Fig. 2** The breast augmentation flow diagram

Pre- and intra-operative complications	Early post-operative complications	Late post-operative complications
<ul style="list-style-type: none"> <li>• Poor planning                             <ul style="list-style-type: none"> <li>- Incision</li> <li>- Incorrect measurement</li> </ul> </li> <li>• Bleeding                             <ul style="list-style-type: none"> <li>- Surgical</li> <li>- Medical</li> </ul> </li> <li>• Over-dissection</li> <li>• Implant malposition</li> <li>• Pain</li> </ul>	<ul style="list-style-type: none"> <li>• Haematoma</li> <li>• Seroma</li> <li>• Infection</li> <li>• Implant malposition</li> <li>• Pain</li> <li>• Implant Rupture</li> </ul>	<ul style="list-style-type: none"> <li>• Infection</li> <li>• Seroma</li> <li>• Capsular contracture</li> <li>• Poor muscular animation (excessive, unusual, painful, distortion)</li> <li>• Implant visibility</li> <li>• Implant malposition (descent, double bubble, waterfall, etc)</li> <li>• Implant rippling and palpability</li> <li>• Synmastia</li> <li>• Poor scar healing, hypertrophy</li> <li>• Implant Rupture</li> </ul>

**Fig. 3** Authors' classification of complications

Inaccurate measurements or wrong position of the surgical access location could lead to the infringement of the IMF.

The first mistake that could be done when planning a breast augmentation is the wrong choice of implants: for instance, too big in relation to the patient's anatomical features, with the aim to fill a ptotic breast with redundant skin, instead of planning a mastopexy in association with the breast augmentation.

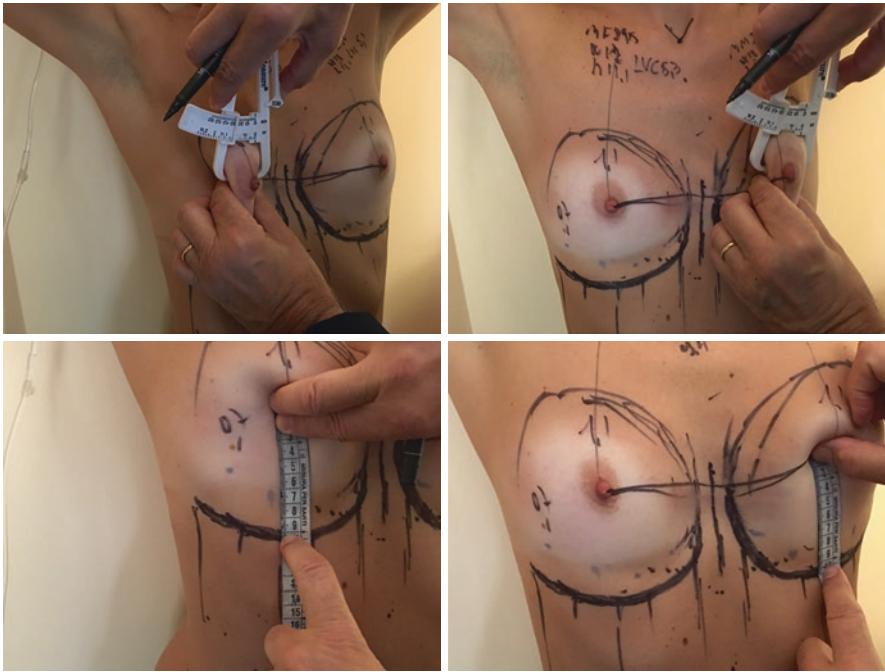
In order to avoid this potential mistake, we can suggest a useful tip when having the consultation with the patient. Ask the patient to lift up the hands as much as she can: if you cannot see the IMF, mastopexy is mandatory, not negotiable at all (Fig. 4). If we use an implant that is too big in order to fill the skin envelope (instead of correctly performing a mastopexy), we could easily experience early postoperative complications due to pain and tissue reactions that could lead to inflammation and capsular contracture, apart from clearly increasing the risk of breast ptosis and implant malposition, with breach of the IMF.

