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Clinical And Biomechanical Basis Of Implant Based Breast Reconstruction

Mubashir Cheema, Sairah Naseem

IMPORTANCE Breast cancer is one of the most common malignancies around the world. In a developing country like Pakistan the patients may present late or be unreliable/irregular in follow up. Hence mastectomy and implant based reconstruction are a typical form of management. Our aim is to summarize the principles of patient assessment, types of breast prostheses their common indications as well as the limitation of implant based breast reconstruction.

DISCUSSION Ability to deconstruct the defect in smaller subunits (e.g. using the "three step principle") helps understand the defect and plan appropriate management for any breast defect. Management starts with choosing an appropriate type of prosthesis. Physical dimensions of the implant are chosen to achieve symmetry with the contralateral side (or an idealized shape, in case of bilateral reconstruction). Different implant characteristics may be chosen to "fine tune" the reconstruction to the individual patient. The technique however, does has its limitations.

CONCLUSIONS Implant based reconstruction is just one tool in the surgeon's toolbox to manage defects resulting from resection of breast cancer. A knowledge and competence in all possible options can help the surgeon individualize management for each of their patients.

KEYWORDS Breast, reconstruction, implant, prosthesis, expander, Becker

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Author Affiliations: Author affiliations are listed at the end of this article.

Corresponding Author:
Mubashir Cheema FRCS(Plast), EBOPRAS, MRM
Department of Plastic Surgery, University Hospitals Birmingham, UK
mubashir.cheema@nhs.net
+44 121 371 2000
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Breast cancer is one of the most common malignancies in women, affecting an estimated 2.3 million per year[1] around the world. Its management depends on the histologic type and clinical stage at the time of diagnosis. This, in turn, determines the final size of the defect after any tumor extirpation. The physical size of this defect and its proportional relation with the breast size factor in to the decision for breast conservation surgery (BCS) vs mastectomy. The reconstructive options, especially in developing countries take in to account the patient and the surgeon characteristics. Due to a combination of poverty, illiteracy, misconceptions and long distances involved in reaching surgical care, the patients may not return for multiple follow-up visits. While there are autologous and prosthetic options possible for a given patient, the surgeon may not be well versed in autologous reconstruction and/or may wish to keep the surgical option as simple as possible, in view of patient characteristics.

Our aim is to summarize the principles of patient assessment, types of breast prostheses their common indications as well as the limitation of reconstruction using prostheses.

Principles of assessment: A simple reproducible way to assess the defect involved is to deconstruct the breast shape in to simpler ones and compare them with contralateral (or to the intended result). Blondeel at al.[2,3] have described this as a "three step principle" that assesses the so called foot plate, conus and the envelope (Figure 1).

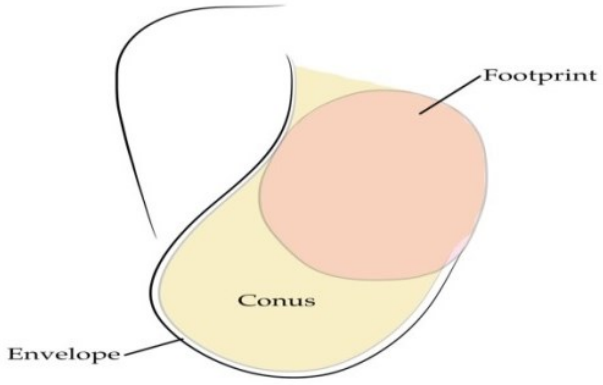

Figure 1: Three step principle deconstructs the shape of Breast to a footplate, conus and envelope to allow assessment and decision making about each part independent of the other.

Foot plate (also known as the 'Base') is the imprint of the most proximal part of the breast on to the chest wall. It has been classically described as extending from 2nd to 6th intercostal space in vertical dimension and from anterior axillary line to parasternal in horizontal dimensions. The foot print is relatively consistent, with exception of congenital anomalies of development or tubular breast deformity. The "envelope" refers to the skin covering of the breast tissue

and may be thin or lax. Due to the skin's viscoelastic properties (i.e. it is prone to stretch), it cannot provide lasting shape to the breast tissue by itself. In contrast, the "conus" represents the volume of breast parenchyma, and does not include the skin. The distinction between envelope and conus becomes important in immediate vs delayed breast reconstruction.

