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ORIGINAL ARTICLE BREAST SURGERY

Staying Out of Double-Bubble and Bottoming-Out Deformities in Dual-Plane Breast Augmentation: Anatomical and Clinical Study

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Abstract

Background Double-bubble and bottoming-out deformities represent the second most common reason for revision surgery in breast augmentation. Etiopathogenesis of these complications is still unclear. The aim of this paper is to report our findings in breast cadaver dissections focusing on the inframammary fold (IMF) applied anatomy and to critically review our ten-year experience in breast augmentation.

Methods A cadaveric study has been performed on four consecutive embalmed cadavers. A retrospective review of 207 consecutive women who underwent breast augmentation, using the submuscular dual-plane technique with a periareolar approach, between January 2003 and January 2013, was performed.

Results According to our dissections, the IMF is a complex osseo-fascio-cutaneous structure in which the superficial pectoralis fascia represents a key structure in breast augmentation surgery. Hence, a critical analysis of the IMF relationship with surrounding breast structures helps to understand the etiology of double-bubble and bottoming-out deformities and gives the anatomical basis to prevent them. In our early clinical experience, we experienced 3% of double-bubble and 6% of bottoming-out deformities. Those complications were avoided later by dissection in the inferior pole according to the anatomical findings.

Conclusions Bottoming-out and double-bubble deformities can be avoided if an anatomical approach is used during pocket dissection at the level of the IMF, paying attention to avoid disrupting the superficial and deep attachments of the superficial pectoralis fascia at the IMF. A comprehensive understanding of IMF anatomy and the key surgical maneuvers to avoid these complications must be taken into account for each route of dissection.

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Keywords Breast augmentation · Augmentation mammaplasty · Breast implant · Implant malposition · Periareolar breast augmentation · Inframammary fold breast augmentation

Introduction

Double-bubble and bottoming-out deformities are usually grouped within the category of implant malposition complications after breast augmentation (BA). After capsule contracture, they represent the second most common reason for revision surgery.

Double-bubble deformity is clinically characterized by double convexity of the lower pole due to the visible indentation of the old inframammary fold (IMF) that sits in the middle of the two convexities. This is more common in tuberous breasts, when a large implant is used, or both, and the surgeon needs to lower the existing IMF.

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The bottoming-out deformity is an inferior implant displacement with a high riding nipple, resulting in the lower pole being longer than it should be.

Besides being two distinct inferior implant malpositions, they are both related to inferior pole dissection technique and, particularly, to IMF lowering.

The aim of this paper is to report our findings in breast cadaver dissections focusing on the IMF applied anatomy and to review the ten-year experience of the senior author (MS) in breast augmentation via the periareolar approach, integrating the anatomical findings with the surgical techniques, focusing on prevention of double-bubble and bottoming-out deformities.

Methods

Cadaver Dissections

Breast dissections were performed on four consecutive embalmed female (mean age 57, ranging from 51 to 72) cadavers by the junior author (GV) with a focus on the IMF anatomy and breast ligamentous structures. On the body records, there was no history of breast surgery and no scars appeared on the breasts. Breasts were dissected according to the following protocol. IMF was marked by placing 18G needles perpendicularly and left in place. Skin was incised along the clavicle, mid-sternum to 6 cm below the lowest point of the IMF, transverse on the abdomen staying 6 cm below the lowest point of the IMF to the posterior axillary line, along the posterior axillary line up to the armpit and finally along the deltopectoral groove ending at the lateral clavicular incision. The entire breast and abdominal skin were then raised over the superficial pectoralis fascia (SPF), axillary and abdominal muscular fasciae. The dissections were stopped 1 cm from the IMF, both superiorly and inferiorly. Then, the SPF was dissected off the pectoralis major (PM) muscle to its inferior margin, from the superomedial to the inferolateral direction. The upper SPF extension and the SPF sternal adhesions were interrupted at the clavicle and at the sternum, respectively, to allow the dissection.

Patients and Methods

Between January 2003 and January 2013, 207 consecutive women underwent submuscular dual-plane BA with the periareolar approach, of which 124 cases were performed before the cadaveric study and the latest 83 cases were performed after it (Fig. 1).

This study followed the guiding principles of the Declaration of Helsinki.

