UDC 618.19-089.844 -089.197.7-77-007.41(048.8)
DOI http://doi.org/10.30978/GS-2023-2-76

ISSN 2786-5584 print
ISSN 2786-5592 online

Management of breast implant malposition. Literature review

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Breast augmentation mammoplasty (BAM) remains the most common surgical procedure for women. According to ISAPS data, 1685471 women underwent BAM in 2021. At the same time, there is a high percentage of reoperations after primary breast augmentation, including breast implant malpositions (BIM): 4.7 %-5.2 % after primary BAM and approximately 10 % after revision BAM. These statistics refer only to severe BIM, which causes significant changes in the shape and contour of the breast and makes it look ugly. If all degrees of BIM severity are taken into account, its incidence may be much higher. The tendency of a foreign body to dislocate is a common medical problem. Implants are no exception, especially since their fixation cannot be recognized as absolute. Therefore, BIM is, to some extent, an expected complication.

This literature review is devoted to one of the controversial problems of aesthetic surgery: the management of breast implant malposition (BIM) after augmentation mammoplasty. The review provides a critical analysis of the data on the classification, etiology, pathogenesis, diagnosis of BIM, and assessment of its severity. The methods of treatment of BIM, including the use of own tissues and additional materials, are comprehensively covered, with an emphasis on controversial aspects. The approaches to the prevention of BIM are outlined. According to the literature, the frequency of BIM is not known for certain since no quantitative or even qualitative assessment of its degree has been developed so far. This also limits the ability to compare the results of different treatments for BIM in terms of the frequency and severity of malposition. Risk factors are not sufficiently assessed, and as a result, there are no generally accepted algorithms for their prevention and treatment. There is a lack of comparative studies of implant malposition treatment methods. Most studies include different revision surgeries, different anatomical implant placement planes, different implant styles, and different follow-up durations for postoperative patients. Because of this and the lack of standardization in research, it is unclear which procedures achieve the best results. Further research is needed on the prevention and treatment of MIMS.

Keywords
breast implant malposition, classification, «bottomed out» and «double bubble» deformities, symmastia, diagnosis, surgical treatment, prevention.

ARTICLE • Received 2023-09-05 • Received in revised form 2023-10-02

Augmentation mammoplasty (AMP) remains the most common surgical procedure for women. According to ISAPS data, 1,685,471 women underwent this procedure in 2021. Due to the Covid-19 epidemic, the surgery application rate has decreased to only 0.5 % over the last four years [61]. At the same time, there is a high percentage of repeated surgeries following primary breast augmentation, and in some publications, this indicator reaches 36 % [21]. The number of implant removal surgeries has also increased by 22.6 % (+49.6 % over the past four years) [61].

One of the reasons for implant removal or replacement is its malposition [36, 57]. Breast implant malposition is a broad term meaning the improper position of the prosthesis that can occur as a result of incorrect implant placement during augmentation mammoplasty or due to implant displacement in the breast pocket after the surgery. In this work, the term «malposition» will be used in a narrow sense, as a postoperative displacement of one or both breast implants from the primary location.

Implant placement into a certain part of the body for medical or aesthetic purposes always faces the need for reliable fixation in the selected area. Foreign body dislocation is a common medical problem. Breast implants are no exception, especially since their fixation cannot be considered absolute. Far-forth dislocation of breast implants in any direction from the placement area can always be expected. The frequency of revision surgeries due to implant malposition after primary breast augmentation is 4.7 %-5.2 % [56, 63] and approximately 10 % after secondary breast augmentation [75, 79, 83, 117]. These statistics refer only to pronounced implant malposition resulting in significant changes in the shape and contour of the breasts, making the appearance ugly. With all breast implant malposition (BIM) severity degrees taken into consideration, its frequency can be much higher, but only a small number of works are dedicated to this subject. E. J. Strasser detected BIM in 94 % of cases 7 years after subpectoral augmentation mammoplasty [122]. Similarly, V. G. Mishalov et al. have discovered a significantly higher frequency of rotational malposition of anatomical prostheses one year after augmentation mammoplasty (82.4 %) considering all degrees of implant rotation starting from 30° [2]. At the same time, other researchers state a frequency ranging from 0.9 to 14.0 %, but only of clinically significant rotation (usually more than 60°) [86].

Types of breast implant malposition

Although breast implant migration can occur in any direction, conventionally, the four directions of its malposition are as follows: inferior, medial, lateral, superior, as well as rotational malposition [2, 29, 86, 116].

Inferior (inframammary). Inferior malposition is the most common type of breast implant displacement [63]. It is not breast ptosis, although it can be combined with it [116], and it is manifested by such deformities as «bottomed out» and «double bubble» [66, 104]. In case of pronounced «bottomed out» malposition, the lower part of the breasts looks excessively full, without a sense of beauty, while their upper part or even the lower part of the nipple areolar complex (NAC) looks empty or, as such, has no volume. The implant partially occupies a position below the inframammary fold (IMF); therefore, in the case of a previous submammary approach, the postoperative scar rises to the breast elevation. Typical in this case are an increase in the lower pole of the breast and an increase in the distance between the nipple and the IMF, as well as an upward relocation of the nipple in relation to the lower pole of the breast [29, 66, 104], which can cause a «star-gazing» deformity.

In case of double bubble deformity, two parallel folds are formed under the breasts. The upper fold is the natural IMF, while the lower one is the level to which the implant has descended. These folds create two separate contours or sacs (bubbles). The lower sac is formed by the part of the breast implant, while the upper one is natural breast tissue.