Mastectomy patients in whom immediate breast reconstruction is contemplated, the native skin envelope is preserved as well as the foot plate. The only thing needed is the volume of the breast conus, which can be provided with autologous tissue (i.e. pedicled or free flap) or using synthetic material (i.e. a definitive implant).

In delayed breast reconstruction, all three features are missing. While the foot plate (or base) can be copied from the contralateral side, the conus and the envelope present a challenge. While autologous reconstruction (with pedicle or free flap) can bring in both volume as well as extra skin at the same operation, implant based reconstruction cannot provide both at the same time, hence we need to place a tissue expander to "create" extra skin for the envelope over a period of time. Once the skin envelope is large enough, the expander is replaced with a definitive implant. Note that due to thin skin, the final shape of the breast follows from the shape of the implant placed. This of course has its limitation that it can only match the volume but it cannot reproduce natural ptosis which may exist on the contralateral side. (In such a situation, one option may to perform a symmetrising procedure to shape the contralateral non-diseased breast to match the ipsilateral reconstructed side. However, this option, of placing scars on an otherwise healthy tissue, may not appeal to every patient).

Types of Prostheses: Prostheses used for breast reconstruction may be a tissue expander (also called breast expander), a definitive prosthesis or an expander-implant (also called Becker prosthesis).

1) Tissue/ breast expander is a medical device consisting of a shell of silicone polymer that is placed in sub-pectoral (or more recently, pre-pectoral) space in patients needing delayed breast reconstruction. The expander is regularly topped up with saline through a remote or integrated "port" to increase its volume. The increase in volume also increases its surface area which recruits as well as stimulates the growth of new skin via the process of tissue expansion.

2) Definitive prosthesis has a silicone elastomer shell and is filled with either saline or silicone polymer (different in composition from that of the shell). In contrast to an expander, the volume of a definitive prosthesis is fixed and cannot be changed.

3) Expander-implant, also known as "Becker implant" have a silicone shell but the inside consists of two separate chambers. In one chamber is a certain fixed volume of silicone polymer, and the other is potentially empty but can have a variable amount of saline injected in to it through an attached port.

Characteristics of a definitive breast implant:

(A) Fill

An implant may be filled with saline or silicone, making it a saline or a silicone implant. Saline implants are possibly only used in some places within the USA. We think that it is due to the historical "silicone controversy" of the 1990s when FDA placed a moratorium on silicone breast implants[4]. However, since then several studies confirmed the safety of silicone implants against concerns cited in the original controversy[5].

Silicone gels of different viscosities (also called cohesiveness or cohesivity) have been developed over the years. Less viscous gels are considered softer to touch but increase the tendency of "rippling" (i.e. any unevenness of the implant surface may be visible through the patient's skin) . Implants with softer gels are more likely to lose shape in case of implant rupture or physical damage to the implant shell.

(B) Surface

One of the most common sequelae of breast implants is the formation of a fibrous capsule, called capsular contracture (CC). Histologically, it consists predominantly of fibroblasts and myofibroblasts. Clinically, it grows slowly over time and can make the breast feel firmer over a period of many years. After any radiotherapy for breast cancer, there is increased risk of developing an excessive capsule ("adverse capsular contracture")[6,7] which in addition to making the breast firmer, can make it contracted/misshapen or even painful[8]. The myofibroblasts in the adverse capsule are more likely to be aligned in one direction, therefore providing a cumulative force of contraction.

To counteract this effect, textured implants were developed where the surface has microscopic irregularities, in order to try to reduce the net vector of contraction by the fibroblasts[9]. The current surface technologies available are the Siltex™ "microtextured" surface by Mentor Inc. (J&J, USA) and the nanotextured surface by Motiva implants (Establishment Labs, Costa Rica). The difference between micro- and nano-textured surfaces is the size of the surface irregularities.

While fibroblastic response to radiation accounts for post-radiotherapy capsule formation, many patients develop adverse capsules in absence of local irradiation. Various factors have been implicated in this situation, all of which result in a limited sub-clinical inflammatory process that continues to produce fibroblasts over a continued period of time. The most important of these processes is sub-clincial infection with Staph epidermidis[10]. Other factors include tissue injury from blunt dissection or fibrosis resulting from any small hematoma or foreign material. This foreign material may be microscopic debris on surgical gloves, latex

microparticles from gloves, desquamated skin cells from adjacent to the wound, electrocautery products retained in the dissection pocket, or dust particles from the theatre environment attracted by electrostatic charges created by friction between implant and its environment before implantation.