Dual-Plane BA with Periareolar Approach: Surgical Technique

A periareolar skin incision is placed along the inferior hemi-periareolar margin, and a full-thickness incision of the breast tissue is carried down perpendicularly to the PM. At this level, the PM muscle is incised full thickness for a length of 4 cm along the fiber direction and the submuscular space accessed. A fiber optic retractor is inserted and a submuscular pocket developed. Under direct vision, the subpectoral plane is dissected and insertion of the PM muscle to chest wall is divided to the lower margin of the PM, where the inferior most PM fibers and overlying SPF are interrupted and the plane of pocket dissection continues superficial to the SPF (i.e., in the subglandular plane) up to the new IMF. Medially, the PM fibers are preserved or only partially released up to the desired level to preserve the external fibers and SPF continuity. Laterally, the dissection ended up to the desired level keeping the subpectoral plane of dissection (i.e., below lateral pectoralis fascia/axillary fascia and above serratus anterior muscle and fascia). Then, the pocket is bluntly completed superiorly.

The contralateral breast pocket is then dissected symmetrically. The selected breast implants are placed, and the intraoperative result double-checked by semisitting the patient. The glandular opening and subcutis are approximated with absorbable stitches and skin closure achieved with intracuticular suture.

Results

Cadaver Dissection

All our cadaveric dissections resulted in constant findings relatively to ligamentous structures.

The SPF is located on the outer side of the PM, just below the deep layer of the superficial fascia (i.e., breast capsule). Loose fibrous connections exist between the SPF and the deep layer of the superficial fascia. The cleavage between the SPF and PM is anatomically not well delineated because of the strict relationship between the SPF and PM epimysium.

For this reason, few PM fibers have to be included in the fascia dissection.

We found that the SPF shows a peculiar behavior at the level of the IMF. At this point, the SPF has a fan-shaped structure with two main divergent directions: upper fibers that go superficially ending in the subcutaneous ligamentous structure (i.e., superior wing) and lower fibers going inferiorly, fusing with the fifth rib periosteum and vanishing over the rectus abdomens (RA) sheath (i.e., inferior wing) (Figs. 2, 3). The SPF is anatomically superficial to

Fig. 1 Three types of breast features at high risk of developing double-bubble and bottoming-out deformities. **a** A 24-year-old patient; **b** 30-year-old patient; **c** 23-year-old patient

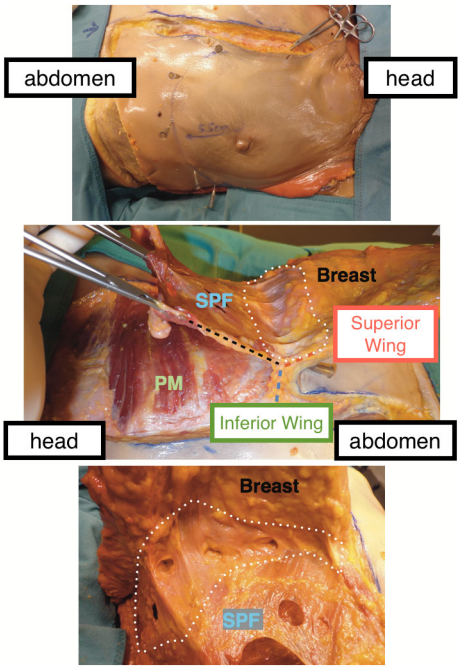

Fig. 2 Cadaver dissection of 51-year-old female. (*Above*) Boundaries of the left breast dissection, the inframammary fold has been marked with needles. (*Middle*) The breast has been dissected off along the breast posterior capsule. The upper abdominal adipocutaneous flap has been raised over the abdominal fascia up to the inframammary fold (undissected). The superficial pectoralis fascia (SPF, *black dotted line*) has been dissected from the pectoralis major (PM) muscle to the inferior muscle margin and then up to the inframammary fold. Notice the fan-shaped behavior of the SPF at the IMF with superior-oriented fibers to the breast (*red dotted line*, superior wing) defining the superficial fibers of the triangular fascial condensation (*white pinpoint line*). The *blue dotted line* identifies the inferior-oriented fibers of the SPF going toward the fifth rib (inferior wing). (*Below*) Superior view of the breast dissection demonstrating the superior fibers of the triangular fascial condensation (*white pinpoint line*)

the RA fascia and vanishes on it without having any continuity. Lateral to the PM, the SPF fuses with the deep pectoralis fascia defining the axillary fascia (AF) that extends laterally to the lateral margin of the latissimus dorsi muscle and enwraps it. This superficial fascia (i.e.,