Medial. Medial breast implant malposition means the displacement of one or both implants to the middle sternal line. The maximum convergence of implants due to the loss of adhesion between the sternum and the presternal skin was named symmastia [120]. In this case, breasts visually fuse, which is regarded as a «uniboob» or «breadloafing» deformity. After augmentation mammoplasty, two types of symmastia are possible: bicapsular and monocapsular (in case of connecting breast pockets) [47]. In case of medial malposition, the interthoracic cleavage is unclear or absent, the distance between the breasts is too small, and the nipple deviates laterally (the distance of the no-touch zone being too short and the nipple position being deflected outward without holding the highest point of the breast's convexity). Medial malposition should be distinguished from the term «symmastia». Medial malposition is a general breast fusion, while symmastia is specifically defined as a medial internal fascia deficit and insufficient skin lifting [95].

Superior. Superior malposition, also known as a «high-riding implant», is caused by the upward displacement of the breast spot (base). In contrast, the lower breast pole is flat, while the nipple-to-fold distance is relatively short. In the case of superior malposition, there may be a ptosis-waterfall effect [41].

Lateral. Lateral malposition, also known as telemastia, is the displacement of the implant laterally from its original location. It usually applies to both implants. It results in the abnormally wide distance between the breasts, which is best manifested in the supine.

Rotational. Prosthesis rotation is a circular displacement on a plane or in 3D space. And if on a plane a prosthesis rotates around a certain centre or rotation point, in 3D space, the rotation occurs around a line called the rotation axis [39]. Thus, speaking of breast prosthesis rotation, it is necessary to distinguish between its two types. The first type concerns anatomical implants that usually rotate in a frontal plane around a point located on the prosthesis's vertical axis of symmetry by an angle from 30° to 180°, but most often by an angle of 30° and 59° [2]. The prosthesis axis rotation occurs in the lateral direction more often than in the medial and can be different in two breasts, both in terms of direction and angle of rotation [2].

The second option concerns round prostheses. Clinically significant rotation of such prostheses is associated with rotation in 3D space, in which the prosthesis rotates 180 degrees around either the horizontal or vertical rotation axis. At the same time, its frontal surface turns back and its posterior surface — forward. Flipping of the round prosthesis in the frontal plane, even if it has occurred, is not clinically manifested. In most studies, the problem of malrotation of round prostheses is not analyzed. J. L. Baeke has described his experience with anatomical implants placed in both subglandular and submuscular positions. According to his estimates, the risk of malrotation is at least 14 % [14]. According to J. M. Schots et al. [106], out of 73 women who underwent subglandular breast surgery (Natrelle Style 510 Allergan), 12 (8.2 %) had unilateral malrotation of the implant, and 7 of them needed surgery. In the same study with Style 410 implants, malrotation occurred in 23 patients. In all but three women, the malrotation was unilateral.

Breast implant malposition severity assessment

Diagnostics of malposition type is based on qualitative characteristics: too low, too high, too medial, and too lateral [43]. BIM severity degree or severity assessment is not yet fully developed, which negatively affects its frequency determination and prevention as well as treatment (elimination) methods unification. Only a few works emphasize the differentiation of patients by BIM severity.

E. J. Strasser [121] proposed to classify BIM, like other mammoplasty complications, based on the concept that perfection is the absence of imperfection. The evaluation of the result was based on the detection of imperfections or flaws deviating from the ideal — in other words, on the researcher's subjective feelings about BIM. He singled out 4 grades and assigned them a certain score: ideal state of breasts — 0 points, noticeable malposition — 1point, obvious malposition — 5 points, obvious malposition with breast deformity — 15 points. The total number of points in the categories of all cosmetic defects was added to the total score. The ideal result has 0 flaws and receives a score of 0. Scores 1—4 are good results, and 5—14 — are mediocre result, i 15 are poor results.

In the work of J. D. Namnoum et al., dedicated to the results of primary augmentation mammoplasty, the authors point out that the severity degree of complications (including prosthesis rotation, incorrect location, superior, inferior, medial, and lateral malposition) was assessed on a 5-point scale (no complications, mild, medium, severe, and very severe degree) [94]. At the same time, no objective or even subjective criteria for a complication severity assessment are given. A. M. Munhoz et al. defined implant malposition as implant displacement from the correct initial placement and graded it as «has occurred» or «has not occurred» [90]. Implant malposition was defined as the displacement of an implant that was initially placed correctly and was graded as having occurred or not having occurred.

In 2006 and later, the FDA issued guidelines for prosthesis rotational malposition degree by monitoring the location of special markers on the prosthesis using magnetic resonance imaging (MRI). However, studies have shown that the method itself and recommendations have not been widely used due to the high cost of the procedure. An alternative was high-resolution ultrasound scanning, proposed in 2008 by M. Hahn et al. [48]. The authors detected prosthesis rotation in 26.8 % of cases within 2—3 years after the surgery. Later, V. G. Mishalov et al. improved the ultrasound diagnostics of rotational malposition and found that one year after primary augmentation mammoplasty, subclinical rotational malposition (at an angle of 60°) occurred in 21.8 % of the placed implants, while clinically significant malposition (at an angle of 90° and more) occurred in 7.0 % of implants [2].

Modern views on etiology and pathogenesis of breast implant malposition

Incorrect implant position can occur immediately after the surgery due to technical errors in prosthesis placement, or it can occur in the remote postoperative period for various reasons. Among the causes of implant malposition are usually those related to the patient's specifics, surgical intervention, and implants used [29, 43].

Factors related to the patient's specifics

There are certain individual anatomical factors favouring breast implant malposition, and they are divided into musculoskeletal features of the chest and soft tissue features [36]. It is shown that the presence of *pectus excavatum* is associated with medial implant displacement, whereas *pectus carinatum* may lead to lateral displacement [21]. Women with a more rounded chest are more prone to telemastia compared to women with a normal chest [66], while a rectangular chest increases the probability of implant medialization [56].