Another potential source of malpositions of the IMF is the wrong estimation of the level of the new IMF, where performing the surgical incision. We advice to strongly prefer IMF incisions to minimize contaminations and to perfectly recreate the new IMF position. During my planning this is not negotiable at all. I perfectly know that another choice could increase my complication rate. However the surgical access will be defined according to the patient's wishes and surgical skills trying to reduce tissue trauma and trade-offs. A peri-areolar access could be chosen if a peri-areolar scar is already present and the patient desire not to have other scars. Anyway in case of peri-areolar access, the gland must not be passed through, only small volume implants could be used and the patient must be informed about the higher risk of complications and IMF malpositions.

Several methods have been described in order to define the level of the new IMF, as the ICE principle [1], the method reported by Tebbetts with the TEPID system [2] or that described by Heden et al. [3]. We prefer to calculate the position of the new IMF (distance between the nipple and the new IMF) adding the half parenchymal pinch thickness to the implant's Lower Ventral Curvature (LVC). It is important to mark the new IMF position on full gentle stretch of the skin and

**Fig. 4** How to choose if needing a mastopexy or not in association with a breast augmentation. Ask the patient to lift up the hands over her head as much as she can: if you cannot see the inframammary fold, a mastopexy is mandatory, as in this case





**Fig. 5** Authors' method to define the level of the new IMF. We calculate the position of the new IMF (distance between the nipple and the new IMF) adding the half parenchymal thickness to the implant's lower ventral curvature (LVC). It is important to mark the new IMF position on full gentle stretch of the skin and patients' hands on the head

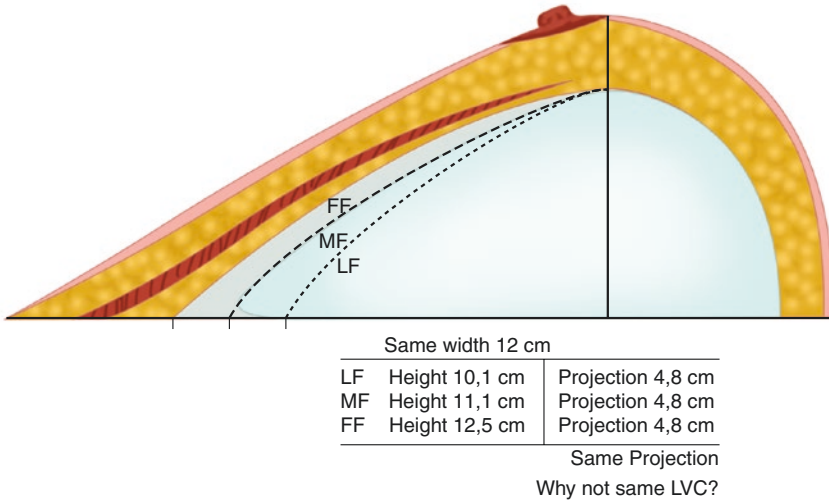
patients hands on the head (Fig. 5). We prefer to use the half pinch thickness plus the LVC better than the half implant height and LVC as described by Mallucci and Heden [1, 3], as the maximum implant projection for anatomical implants with different projection and same width is in the same position (Fig. 6), thus basing the estimations of the new IMF location on the height of the implant could lead to suboptimal results.

Complications and malpositions could also derive from intraoperative mistakes.