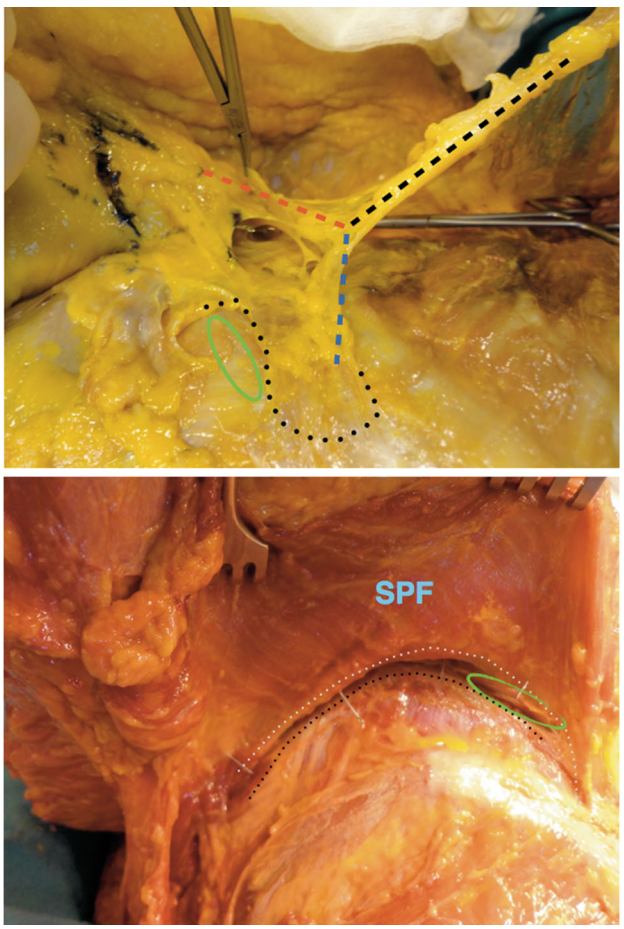

Fig. 3 Cadaveric dissection of a 59-year-old female. (*Above*) Close-up view of the superficial pectoralis fascia (SPF, *black dotted line*) at the inframammary fold. Notice the fan-shaped behavior at the level of the inframammary fold with superior-oriented fibers (i.e., superior fibers of triangular fascial condensation, *red dotted line*) going toward the breast, and inferior-oriented fibers (*blue dotted line*) going toward the fifth rib periosteum but vanishing over the rectus abdominis sheath (*green ellipse*). *Black points* represent the end of the SPF over the rectus abdominis sheath. (*Below*) SPF has been dissected off with periosteum along the fifth rib (*black points*). Notice that the IMF structure is preserved (*white pinpoint line*). The needles have been placed percutaneously through the IMF. The *green ellipse* highlights the rectus abdominis fascia that is anatomically deeper than SPF

AF) along with the intermediate clavi-coraco-pectoral fascia (enwrapping the pectoralis minor and subclavian muscle) and the deep serratus anterior fascia is the structures that define the lateral fascial confluence.

Clinical Experience

The mean age of the patients was 26 years (range 19–36 years old). Forty-five patients were smokers; 157 patients (76%) were normal weight (BMI range 18.5–24.9 kg/m^2); and 50 (24%) were overweight (BMI range 25–29.9 kg/m^2).

Sixteen (8%) patients had high IMF (areola to IMF distance lower than 4.5 cm), 12 patients (6%) showed a constricted lower pole/tuberous breast, and 26 patients (13%) had a poorly defined IMF (Fig. 1).

In a total of 207 patients, 27% (54 patients) had anatomical features which could have increased the risk of bottoming-out/double-bubble deformities.

The average follow-up time was 28.5 months (range 18–42 months). The average implant volume used was 280 cc (range 240–380 cc). In 21% of the cases, silicone gel-filled anatomical implants were used and in 79% of the cases silicone gel-filled round implants were used.

We experienced six cases (3%) of double-bubble deformities. Four of those patients had constricted lower poles, and two had short IMF.