Women with a tubular breast deformity or a short nipple-to-fold distance (< 4 cm) are prone to «double bubble» deformity [50, 66]. Pathological-anatomical studies conducted by Sanchez et al. [105] have demonstrated that in some people, greater pectoral muscle (GPM) at the point of its attachment to the sternum from the 2nd to the 5th rib can be thin (3—4 mm). There is an opinion that women with such GPM thickness have a high risk of medial malposition and symmastia after submuscular augmentation mammoplasty [47, 64].

Patients with a rounded anterior chest wall may be more prone to lateral implant malposition [66]. In these women, it is recommended to use implants with a wider base width and moderate lateral dissection when forming a submuscular neo-pocket [66]. Among the possible risk factors for clinically significant rotational malposition of anatomical implants (such as pre- and postoperative bra cup size, body mass index, and children), a connection was found only with the preoperative bra cup size, i.e., with breast size [86]. According to the authors, for the creation of a breast pocket, large breasts require a wider dissection and blood vessel cauterization. This increases the risk of hematoma and/or fluid accumulation, which may interfere with prosthesis adhesion.

Another important factor affecting BIM is the individual properties of capsular tissue. Capsular tissue permanently resists the pressure from the prosthesis due to gravity and/or GPM contraction. With time, this pressure can facilitate capsule thinning and failure to hold the implant in its original position [9].

Obviously, Scarpa's fascia peculiarities contribute to breast implant malposition proneness. It has been shown that in young women without breast ptosis, Scarpa fascia has histological and morphometric heterogeneity, which is due to the different thickness of collagen fibres and the different density of their distribution, i.e., «scattered» — 29.7 % and «compact» — 70.3 %. It has been proven that in breast ptosis patients, the «scattered» type prevails at 56.9 %, and the average specific optical density of fascia samples is significantly lower, while the standard deviation of the specific optical density is larger compared to patients without breast ptosis [92]. It is likely that such congenital features of Scarpa's fascia leading to breast ptosis also contribute to breast implant malposition, but studies on this subject are absent.

It is suggested that weight change, pregnancy, and soft tissue atrophy can contribute to malposition over time [34, 50, 66].

Factors induced by surgical intervention specifics

The role of surgical approach

There are several approaches to breast prostheses implantation: submammary, periareolar, and transaxillary. An inframammary approach can lead to inferior implant malposition due to a violation of IMF integrity or its weakening [112]. The risk of inferior implant malposition also increases with the periareolar approach due to possible breast hump detachment at the time of subcutaneous dissection of the breast parenchyma down to the IMF [106].

It is known that the transaxillary approach poses a greater risk of superior implant malposition because of difficult control of the breast lower pole dissection due to inadequate IMF visualization and «blind» dissection of GPM lower fibres [69]. Research by J. D. Namnoum et al. has demonstrated that the risk of malposition has significantly increased with a transaxillary approach compared with an inframammary approach (RR: 3.72 (95 % CI: 1.72; 8.06), $p < 0.001$), and also with a periareolar approach compared to an inframammary approach (RR: 1.62 (95 % CI: 1.04; 2.53), $p < 0.05$). In its turn, a higher risk of malposition was reported with the transaxillary approach compared to the periareolar approach (RR: 2.39 (95 % CI: 1.09; 5.22)) [94].

The role of factors induced by breast pocket creation technique

The main reasons for any type of breast implant malposition are discrepancies between the breast pocket size and implant volume, inadequate GPM preparation, and errors in centering the breast pocket spot (base) [5, 14, 86].

A pocket, oversized due to excessive preparation, allows the implant to move within it, which can result in inferior, medial, or lateral implant displacement depending on the location of the excessive preparation. For example, excessive preparation of the breast pocket in the subglandular plane above the sternum creates conditions for medial malposition, or symmastia [64]. Excessive tissue preparation for breast pocket creation in a lateral direction is a risk factor for lateral malposition [57, 66, 134]. Too narrow a pocket can lead to superior malposition.

Inaccurate determination of the future IMF (which must be performed before the surgery with a patient in a vertical position) at the time of subglandular pocket creation can lead to too high or too low placement of an implant.

Too low an approach at the time of pocket creation (below the existing IMF) can cause a «double bubble» deformity [104].

As for implant malposition causes in cases of submuscular or biplanar location, apart from pocket sizing problems, there are also factors related to GPM preparation and function. In cases of submuscular location of an implant, either dissection or disconnection of a small area of the GMP attached to the 5th and 6th ribs is necessary. Failure to perform this manipulation leads to superior malposition because GPM will constantly hold the implant in a high position, like an internal bra. Conversely, excessive preparation of the submuscular neo-pocket may result in inferior, medial, or lateral malposition.

In case of the submuscular location of an implant, GPM contraction creates a force vector pushing the implant in the lateral direction, thus creating conditions for lateral malposition, but if the GPM fibres are disconnected from the sternum, muscle contractions will push the implant in the medial direction, thus provoking medial malposition [47].

Such post-surgical complications as hematoma, seroma, and capsular contracture can also alter the implant position [66].

The role of breast pocket localization

A breast pocket can be created in subglandular, submuscular, and subfascial spaces, as well as in a double plane. Neither breast pocket type guarantees no malposition of the implant. However, according to J. D. Namnoum et al. data, the frequency of moderate and severe BIM is lower with the submuscular implant placement compared to the submammary — (RR: 0.68 (95 % CI: 0.46;1.00), $p < 0.05$) [94]. The risk of medial malposition and symmastia is probably higher with submuscular implant placement. In the published review by D. Guillier et al. of 15 articles, which included the treatment of 109 patients with symmastia after AMP, the submuscular position of implants was reported in all cases [47].