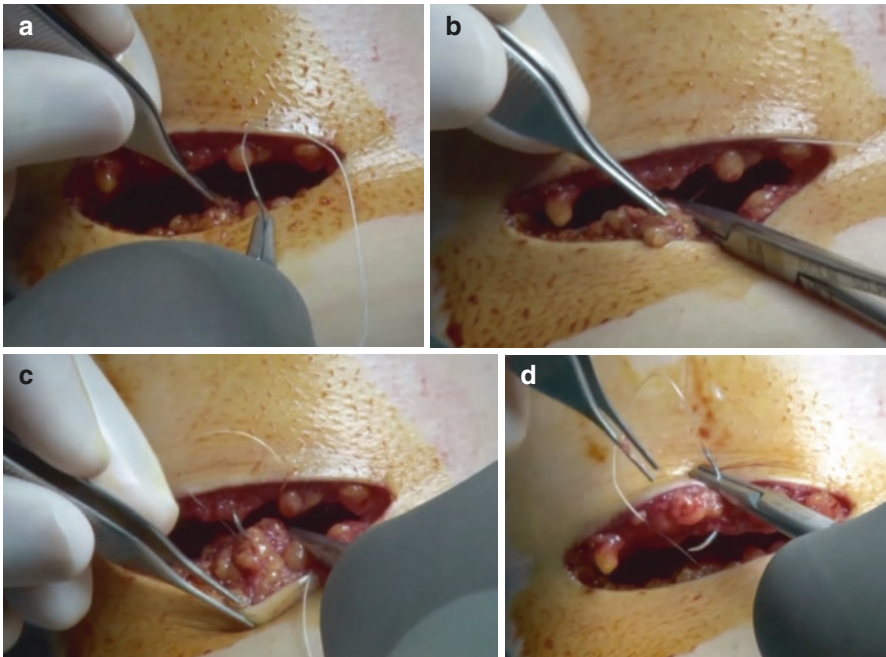
In order to reduce malpositions of the IMF, it is of primary relevance to properly close the IMF when using an inframammary approach. It is important to fix the IMF on the pectoralis major, pinching the muscle with the stitch that will close the fascia superficialis at the IMF (Fig. 7). Note that both in a subglandular and in a dual plane approach it will be possible to fix the stitches to the pectoralis major as also in a dual plane approach a strip of muscle will be left on the thoracic wall when the pectoralis major is cut at different levels according to Tebbetts' classification [4].

Following this rigorous approach towards breast augmentation, the rates of malpositions of the IMF will be significantly reduced, but if a malposition in the IMF would occur, the surgeon should know how to properly manage and solve it.

The chance of managing IMF position defects starts with an accurate knowledge of the characteristics and anatomy of this area.



**Fig. 6** Defining the position of the new IMF. Author's personal drawings. We prefer to use the half pinch thickness plus the LVC better than the half implant height and LVC, as the maximum implant projection for anatomical implants with different projection and same width is in the same position, thus basing the estimations of the new IMF location on the height of the implant could lead to suboptimal results



**Fig. 7** Closure of the inframammary access. (a) Pinch the pectorals major; (b) Pass the stitch through the pectorals major fibers first; (c) Pass the same stitch through the inferior edge of the fascia superficialis; (d) Pass the stitch on the superior edge of the fascia superficialis and close it in an inverting fashion; (e) Final result





Fig. 7 (continued)

## 2 The Inframammary Fold

The inframammary fold represents one of the primary elements in breast aesthetics. The harmony of the breast is related to four IMF characteristics: contour, level, angle, and symmetry.

Contour represents the lower base of the breast on the thoracic wall, appearing as an uninterrupted visual line composed of three parts: the midpoint (i.e., the lowest point of the fold) and two segments, medial and lateral, respectively. The course draws a convex arch downward as being C-shaped, U-shaped, or nearly horizontal.

Level is at the fifth and sixth ribs, with the lowest part usually reaching the sixth intercostal space. The average distance from the areola is 5.5–7 cm for small breasts and 7–9 or more cm for large breasts. This transverse level is usually proportioned to the chest width and patient's height. The proportion of the upper breast pole to the lower pole is a 45:55 ratio, the angulation of the nipple is upwards at a mean angle of 20° from the nipple meridian, the upper pole slope is linear or slightly concave and the lower pole is convex [5].

Angle derives from the intersection of the lower profile of the breast with the thoracic plane. It is related to breast ptosis. An open angle appears in small non-ptotic breasts. A 90-degree or something more angle accentuates the beauty of a youthful breast. In contrast, a sharp angle that appears in large breasts, also having a fascial laxity, is typical of elderly breasts and can be less pleasant. The IMF angle is one of the most important features in the aesthetic appearance of the breast.

Symmetry depends on the previous characteristics as comparing the left with the right side. Breast harmony largely depends on symmetry and embraces two kinds of symmetry: metric and visual. Metric symmetry must be of concern during the preoperative approach but surgeons should always be aware of the patient's wishes and body self-perception that are related to visual symmetry rather than to metric symmetry.

Anatomical landmarks are fundamental in creating IMF contour and level and the angle sharpness, due to breast ptosis and weight, is deeply influenced by the modifications of the fascial system by aging. A clarification of the IMF anatomic structure is needed to understand the unique nature of IMF as a separate anatomic

unit and for recreating it when the patient experiences the bad results of a previous breast augmentation, with a malposition of the IMF (asymmetry, bottoming out, double bubble deformity, etc.).