We registered 12 cases (6%) of bottoming-out deformities. Seven of those patients had ill-defined IMF, whereas in the remaining five cases a large implant (380 cc) was placed.

All these cases were experienced before the detailed anatomical study was performed (i.e., in the first 124 cases that were performed before the cadaveric study). A dissection respecting the IMF defining structures in the lower pole allowed us to avoid those complications even in patients with high-risk features (no double-bubble and bottoming-out deformities in the latest 83 cases that were performed after the cadaveric study).

Discussion

Double bubble and bottoming out are typical iatrogenic deformities of breast augmentation surgery.

Both deformities can be identified as inferior implant malposition deformities; however, they are two very distinct problems.

Double-bubble deformity is an implant breast surgery-related deformity, which is experienced in submuscular/dual-plane implant pocket dissection. This deformity is observed when there is the need of lowering the IMF. By lowering the pocket below the IMF using an incorrect dissection route (i.e., deeper route, releasing the entire IMF as shown later), the native IMF is not correctly lowered and it will appear as a groove or indentation. The final appearance is an augmented breast with double convexity, one above the indentation created by the native IMF and

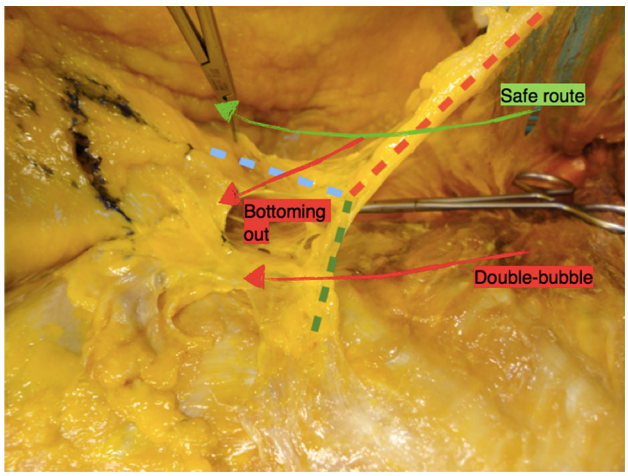

Fig. 4 Cadaveric dissection of a 51-year-old female. Routes for dual-plane pocket dissection via the periareolar approach. The *green arrow* identifies the safe route for inferior pole lowering without disrupting the IMF, meaning that the submuscular pocket in the lower pole is better opened by severing the inferior most PM fibers. When the submuscular pocket is opened a bit inferiorly or the submuscular pocket is continued straight over the rectus abdominis fascia, double-bubble may be experienced. If the dissection is carried out in the subglandular plane over the IMF completely severing the superior fibers of IMF, bottoming out may develop

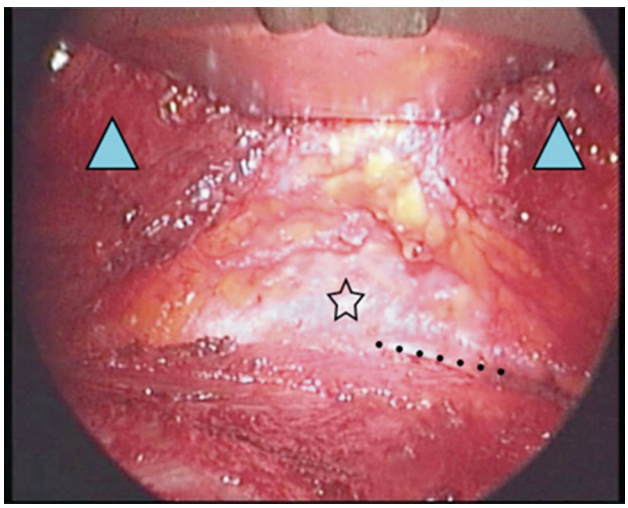

Fig. 5 Endoscopic view of dual-plane pocket in breast augmentation. The *blue triangles* identify the PM muscle, the star identifies the SPF below PM, and the *dotted line* identifies the rectus abdominis fascia. In this picture, the SPF has just been interrupted as soon as the inferior PM margin has been approached and the rest of the dissection will be carried out in the subglandular plane above the upper portion of the SPF (IMF superior wing)

another bulge located below the native IMF. For this reason, it is called double-bubble deformity.