When two thirds of the implant is under the GPM and one third is under the mammary gland, the risk of superior implant malposition increases in women who had AMP in two planes. This is something that E. J. Strasser found to happen in 94 % of women over 7 years of follow-up [122]. In the case of subglandular placement of an implant, inferior malposition occurs more often [50, 66]. «Double-bubble» malposition of an implant occurs only in the case of subpectoral or two-plane implantation [40, 63].

Superior malposition usually occurs with subpectoral placement of an implant through a transaxillary approach in cases where the preparation of the lower fibres of the pectoral muscle is insufficient [29, 106]. It can also occur when implants are placed in the subfascial space.

A certain importance in BIM occurrence (the breast pocket of which is located in the submuscular space or in a double plane) is given to pectoral muscles. There is an opinion that the contraction of pectoral muscles along with their thickening [8, 118] is a factor prompting implant dislocation.

On the other hand, there is a theory that GPM atrophy and weakness can result in implant dislocation. It is known that during long-term compression, muscle tissue is prone to damage due to ischemia and myocyte deformity [27, 44, 107]. One year after submuscular augmentation mammoplasty, volumetric MRI showed GMP atrophy, probably due to the pressure of the implant on the pectoral muscle. The average volume loss was 49.8 % [102]. Recently, the significant reduction of muscle fibre area in GPM preparations compared to the pre-surgery baseline was reported in women who underwent augmentation submuscular mammoplasty: baseline — 94.1 ± 0.02 %, after one year — 80.7 ± 0.5 %, after three years — 71.0 ± 0.3 %; it inversely depends on implant weight: linear $R = 0.604$ and linear $R^2 = 0.582$, respectively. At the same time, anatomical breast implant rotation (malposition) was diagnosed in 80.0 % of patients (after one year) and in 93.3 % (after three years) by an angle from 30° to 180° that reliably negatively correlated with the percentage of muscle fibre area (after one year: $r = –0.816$; after three years: $r = –0.788$) [1].

Impact of implants

The choice of an appropriate implant in terms of size and surface quality is decisive in achieving the desired cosmetic effect of augmentation mammoplasty. Implants that are too large will distort the pocket and stretch the breast parenchyma and skin, which contributes to implant malposition. Choosing an implant is a complex problem, the solution to which hasn't yet been found. It is no coincidence that W. P. Adams Jr. and D. Mckee have discovered thirty-three implant size selection systems [6]. The study of 3D breast imaging for implant size choice has started recently. The preliminary results are suggestive of the relevance of such an approach [59], but further research is needed. It should be noted that routine measurements of breast parameters are almost as good as those received via 3D breast imaging [53]. Currently, one of the popular algorithms is the High Five approach described by J. B. Tebbetts and W. P. Adams [126]. It allows for choosing implants with regard to implant parameters (volume, weight, and size), predicted coverage with soft tissue, IMF location, and surgical approach.

Textured implants have been introduced for tissue adhesion maximization with the avoidance of implant displacement [81]. It was believed that attachment of textured device to the surrounding tissues guarantees no implant malposition, even with a large breast pocket [22, 23, 74, 81]. The incidence of malposition of implants with the textured surface/anatomical forms / highly cohesive silicone-filled implants compared to smooth surface / round surface / silicone implants was significantly lower (RR: 0.29 (95 % CI: 0.15;0.56), $p < 0.001$) [94].

However, until now, there have been no substantiated publications confirming the «adhesion» of textured implants to the surrounding tissues. Besides, texture ability to create frictional forces for balancing muscle contraction force and implant weight, which can cause implant malposition, is questioned [33]. Capsular fluid presence [20], double periprosthetic capsule formation [42, 45], and capsular contracture are considered BIM potential causes.

In recent years, the link between textured implants and BIA-ALCL likelihood has been reported, which has resulted in their limited use [30, 31, 50, 83, 87, 88, 91]. Smooth surface implants are being used more and more often. One of these is the *SmoothSilk* Implant, the first generation with a very slightly rough surface achieved through the use of inverted 3D printing technology, allowing for the avoidance of tissue ingrowth, implant adhesion, and biofilm formation minimization [87, 88, 90, 91, 108, 109]. The absence of a connective tissue adhesive layer between the implant and the capsule allows the implant to move in the pocket [90, 108, 109], which may lead to malposition. For this reason, the importance of matching pocket and implant dimensions increases significantly [90, 108].

Intra- and post-operative causes of implant malposition

BIM risk increases in case of the formation of an insufficiently sized neo-pocket, excessively sized neo-pocket [29], fluid accumulation around the implant (seroma, hematoma), and unremedied damage to the IMF. Improper use of a bra and breast supporting tape, post-surgical breast massage, and excessive physical activity are also associated with possible BIM [56].

In other words, the literature mentions many factors contributing to implant malposition after augmentation mammoplasty. At the same time, only larger incision sizes in the group of women who underwent primary augmentation ($p = 0.0003$), capsulectomy at the time of implantation in the group of women with repeated operations ($p = 0.0028$), and implantations performed in physician offices vs. hospitals or autonomous surgical facilities in both groups ($p < 0.0001$) were recognized as significant risk factors for *Natrelle 410* implant malposition by P. McGuire et al. [83]. It should be pointed out that no information on detection methods or malposition types was provided by the authors in their study.

Methods for the correction of implant malposition

Surgical correction of implant malposition is a complex surgery combining elements of augmentation, treatment of previous complications, and implant stability ensuring [92]. A higher frequency of complications than after primary breast augmentation [14, 83, 114], including implant malposition recurrence [67, 86], is reported after this procedure.

Having analysed the results of BIM surgical treatment based on the data from 21 clinical studies, K. Chopra et al. came to the conclusion that there was a low level of evidence presented in the articles, as well as difficulties in summarizing study results because different methods, implant placement planes, and implant types were used [29]. G. P. Maxwell et al. also pointed out the lack of consensus regarding the choice of BIM elimination method [79] inexistent until now.