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### 3 Anatomy of the Inframammary Fold

There are three anatomic aspects of the superficial fascia that produce the IMF with no reference to large-scale structures as ligaments.

First, IMF appears to be a zone of subcutaneous adherence (thick retinacula between the superficial and deep fascia), where contiguous connective structures of both superficial and deep subcutaneous layers persist as different anatomic micro units of the same fascial frame, according to the concept of the skin-superficial/fat-superficial fascial system functional unit described by Lockwood [6] and applied in the study published by Nava et al. [7].

Second, the superficial fascia of the inframammary region, direct prolongation of the abdominal one, extends to the retromammary space above the deep (muscular) fascia, deepening the level where IMF starts. The deeper plane is generated by the changing thickness of the deep subcutaneous layer that, in the abdomen, is separated from the deep fascia by a fatty layer, whereas, in the submammary region, this layer becomes more fibrous than fatty and hence thinner. The sternal depression, similarly due to absence of fat in the deep layer and presence of adherent retinacula, can become a true fold in obese people.

Third, the superficial fascial layer is a constant fibrous membrane thicker in the inframammary zone and in the whole abdomen (also called Scarpa's), than in the retromammary zone of the female breast. Its thickening increases in time due to the action of breast weight.

Another important issue to clarify is how to merge the inframammary frame of the superficial fascial system with the entire connective frame of the mammary gland.

The Cooper's ligaments detach from the superficial fascia and go up to the skin. The same behavior can be observed regarding the capsular envelope, which is a fascial annex covering the anterior surface of the mammary gland. Such a fibrous band is made of merging thick retinacula, more apparent at IMF, at the site of detachment from the superficial fascia. This is the fibrous membrane that many authors confuse with the inframammary ligament: it can be interconnected to the muscular fascia through the superficial fascia; it can be joined to the presternal fascia at the medial extremity; the orientation follows the breast shape instead of the pectoral inferior border; the density and thickness are related to age, breast size, and weight. It is not a true ligament but rather the capsule of a gland of ectodermal origin.

It is important to underline that the IMF anatomy has been debated for many decades and it is strictly linked to the theories about the two-layered [8–11] or unilayered [12–14] superficial fascia. The fold had always been neglected by anatomists, perhaps because they did not believe it to have anatomic identity, even though it would appear to have a constant position.



Based on the authors' anatomic dissections on fresh cadavers, histologic and surgical investigations conducted on live dissections [7, 15], it can be asserted that there is not a macrostructure featuring the IMF, but that its anatomic fundamentals lay on a special microstructure as totally generated by the superficial fascial system.

A clear and correct understanding of the anatomy will facilitate surgeons in safeguarding the IMF and rebuilding the interrupted frame after breast augmentation and IMF malposition.

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#### **4 How to Recreate the Inframammary Fold by Means of the Superficial Fascial System Following Malpositioning Subsequent to Breast Augmentation**

Dealing with malpositioning of the inframammary fold following breast augmentation is a challenging task. We will try to offer some useful tips to correct different types of inframammary fold malpositioning.

A correct planning allows surgeons to decide how to reshape the inferior pole of the breast, the level of ptosis, and the IMF positioning to correct a bottoming out or a double bubble deformity.

The surgeon could face two possible IMF malpositions: the IMF could be in higher or lower position compared to that of an ideal breast, due to poor planning, wrong choice of the implant, or inaccurate surgical technique.

Preoperatively the IMF level is marked as being equal to the contralateral one. Preoperative planning is of primary importance in order to reach a good cosmetic result as for each breast surgical procedure.

First, it is important to identify the inframammary fold level. The second step will be the identification of the existing skin incision, discussing with the patient the possibility of a new one. We advice to use an IMF approach that could be on the previous surgical access or a new incision, being the previous completely dislocated or peri-areolar only if a peri-areolar scar is already present, the patient refuses other scars even though informed of higher risk of complications and always without passing through the gland, to reduce contamination.

If the patient refuses other scars apart from the previous peri-areolar one, even though well informed about the possibility of higher complication rates, you can follow the subsequent step to improve the IMF location and definition.