Bottoming-out deformity is an implant breast surgery-related deformity, which can be experienced in both submuscular and subglandular pocket dissection. As for double bubble, it is observed when there is the need of lowering the IMF. By lowering the pocket below the IMF using an incorrect dissection route (i.e., intermediate route, releasing the superior wing of the IMF as shown later), the native IMF is disrupted and the implant does not have any structural support in the lower pole, if not reconstructed with sutures. The final appearance is an augmented breast with an inferior pole that is too low and an unaesthetic lengthening of the nipple to fold distance. It differs from the double bubble, because there is no groove or indentation along the inferior pole convexity.

Even if predisposing factors have been ruled out such as breasts with constricted lower poles and tuberous breasts, an ill-defined IMF and the use of large implants, these deformities can be encountered also in patients without these risk factors. The reason behind this is the lack of knowledge about IMF anatomy and, especially, about its relationship with other breast defining structures.

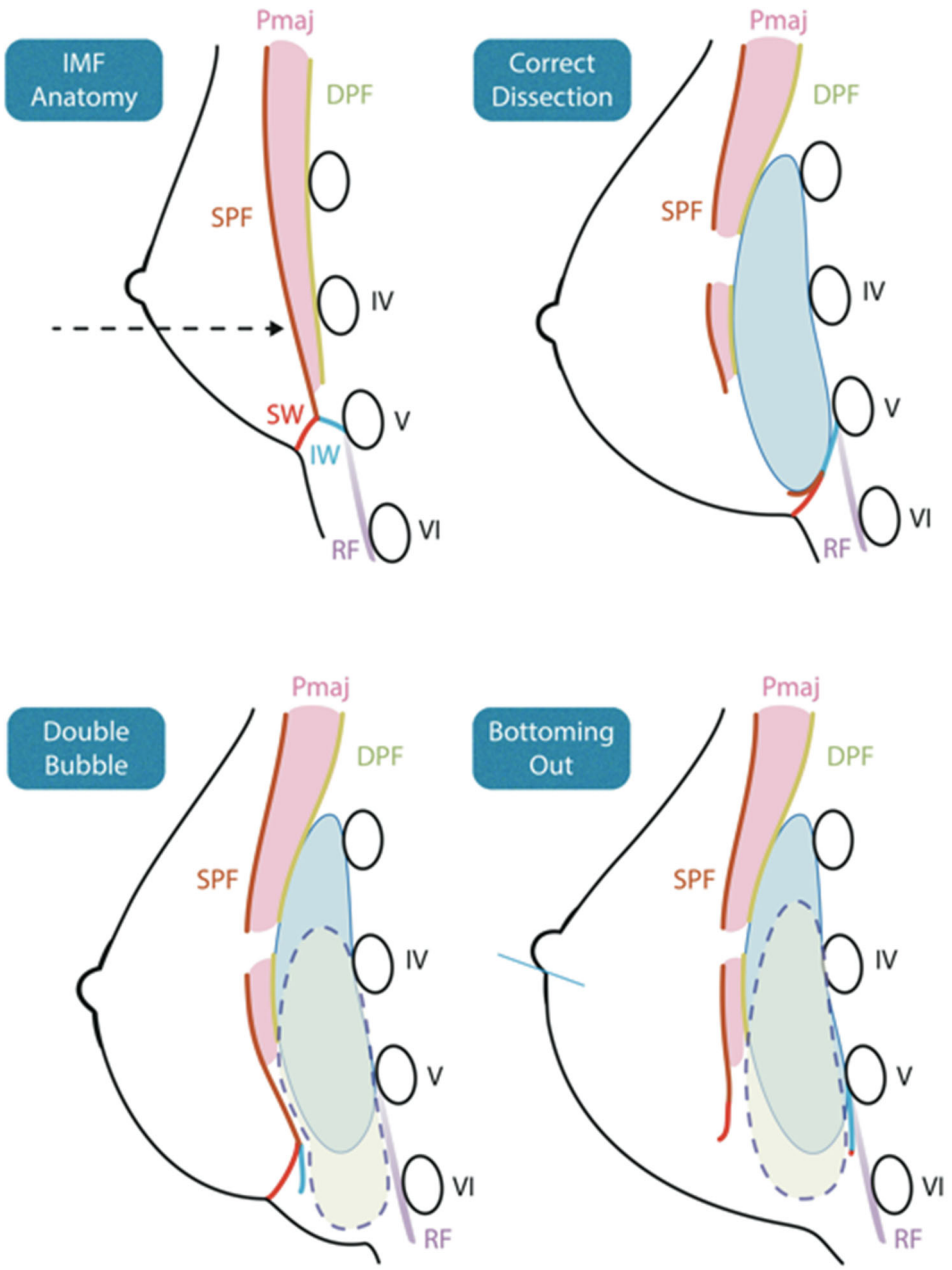

Fig. 6 Diagrams of sagittal breast axis of normal IMF anatomy (*above*, *left*) where the *dotted line arrow* indicates the full-thickness incision of the breast tissue to reach the PM with the periareolar approach; implant positioning in a correct dissection route (*above*, *right*); double bubble characterized by the presence of a groove or indentation which creates a double convexity (*below*, *left*); and bottoming out characterized by a too lowered implant, without any double convexity and with an unaesthetic lengthening of the nipple to fold distance (*below right*) deformities

Fig. 7 (*Above*) Preoperative pictures of a 31-year-old woman planned for implant breast augmentation. (*Below*) The 7-year postoperative pictures after periareolar dual-plane breast augmentation with polyurethane-covered implants 315 cc

Since the first anatomical report in 1845, many studies have been published on this matter with no general consensus about the true IMF anatomy [1–8]. In general, two schools of thought can be outlined: those supporting the existence of a true IMF ligament originating from the fifth rib periosteum medially and in the interspace between the fifth and sixth ribs laterally [1–3] and those, contrarily, outlining that the IMF is defined by a peculiar behavior of the Camper and Scarpa fasciae which fuse