BIM elimination approaches are divided into two groups: those presupposing revision (correction) of the existing one and those presupposing creation of a new implant pocket in a different plane. With each of these approaches, additional materials can be used for pocket stabilization and strengthening [29, 43].

Existing pocket revision (correction)

Capsulorrhaphy

Too large or too small a pocket is a leading factor in malposition; therefore, it is logical to match pocket and implant dimensions during the revision surgery. This can be achieved by pocket size reduction, enlargement, or implant replacement with one of a different size, or a combination of both procedures. The main method of pocket size correction is capsulorrhaphy. The first results of its application for BIM were published by S. L. Spear and J. W.R. Little in 1988 [116]. Multilayer casulorrhaphy with sutures was performed on 40 women. The authors believed that this technique was simple, safe, and reliable [116]. But the problem of malposition recurrence due to the capsule weakness in the suture area remained. Further improvement of the technique was aimed at capsulorrhaphy zone strengthening. To reduce the load on capsule sutures, in 2008, P. E. Chasan and C. S. Francis suggested the additional inverted capsulotomy [28]. No complications were reported during the 21-month follow-up. According to the authors, 35 patients who had completed the questionnaire were «generally satisfied with the surgery» [28].

However, suture capsulorrhaphy has some disadvantages. Firstly, suturing can be problematic because it is difficult to determine the exact location of the sutures. Secondly, repeated passing of the needle through the fragile capsule can weaken or tear it. Thirdly, these sutures may cause dimples along the new lateral breast border [12].

In 2005, C. Randquist developed the popcorn capsulorrhaphy technique, employing thermal energy. Starting in 2005, this technique was demonstrated in educational institutions and teaching courses in Sweden and Southeast Asia, and its first presentation in the USA took place at the 27th Annual Breast Surgery Symposium in Atlanta in 2011 [100]. According to this method, capsule cauterization is performed after every centimetre. Thermal energy causes quick whitening and shrinking of target tissues, as well as the formation of thickened blisters. The bursting of these blisters often provides a loud popping sound; hence, the technique was called «popcorn capsulorrhaphy». The technique made cardinal breast pocket reshaping and resizing possible by more than 50 % [100].

In 2014, R. Harris et al. offered a capsulorrhaphy type combining sutures and thermal energy called thermocapsulorrhaphy (TCR). Capsule thermocoagulation and suturing are performed from the internal side of the capsule after implant removal. With this technique, the excess capsule is cauterized evenly over the entire area via 40—80 W electrocoagulation. At the time of coagulation, the electrode is in constant motion in order to avoid destruction of any area or excessive heat transfer to the skin. After this, part of the capsule that has undergone coagulation is sutured in two rows. The authors were of the opinion that heat treatment of the capsule compresses and thickens its wall, while suturing improves the contact of the damaged walls reducing dead space and increasing capsule strength. After 157 TCRs performed over 2 years, a successful result was reported in 90 % of cases, a partially successful result was reported in 2 %, and in 8 % of cases, the procedure was ineffective [52].

In 2020, M. B. Calobrace et al. published the results of the treatment of 149 women with an average age of 42 and an average body mass index of 24.2 kg/m^2 who underwent advanced popcorn capsulorrhaphy, for a total of 266 mammary glands. With this technique, thermal energy is transmitted through forceps directly to the breast capsule, minimizing the risk of skin burns. The main indication for the surgery was BIM — 61.3 % of breasts. Revision surgery was needed in only 6.0 % of the total number of cases [24].

Capsulorrhaphy, including TCR and popcorn capsulography, is considered a simple, reconstructive, and low-cost method [88, 130]. Most often, it is indicated in cases of lateral and superior BIM [89], as well as in cases where there is not enough tissue to relocate the implant into the submuscular plane [66]. In such cases, TCR [21, 52] or «popcorn capsulography» [24, 100] is the procedure of choice. Additional suturing of the burned area with non-absorbable sutures or even barbed sutures is deemed appropriate for greater stability and uniform load distribution along the suture line [52, 85, 89, 132].

Although TCR is a simple and cost-effective method, it has certain limitations and should be avoided in thin breast and capsule tissues [29, 52] to avoid skin burns. The long-term results of capsulorrhaphy are sometimes unsatisfactory [66, 115, 134]. Recurrence can occur if malposition causes are not eliminated. Tension created by the implant can disrupt the capsulorrhaphy zone, while pectoral muscle contraction can lead to separation of the adhesions and fusions between prosthesis capsule leaves [17, 29, 66, 115, 134].

Recently, C. J. Awaida et al. described the technique of argon beam coagulation (ABC) of a prosthetic capsule [12]. ABM is a non-contact monopolar electrosurgical technique employing a high-frequency current directed at target tissues and ionized argon. ABC causes surface coagulation and desiccation, causing direct tissue shrinkage. Unlike thermal capsulorrhaphy employing conventional monopolar energy, ABC penetration depth is limited to 1—2 mm, therefore the risk of surrounding tissue necrosis is low. The ABC-induced desiccation zone suppresses further electrical conductivity and limits the depth of coagulation; therefore, the ABC effect is self-limiting [125]. According to the published method, capsulorrhaphy is performed until the excessive surface of the capsule is completely folded and reduced. This takes approximately 2—3 min depending on the area to be treated. Reinforcing suturing is not used [12]. Although ABC was used by the authors in reconstructive breast surgery, this technique may prove useful in aesthetic breast surgery as well. However, future adequate randomized controlled trials are necessary for the comparative analysis of different capsulorrhaphy techniques.