If the implant is dislocated upward, the dissection must reach the IMF level; in contrast, when the implant is displaced downward, the lower skin envelope must be lifted up and then fixed at the new level. When feasible, we prefer to perform a total capsulectomy or, if possible, to preserve a portion of the capsule to better define the IMF. If this is not possible, both scoring and resection of the capsular and scar tissue of the lower pole of the breast are the first maneuvers to expand the implant pocket and to expose the deep subcutaneous layer.

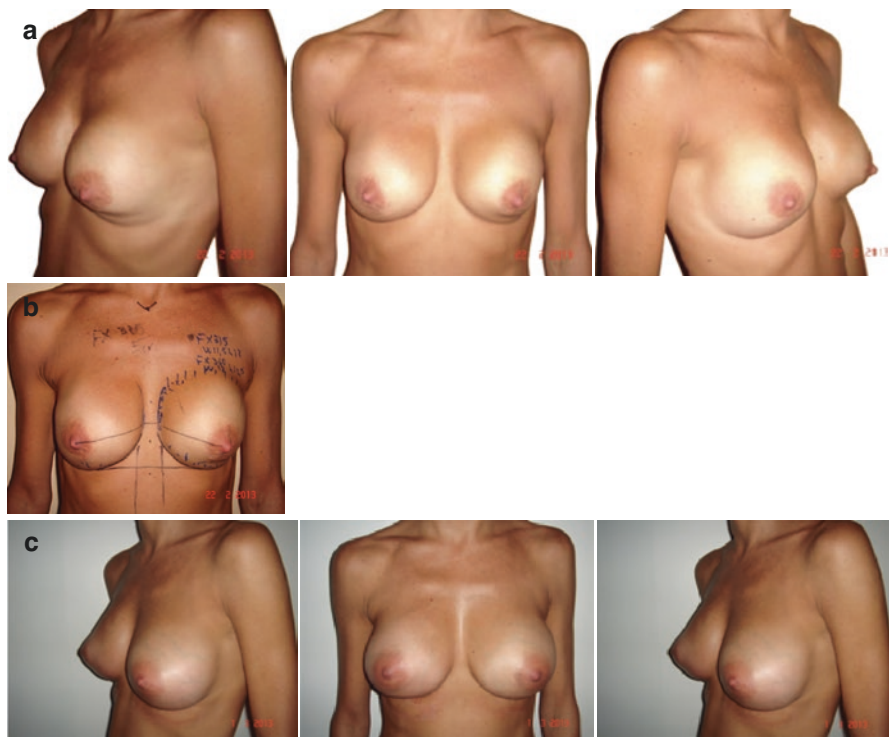
The IMF incision will release the superficial fascia along the new IMF contour. Then the lower of the two newly scored edges is grasped, this action dragging the superficial fascial system upward with a smooth and easy effect on the skin. This is

the right position where the sutures to recreate the IMF should be positioned. The thoracic anchorage is safely given by the fibrous capsular tissue created around the previous implant. The fold is recreated pinching the posterior aspect of the capsule on the pectorals major muscle (if following a subglandular or dual plane approach) or on the thoracic wall (if following a submuscular approach), then passing the same stitch through the inferior edge of the fascia superficialis, so on the superior edge of the fascia superficialis and closing it in an inverting fashion.

The suture will fix the fascia superficialis to the thoracic wall (if following a previous sub pectoral approach) or to the pectorals major (if following a sub glandular or dual plane approach). It is important to externally check the right placement step by step, always using the seated position for the patient, the supine position modifying the IMF level.

We present some examples of different malpositions of the IMF, analyzing the causes leading to the poor outcome and the best technique to properly and effectively correct them (Figs. 8, 9, 10, and 12).