themselves with the dermis at the level of the IMF [4–6]. Surgical reports on IMF reconstruction in breast cancer patients using a lipofascial flap [7] or combination of capsulotomy, fasciotomy and suturing [8] and recently to correct double-bubble deformities [2] have favored the belief that the IMF is more a fascial structure rather than a true osseo-cutaneous ligament. Recently, Matousek et al. [3] performed a cadaveric study evaluating breast macro-sections outlining key breast ligamentous structures. As for IMF anatomy and the inferior breast pole, they found a ligamentous structure that fans out in a triangular fashion from the periosteum of the fifth rib of which the inferior fibers insert into the dermis at the level of the IMF and the superior fibers insert into the dermis of the inferior pole. They named this ligamentous structure triangular fascial condensation, of which its apex is defined by the intermuscular septum between the rectus abdominis (RA) and pectoralis major (PM) muscles. We performed a surgical dissection study that allowed us to better outline the IMF anatomy applied to breast augmentation. Our findings are in agreement with those of Matousek, besides the description of the intermuscular septum between the PM and RA that in our dissections is clearly defined by the SPF. As the SPF is anatomically superficial to RA fascia and vanishes on it without having any continuity with the RA fascia, this cannot be anatomically identified as a true intermuscular septum between the PM and RA muscles.

According to our dissections, the IMF is a complex osseo-fascio-cutaneous structure in which SPF represents a key structure in terms of clinical translation in breast augmentation surgery. Hence, a critical analysis of the IMF relationship with surrounding breast structures helps to understand the etiology of double-bubble and bottoming-

Fig. 8 (*Above*) Preoperative pictures of a 34-year-old woman planned for implant breast augmentation. (*Below*) The 7-year postoperative pictures after periareolar dual-plane breast augmentation with textured round implants 340 cc on right side and 370 cc on left side

out deformities and gives the anatomical basis to prevent them (Fig. 4). An incorrect dissection route in an inferior pocket dissection/IMF lowering procedure may favor the development of double-bubble or bottoming-out deformities. The likelihood of experiencing these complications is also related to the type of implant pocket chosen (i.e., subglandular, subfascial and subpectoral) (Figs. 4, 5).