Capsular flap

Capsulorrhaphy protection is possible with periprosthetic capsule flaps. Flaps created from vascularized capsule tissue act as a supporting sling or hammock, relieving the implant weight-induced load from the capsulorrhaphy suture line and allowing for suture line placement away from the maximum implant weight [134]. The advantage of capsulorrhaphy is its technical simplicity. Successful restoration of a cosmetic defect through a capsular flap has been reported [49, 52]. However, capsular tissue strength can be lost over time if the deforming forces that caused the initial malposition are not eliminated. Such persistence of deforming forces can stretch capsular flaps, which will lead to malposition recurrence [66, 134].

Creating an implant pocket in a new plane

In the mid-90's, G. P. Maxwell et al. presented the «site change without plane change» concept, or, in other words, the creation of a new implant pocket at the time of revision surgeries, including those for implant malposition [82]. According to the authors, an implant can be relocated from one plane to another. The new pocket matches implant dimensions better than the post-capsulorrhapy modified one (thermal and/or suture) or the application of capsular flaps. An implant neo-pocket can be created in the subglandular, submuscular, total subfascial (subaponeurotic) planes, and in the dual plane, providing the opportunity to start anew.

Changing implant location without a plane change

Implant location change is possible without plane change when it is placed in the so-called «neopectoral pocket» in the pre-capsular space [80]. This technique was first described by G. P. Maxwell and A. Gabriel. It involves mobilization of the implant capsule front surface from the GPM back surface through a submammary approach; capsule dissection and implant removal; suturing of the anterior and posterior capsule walls; and placement of the implant, as before, in a double plane but in front of the capsule duplicate [80]. The remaining capsule is integrated into a new pocket, which strengthens it. S. L. Spear et al. proposed a similar method, but through a periareolar approach [115]. This technique has other synonyms: «neosubpectoral pocket», «precapsular pocket», and «precapsular-submuscular pocket» [25, 70, 115].

Creating a neosubpectoral pocket can be complicated if capsular tissue is thin [66]. Besides, the creation of a neosubpectoral pocket in itself does not solve the problem of incorrect muscle position that may exist after the previous operation. In this case, a GPM correction is required.

The advantage of relocating the implant into the neosubpectoral pocket compared to the subglandular pocket is the minimization of breast contour deformation risks, especially in women with insufficiently developed breast parenchyma [70, 76, 80].

Surgery outcomes turned out to be good during the average follow-up period of 26.2 months in patients with various implant malposition types [76], which was also confirmed by other studies [70, 115].

Implant relocation into the subfascial (subaponeurotic) plane

An alternative to the neopectoral pocket in patients with adequate soft tissue coverage is the relocation of an implant from the subpectoral to the general subfascial (subaponeurotic) plane [111, 131]. The general subfascial plane is located below the deep pectoral fascia of the GPM, dentate, lateral oblique, and anterior rectus muscles. This plane has the advantages of the subglandular and subpectoral planes and none of their disadvantages. In patients with subglandular implants, the transition to the subpectoral plane eliminates many symptoms of implant malposition associated with insufficient soft tissue support. However, proper muscle dissection and release from their insertion site are of paramount importance for avoiding inferior, lateral, medial, or superior deformity and animation deformity.

Moving the implant into the subglandular plane

Relocation of an implant from the submuscular to the intact subglandular space allows for results similar to those of primary subglandular mammoplasty. It also eliminates one of the etiological factors of malposition: excessive muscle force.

The technique provides posterior capsule removal, anterior capsule preservation, and GPM fixation to its natural insertion site. Since GPM fixation reproduces natural anatomy, changes in the plane also eliminate deformities caused by muscle contraction. The achievement of the cosmetic effect with implant relocation to the subglandular plane is due to adequate coverage of the implant with soft tissues; otherwise, subglandular relocation of the implant can lead to such cosmetic defects in implant visibility and palpation [51]. There is also a risk of implant malposition recurrence and capsular contracture.

The data on the effectiveness of this technique for eliminating implant malposition is insufficient. One study reported a high level of patients' satisfaction after subglandular relocation of an implant in 36 patients after 20.2 months of follow-up on average [71].

Implant relocation to a double plane

Implant placement in two planes was proposed by J. B. Tebbetts in 2006 [128]. This technique presupposes GPM separation from the mammary gland parenchyma, followed by further preparation of the muscle from the ribs. The implant installed in such a pocket is covered with GPM only on the upper pole, while the lower pole is located deep under the mammary gland tissues. At the time of GPM contraction, the implant becomes less mobile compared to fully submuscular placement [128]. The submuscular location of the upper part of the implant not only helps to better hide the implant itself in an area where there is usually less fatty tissue but also prevents the occurrence of a so-called «step» between the cleavage area with the ribs and prosthesis [128].

Biplanar relocation of the implant described by J. B. Tebbetts and modifications of this method [19, 60, 65], including the use of a residual breast capsule [55], may be useful in correction of the inferior malposition after subglandular implantation in patients with a lack of adequate tissue for subglandular implantation in the case of implant replacement [51, 66]. This approach is also an alternative to capsulotomy or capsulectomy in cases of superior malposition [127].

The composite reverse inferior muscle sling (CRIMS) technique can be regarded as one of the biplanar implant placement options; the implant is placed in such a way that its lower part is 50—60 % under the GPM, while its upper part is located above the sling, in the subfascial plane [89, 90]. The value for lower pole stretch was 5.5 % ($p < 0.0001$) between 10 days and 1 year, with the majority occurring early in the first 6 months, indicating that the lower pole arc remains steady during the last months of follow-up [90].