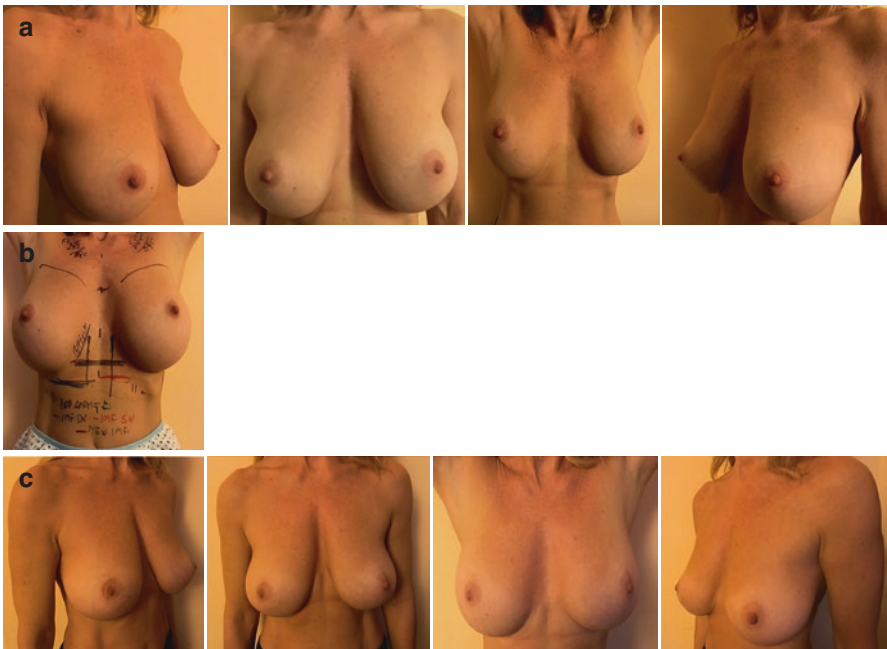
In Fig. 8 we present a case of IMF asymmetry due to poor planning, wrong choice of the implant and surgical technique with a totally submuscular implant positioning (A). The chosen peri-areolar access contributed to the poor result and to



**Fig. 8** (a) Inframammary fold asymmetry and capsular contracture. (b) Preoperative markings; (c) Correction with a dual plane approach with anatomical implants



**Fig. 9** (a) Inframammary fold asymmetry and synmastia. (b) Two-stage corrective approach. Removal of the implants and re-operation at 6 months (preoperative markings); (c) Secondary breast augmentation; postoperative results



**Fig. 10** (a) Inframammary fold asymmetry. (b) Preoperative markings. (c) Postoperative results

the capsular contracture development. According to patient's wishes, we opted to correct the poor outcome using an anatomical implant, a new IMF surgical access (see preoperative drawings in box B). After incising the skin and the fascia superficialis, we reached the pectoralis major muscle and created a dual plane. We performed a total dome capsulectomy and partial capsulectomy on the chest wall, pro-active hemostasis and selective releasing of the medial pectoralis major fibers with the aim of reducing animation deformities. Then we defined and sutured the IMF as shown in Fig. 7.

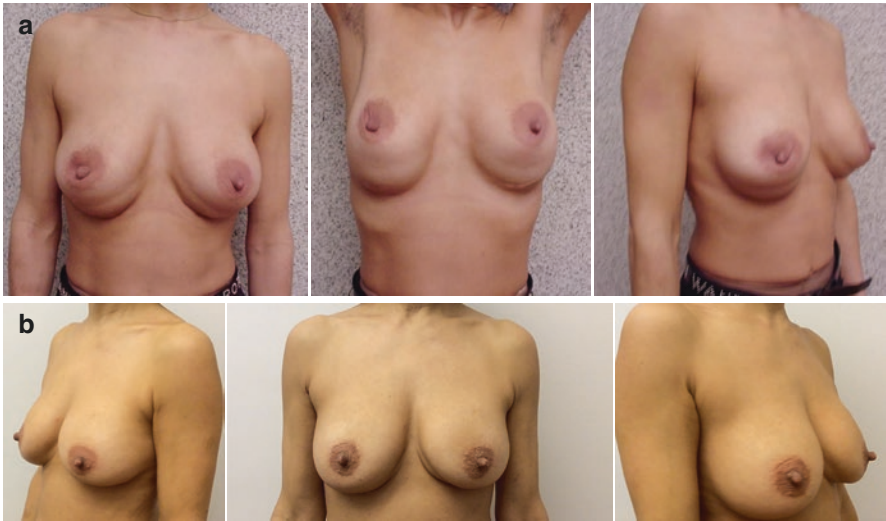
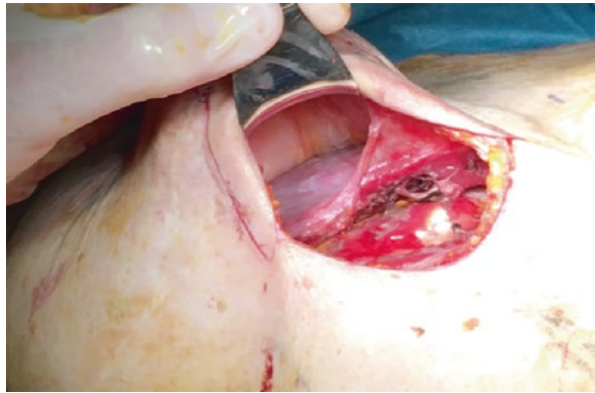
In Fig. 9 we show a case of IMF asymmetry and synmastia (A). In this case the poor aesthetic result and asymmetry between the IMFs are related to a poor preoperative planning (too big pre-pectoral round implants) and a poor surgical technique with the creation of too large implant pockets and implant malposition. We considered a two-stage corrective approach, after thorough patient information, in order to reach an optimal outcome. We removed the implants, performed a total capsulectomy and re-operation at 6 months (see preoperative markings in box B); in box C we show the postoperative results of the secondary breast augmentation with peri-areolar approach, anatomical implant positioning, total detachment of the gland from the fascia superficialis to reach the muscle without passing through the gland and dual plane technique. The IMF has been defined as described above, in the case we have to use a pre-existing peri-areolar skin incision. When dealing with a synmastia, we advice to follow a two-stage approach, removing the implants and delaying re-intervention after at least 6 months, when planning the procedure as a primary augmentation. Treating those patients requires a significant patient engagement and a thorough patient information.