When a subglandular pocket dissection is performed, there is virtually no chance of surgically causing a double-bubble deformity, as the plane of dissection is superficial to the IMF inferior wing, whereas the risk of surgical-related bottoming out is quite consistent. By developing the pocket with the periareolar approach, particular care has to be paid during inferior pocket dissection/IMF lowering as there is the risk of interrupting the IMF superior wing. So, a slightly more superficial subcutaneous plane of dissection should be followed once at the level of the IMF, in order to lower it. When the pocket is developed via the IMF incision, the superior wing is always surgically interrupted to enter the pocket. In these cases, at the end of the procedure, it is important to restore the continuity of the superior wing by suturing back the interrupted superior wing. However, the combination of natural soft tissue aging with the weight of the implant over the skin envelope as well as on the IMF superior wing may favor inferior pole skin stretching and weakening of the IMF superior wing, ending up in a late bottoming-out deformity. Submuscular implant pockets are differentiated as "partial subpectoral," "dual-plane" and complete submuscular. The latter is nowadays not recommended because of the higher morbidity and almost no advantages compared to the other two. The "partial subpectoral" and "dual-plane" techniques are, in practice, a variation of the same theme. In both techniques, the implant sits in two different planes (subpectoral in the upper pole and subglandular in the lower pole) and the implant pocket dissections are technically equivalent regarding the risk of double-bubble and bottoming-out deformities. However, when a partial glandular release over the PM is performed, the technique takes the name of "dual plane."

When a partial submuscular or dual-plane pocket dissection is performed, there is the risk of surgically causing both double-bubble and bottoming-out deformities as both the IMF superior and inferior wings are involved during pocket dissection.

Relative to the periareolar approach, the inferior pole is dissected craniocaudally and the IMF is found at the bottom of the dissection. At this point, the dissection route should continue in a more superficial plane (i.e., just above SPF, i.e., in the subglandular plane). This is accomplished by interrupting the inferior most PM fibers and overlying the SPF that appears as a white opalescent tissue (Figs. 5, 6). By using this route, the IMF anatomy can be preserved with the implant being well supported in the inferior pole by the IMF (Figs. 7, 8).

If the plane of dissection is continued below the SPF, there is the risk of interrupting the inferior wing (i.e., periosteum attachments) of the IMF and of preserving the superficial wing (fascia to dermis attachments) (Figs. 4, 6). This may result in double-bubble deformity, as the implant will sit in the space below the indentation due to the preservation of the superficial IMF attachments.

When the plane of dissection is kept inferior to the SPF and then the SPF is incised too far downward to access the superficial plane, there is the risk of interrupting the superior wing (fascia to dermis attachments) (Figs. 4, 6). This may result in bottoming-out deformity, as there are no supporting structures at the fold with the implant exerting skin stretching due to weight.

Other common approaches in BA include the IMF and transaxillary approaches.

As for IMF lowering, pocket dissection using the transaxillary approach is similar to that of the periareolar approach as the inferior pole is dissected craniocaudally. Besides the blunt techniques where a precise dissection is virtually not possible, when an endoscopic technique is used, we believe that similar concepts of the periareolar approach can be applied.

When an inframammary approach is used, the inferior pole dissection is carried caudo-cranially being opposite to the periareolar or transaxillary approach. As described by many authors performing the IMF approach, the incision is usually designed based on implant dimension planned to be inserted to have the scar along the new IMF. Excluding cases in which there is no need to lower the IMF, in all other cases the incision is below the existing IMF. Based on our observation, if the initial dissection is performed in a suprafascial plane (above SPF) and the subpectoral plane is entered around 1 cm above the PM inferior margin, both inferior and superior wings are not violated. However, if the initial dissection is above the rectus abdominis muscle fascia but below the SPF, we believe that there would be a higher risk of bottoming-out and/or double-bubble deformities. We applaud comments and reports on this matter from authors with extensive experience on the inframammary approach, according to the IMF anatomical insights we provided.

Conclusion

Bottoming-out and double-bubble deformities are two distinct lower pole implant malposition problems related to an incorrect pocket dissection in the inferior pole. Breast tuberosity, use of larger implants and soft tissue flaccidity in the lower pole may predispose patients to such complications. We provided the applied anatomical basis for a correct anatomical approach during pocket dissection at the level of the IMF, which might aid in reducing the rate of these complications. A comprehensive understanding of IMF anatomy and the key surgical maneuvers to avoid these complications must be taken into account for each route of dissection.

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Compliance with Ethical Standards

Conflicts of interest The authors declare that they have no conflicts of interest.

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