Application of additional materials

One of the causes of implant malposition is the weakness of the tissues keeping them in a proper position. Classical methods of implant malposition elimination use patients' own compromised tissues. Besides, over time, due to the presence of an implant, they lose their properties, which is reflected in changed breast parameters. Thus, according to 3D scanning, biplanar augmentation mammoplasty results in a 0.8 cm IMF shift after 1 month and a 0.5 cm shift in the following 11 months. Over 6 months, the distance between the nipple and IMF increases. Compared to the expected values, the final volume of the mammary gland decreases by 10.9 % and gland projection by 25 %. Breast volume reduction and projection are correlated with implant parameters [72]. According to Y. Liu and J. Luan, within a year after a similar surgery with smooth round implant placement, breast volume and projection, according to 3D scan data, were gradually decreasing. After the surgery, the nipple position gradually shifted laterally, upwards, and back [73]. With the above taken into consideration, additional strengthening of mammary gland tissues in critical areas at the time of implant malposition seems appropriate. For this purpose, acellular dermal matrix (ADM) and synthetic meshes are currently used.

Acellular dermal matrix

ADM is a dermal graft without epidermis and all other cellular elements in order to avoid tissue rejection and graft failure [58]. The host's collagen gradually replaces ADM in the surrounding tissues, promoting and supporting the healing process and reducing the formation of scar tissue [97].

In 2001, D. I. Dowde [38] used acellular dermal matrix for the first time during breast revision surgeries. In case of rippling (waviness), the author performed segmental capsulectomy in the projection of rippling and closed the prepared area with an implant. She also suggested prosthetic capsule «reinforcement» with 4 × 12 cm and/or 4 × 8 cm dermal flaps in cases of inferolateral and medial malposition. In 2003, R. A. Baxter [15], based on the results of the treatment of 10 women, including those with malpositioned breast implants, suggested capsule reinforcement with ADM located intracapsularly in the upper and lower poles. It is believed that ADM should effectively support capsulorrhaphy, reduce the excessive load along the suture line, support IMF, and ensure the proper position of the implants in the new pocket [32, 129]. G. P. Maxwell and A. Gabriel regard ADM as an «implant stabilizer» [78].

Many authors have used ADM for various implant malposition types with good long-term results [54, 78, 79, 115, 119, 127]. Usually, ADM was used simultaneously with conventional methods of malposition elimination, such as capsulorrhaphy and breast pocket plane relocation [51, 66]. ADM is sutured in the appropriate position for support and better control over the pocket and implant position. It is emphasized that the use of ADM is especially recommended in women with tissue weakness, and in whom the capsule can stretch over time, leading to recurrence without effective reinforcement [66, 77, 110]. There is an opinion that the high effectiveness of ADM in implant malposition treatment is due to the fact that ADM probably plays a role in preventing capsular contracture, which is a risk factor for malposition recurrence [13, 18]. Although there isn't much evidence about ADM application results in implant malposition, the current data are indicative of a lower frequency of malposition recurrence compared to other methods [113]. Issues of ADM mechanical integrity, durability, and its safety profile in malposition treatment remain debatable [68, 84]. A number of authors believe that although ADM is the main method of breast reconstruction, it is not a viable option for cosmetic purposes as it is associated with high costs and a high frequency of complications [16, 93, 103, 129].

Synthetic mesh

In aesthetic breast surgery, synthetic meshes (non-absorbable, mixed type, and absorbable biodegradable meshes [93]) are used for the same indications as ADM. However, a number of works on their use for the mere purpose of malposition elimination is rather small.

The first works on synthetic meshes used in aesthetic surgery belong to Johnson GW, who described mastopexy suspension techniques mimicking Cooper's and Wuringer ligaments with the use of Marlex mesh [62], E. Auclair et al., who described coverage of the mammary gland with an absorbable mesh through a periareolar approach [11], and J. C. Goes, who described the «double skin» technique aimed at breast ptosis elimination by means of complete mesh coverage of the gland separately from the cutaneous coverage [46].

It was demonstrated that fibrous tissue induced by synthetic mesh acts like an internal support system for a stable long-term aesthetic result [3, 4, 37], does not cause excessive fibrosis when located between the layers of mammary gland adipose tissue [35], and that the mesh price is significantly lower than that of ADM [16, 93]. This gave a reason to consider the introduction of synthetic meshes as a promising new stage in aesthetic surgery [93, 99]. However, the use of synthetic meshes is not a widely accepted and performed procedure [7] because the ideal mesh material has not been created yet [10]. The mesh should meet a compromise between such parameters as durable mechanical strength and stiffness for breast fixation in a certain plane on the one hand and be soft and elastic to ensure breast naturalness on the other hand [34]. Non-absorbable edges of hard nets can be palpated, while softer ones can stretch in one of the directions and fail to keep the shape [35]. Chronic abscess formation [37], hematoma, and mesh separation from the muscles at fixation points due to forced movements have been described [46]. Besides, the effects of continuous and long-term contact of mesh with mammary glands and surrounding tissues are yet unknown [123].

Absorbable or partially absorbable meshes are less rigid; however, reinforcement achieved with them is less reliable. There is an opinion that, in order to achieve certain aesthetic effects, the mesh should reinforce the internal support for at least 3 months. But it is unknown whether the achieved effect will be lasting.

The availability of numerous BIM treatment methods has long required the development of a generally approved algorithm for choosing the optimal method, but currently there is none. Recently, a group of authors proposed an algorithm for reoperative augmentation mammoplasty aimed at soft tissue support optimization, pocket control, and implant stability. The algorithm is based on the composite reverse inferior muscle sling (CRIMS) technique and its technical variations [89]. Reoperative Augmentation Mammoplasty: An Algorithm to Optimize Soft-Tissue Support, Pocket Control, and Smooth Implant Stability with Composite Reverse Inferior Muscle Sling (CRIMS) and its Technical Variations. 72 patients were operated on by the authors pursuant to this algorithm, including 43 (59.6 %) with implant malposition. During the follow-up, 2 cases (3.0 %) of minimal implant displacement and no rotation at all were recorded. But, according to the authors, further accurate evaluation is recommended to understand the benefits or disadvantages of CRIMS compared to other reoperative augmentation mammoplasty techniques [89].