In Fig. 10 we show a case of IMF asymmetry due to poor planning, wrong choice of the implants (too big round implants), and poor surgical technique (subglandular implant positioning without a proper suture of the new IMF and sliding of the implant under the fascia superficialis). You can see both IMFs below the level of the surgical scars (A). We show preoperative markings in box B. We created a new implant pocket in a dual plane position (type 2 according to Tebbetts' classification) using pro-active hemostasis and selective releasing of medial pectoralis major muscle fibers, as usual. The new pocket has been created leaving the implant inside, in order to ease the surgical maneuvers and sparing a portion of the capsule to avoid pectoralis major retractions (Fig. 11). Anatomical implants have been used according to patient's wishes. We recreated the IMF using the same surgical access but correctly closing the different layers as described in Fig. 7.

In Fig. 12 we show a case of double bubble due to a serious planning mistake. A mastopexy would have been advisable in association with the first augmentation, as described above (Fig. 4). According to patient's wishes, we decided to avoid new scars and consequently a mastopexy has not been performed. The correction has been performed using the superficial fascia system and the same implants (anatomical implants). The result is still not perfect but the patient was satisfied and no other surgery has been performed (postoperative result at 25 years in box B).

If the lower pole is too thin, we advice to use ADMs or synthetic meshes, according to personal experience. Using an ADM means to use one more device, thus

**Fig. 11** Tips to create a new implant pocket. How to create a new dual plane: leave the capsule inside when possible, to avoid pectoralis major muscle retractions

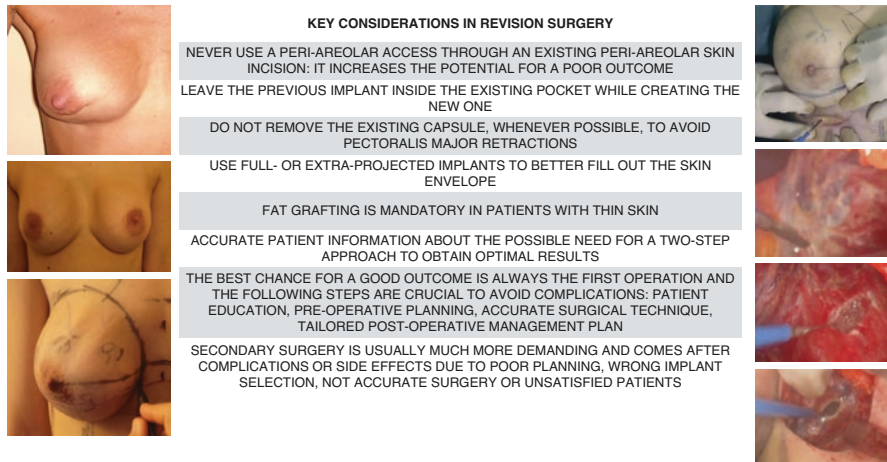


**Fig. 12** (a) Double bubble. (b) Correction using the superficial fascia system and the same anatomical implant. Postoperative result at 25 years