Prevention of implant malposition after augmentation mammoplasty

Although long-term maintenance of aesthetic mammoplasty results remains an unattainable goal in many cases [10], certain measures can prevent or significantly reduce implant malposition severity. Preventive care consists of several stages: a thorough pre-surgical examination, choice of implant, choice of surgical technique, and post-surgical follow-up.

Approximately 90 % of women undergoing augmentation mammoplasty have a certain degree of chest asymmetry [101], as well as musculoskeletal peculiarities of the chest and soft tissues affecting the correct positioning of an implant and ultimately the probability of its malposition [36, 51, 56, 66].

In cases of breast volume asymmetry, filling can be performed [133]. The existing ptosis can be corrected by proper pocket positioning and/or skin envelope correction. Breast base diameter narrowing can be eliminated by IMF release or change.

A pre-surgical examination should also include a careful assessment of breast size and glandular density, which are important for the selection of implant and implant placement plane [26, 29, 43, 126]. The implant should not be wider than the breast base in order to prevent horizontal displacement, and it should not be too heavy to avoid breast tissue stretching.

Breast volume and density are also to be considered while choosing the implant placement plane [96, 102, 122]. As a rule, a subglandular placement is considered in cases with relatively dense breast tissue, while a submuscular placement is the option of choice in cases with insufficient breast volume and density [24]. Biplanar implant placement may be associated with GPM, the main cause of implant malposition. Gentle, blunt medial pocket dissection under direct examination helps to preserve the median fascia and prevent medial displacement and symmastia [95]. In the case of lower pole hypoplasia, there is a risk of a double-bubble deformity that can be prevented by subglandular release of breast tissue from the pectoral fascia. In such cases, some authors suggest the approach above the IMF. Normal lowering of implants occurs after a short time, and the scars remain hidden both in vertical and horizontal positions. This method reduces the short-term risk of reoperation for implant malposition or double-bubble deformity [124].

In the post-surgical period, it is recommended to abstain from breast massaging in order to prevent an inflammatory reaction, from wearing a bra for at least 2—3 months for implant dislocation prevention, as well as to terminate sports activities for a period of 6 weeks, especially those presupposing intensive upper body movements.

Conclusions

Implant malposition is a common situation after primary and revision breast augmentation mammoplasty. It is expected and can be caused by patient-related factors, surgical technique, and/or implant-related factors. BIM frequency is not precisely known since a quantitative or even qualitative assessment of its severity has not yet been developed. Besides, this limits the possibilities of comparing the results of different BIM treatments by malposition frequency and severity. Risk factors are insufficiently evaluated, and, as a result, there are no approved algorithms for BIM prevention and treatment. There is a lack of comparative research on implant malposition treatment methods. Most works include different types of revision surgeries, different anatomical planes for implant placement, different styles of implants, and different post-surgical follow-up periods. Because of this and the lack of scientific research standardization, it is unclear which procedures achieve the best effect. Further research on BIM prevention and treatment is needed.

Declaration of interests

The authors declare that they have no conflicts of interest.

Authors contributions

Y. M. Susak: conception and design; A. B. I. Mohammad: collection, analysis, and interpretation of data, drafting and revision of the manuscript.

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Менеджмент мальпозиції імплантатів молочних залоз. Огляд літератури

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Аугментаційна мамопластика (АМП) молочних залоз (МЗ) залишається найпоширенішою хірургічною процедурою в жінок. За даними ISAPS, у 2021 р. АМП МЗ виконано 1 685 471 жінці. Однак ця процедура асоціюється з високою частотою повторних операцій, зокрема через мальпозицію імплантатів (МІ): 4,7—5,2 % після первинної АМП і близько 10 % після ревізійної АМП. Ця статистика стосується лише виразної МІ МЗ, за якої значно змінюються форма та контур грудей, і вони набувають потворного вигляду. У разі врахування всіх ступенів виразності МІ МЗ її частота може бути значно більшою. Схильність стороннього тіла до дислокації — загальна медична проблема. Імплантати МЗ не є винятком, тим більше, що їхню фіксацію не можна визнати абсолютною, тому МІ МЗ певною мірою очікуване ускладнення.

Огляд літератури присвячено одній із контраверсійних проблем естетичної хірургії — менеджменту МІ МЗ після АМП. Наведено критичний аналіз даних щодо класифікації, етіології, патогенезу, діагностики МІ МЗ та оцінки ступеня її тяжкості. Всебічно, з акцентом на спірні аспекти, висвітлено методи лікування МІМЗ, зокрема з використанням власних тканин та додаткових матеріалів. Наведено підходи до профілактики МІ МЗ. Згідно з даними літератури, частота МІ МЗ точно невідома, оскільки не розроблена кількісна і якісна оцінка ступеня її тяжкості. Це також обмежує можливість порівняти результати застосування різних методів лікування МІ МЗ за частотою і тяжкістю мальпозиції. Недостатньо оцінено чинники, тому немає загальноприйнятих алгоритмів їхньої профілактики та лікування. Бракує порівняльних досліджень методів лікування МІ. Більшість робіт відрізняються за варіантом ревізійних операцій, анатомічними площинами розміщення імплантатів, стилем імплантатів та тривалістю спостереження за пацієнтками після операції. Не зрозуміло, які процедури дають найкращий ефект. Необхідно провести дослідження щодо профілактики і лікування МІ МЗ.

Ключові слова: мальпозиція імлантатів молочних залоз, класифікація, «bottomed out» та «double bubble» деформації, симмастія, діагностика, хірургічне лікування, профілактика.

FOR CITATION

Mohammad ABI, Susak YM. Management of breast implant malposition. Literature review. General Surgery (Ukraine). 2023;2;76-89. http://doi.org/10.30978/GS-2023-2-76.