increasing the risk of complications or side effects. We suggest to use ADMs or synthetic meshes only if really needed. The ADMs must be sutured at the level of the new IMF with the patient seated, as described above. I suggest to preoperatively mark three lines where to fix the first three stitches and then to go ahead with a running suture from the medial inferior edge of the IMF to the inferior lateral one. I suggest to use reabsorbable sutures. When a capsule is present and there are no reasons to perform a capsulectomy, it is possible to spare an inferior pedicled capsular flap and to recreate the IMF using it as an ADM.

We could summarize some key consideration in revision breast surgery to correct post-breast augmentation deformities (Fig. 13):





**Fig. 13** Key considerations in revision surgery

- Never use a peri-areolar approach through an existing peri-areolar incision: it increases the potential for a poor outcome.
- Leave the previous implant inside the existing pocket while creating the new pocket.
- Do not remove the existing capsule, whenever possible, with the aim of avoiding pectoralis major retractions.
- Use Full or Extra-projected implants to better fill out the skin envelope.
- Fat grafting is mandatory in patients with thin skin.
- Accurate patient information about the possible need for a two-step approach to obtain optimal results.
- The best chance for a good outcome is always the first operation and the following steps are crucial to avoid complications: *patient education, preoperative planning, accurate surgical technique, tailored postoperative management plan.*
- Secondary surgery is usually much more demanding and comes after complications or side effects due to poor planning, wrong implant selection, not accurate surgery, or unsatisfied patients.

## References

1. Mallucci P, Branford OA. Augmentation: the ICE principle. Design for natural breast. *Plast Reconstr Surg.* 2016;137(6):1728–37.
2. Tebbetts JB. A system for breast implant selection based on patient tissue characteristics and implant-soft tissue dynamics. *Plast Reconstr Surg.* 2002;109(4):1396–409.
3. Hedén P, Jernbeck J, Hober M. Breast augmentation with anatomical cohesive gel implants: the world's largest current experience. *Clin Plast Surg.* 2001;28(3):531–52.



4. Tebbetts JB. Dual plane breast augmentation: optimizing implant-soft-tissue relationships in a wide range of breast types. *Plast Reconstr Surg.* 2006;118(7 Suppl):81S–98S; discussion 99S–102S.
5. Mallucci P, Branford OA. Concepts in aesthetic breast dimensions: analysis of the ideal breast. *J Plast Reconstr Aesthet Surg.* 2012;65(1):8–16.
6. Lockwood TE. Superficial fascial system (SFS) of the trunk and extremities: a new concept. *Plast Reconstr Surg.* 1991;87:1009–18.
7. Nava M, Quattrone P, Riggio E. Focus on the breast fascial system: a new approach for inframammary fold reconstruction. *Plast Reconstr Surg.* 1998;102:1034–45.
8. Bostwick J III. Anatomy and physiology. In: *Plastic and reconstructive breast surgery.* St. Louis: Quality Medical; 1990. p. 67.
9. Rieffel H. L'appareil génital de la femme. In: *Traité d'Anatomie Humaine Publié sur la Direction de P.Poirier et A.Charpy.* T. 5, Fasc.I. Paris: Masson; 1901.
10. Chiarugi G. Istituzioni di Anatomia dell'Uomo. Milan; 1908.
11. Sterzi G. La fascia superficiale. In: *Il tessuto sottocutaneo (tela subcutanea).* Ricerche anatomiche. Firenze: L.Niccolai; 1910. pp. 62–8.
12. Bayati S, Seckel BR. Inframammary crease ligament. *Plast Reconstr Surg.* 1995;95:501–8.
13. Van Straalen WH, Hage JJ, Bloemena E. The inframammary ligament: myth or reality? *Ann Plast Surg.* 1995;35:237–41.
14. Garnier D, Antonin R, Foulon P, et al. Le sillon sous-mammaire: mythe ou réalité? *Ann Chir Plast Esther.* 1991;36:313–9.
15. Riggio E, Quattrone P, Nava M. Anatomical study of the breast superficial fascial system: the inframammary fold unit. *Eur J Plast Surg.* 2000;23:310–5.