Therefore some surgeons[11] recommend a set of precautions at each operation involving implant insertion. These include:

1. covering nipple areola complex in the surgical field with clear adhesive dressings (e.g. Tagaderm™)
2. using sharp atraumatic dissection using electrocautery (facilitated by surgery under direct vision)
3. active extraction of electrocautery fumes
4. change of gloves for insertion of each implant, as well as re-prep of the surgical field (with aqueous antiseptic)
5. instillation of an aqueous antiseptic / antibiotic solution in the implant packaging before its removal (to deliver antibiotic and to minimise any electrostatic attraction of dust particles on to the implant)
6. thorough washout of implant pocket to remove any debris
7. instillation of the implant cavity with antibiotic or antiseptic solution (see below)

There is no consensus in the choice of antibiotic/ antiseptic but combinations range from a single agent (e.g. betadine), two agents (e.g. gentamicin-cephalosporin) or three agents (e.g. an antibacterial-antiviral-antifungal combination). The senior author (M.C.) in his aesthetic practice, uses all the above steps with clindamycin as his choice of antibiotic for instillation. With respect to time taken, we find that with some practice all these steps can be performed swiftly and do not impact overall surgical time.

(C) Shape

A definitive breast implant may be round or anatomical in shape. While the round implants may have a smooth or textured surface, majority of anatomical (also called 'shaped') implants have a textured surface. The exception being the TruFixation™ anatomical implants by Motiva (Establishment Labs, Costa Rica) which have a nanotextured surface and use tabs to suture the implant in place.

There has been a long standing debate about the merits and demerits of each implant shape. Those preferring round implants point to the perceived lack of aesthetic benefit and a certain rate of rotation of the anatomical implants. In the senior author's (M.C.) opinion, the final shape of the breast is determined firstly by the thickness of the soft tissue and then by the underlying implant, i.e. if the soft tissue cover is thin (e.g. most cases of implant-only breast reconstruction) the final shape is determined by the underlying implant[12,13]. But if the soft tissue cover is thick (e.g. a pedicled latissimus dorsi flap) the final shape of the breast is less dependent on that of the implant. In general, anatomical implants are important in cases where a more natural final breast shape is desired, or where there is need for preferential expansion of the lower pole (e.g. in tubular shaped breasts). The anatomic implants are generally more expensive than the round ones.

(D) Dimensions

The chosen implant needs to respect the anatomical landmarks. So it must not breach the boundaries of the foot plate discussed above. This leaves the projection and the choice of implant shape as the determining factors for the final breast shape. A round implant's most projected point is the center of its vertical dimension (i.e. diameter). Aesthetically, that places it well above the existing (in case of IBR) or new (in case of DBR) infra-mammary fold. The most projected point of the anatomical shaped implants is relatively lower in its vertical dimension, which alongside the tear drop shape, can give the final result a more natural shape. However, neither implant shapes can reproduce a ptotic look on their own, which is a limitation of breast reconstruction by implants only.

(E) Volume

The final volume is dependent on the physical dimensions of the implants, but also on the implant shape. Anatomical implants for the same base dimensions and projection, have less volume in the upper pole and therefore have less total volume and are lighter than round implants. Some surgeons emphasize volume as the primary measurement unit for the choice of implant which, in our opinion, misses the opportunity to plan reconstruction using physical dimensions of the base plate.

How to choose and position an implant:

Several methods have been described to allow surgeons to choose an implant for aesthetic breast surgery. Of these, the two most commonly cited methods are those by Per Hedén[14,15] and John Tebbetts16. In turn, these methods have been adapted for use in implant based breast reconstruction.

1. Implant shape is chosen based on the desired result and available soft tissue cover.
2. The dimensions of the contralateral footplate are copied (assuming they are within an acceptable range of dimensions described as "normal). The thickness of ipsilateral soft tissues needs to be subtracted from this measurement to obtain the possible base-dimensions of the required implant. The simplest clinical measurement of the soft tissue contribution is the "pinch thickness" at that point (measured by gently pinching the tissues between the examiner's thumb and index finger). The pinched tissue consists of two layers of skin and soft tissue (Figure 2) Hence the soft tissue

thickness is half of this pinch thickness. Thus half of the local pinch thickness at medial and lateral extents is subtracted from the width of the footplate to get the maximum implant width/diameter. In case of anatomical implants, a similar calculation can provide the maximum height as well.

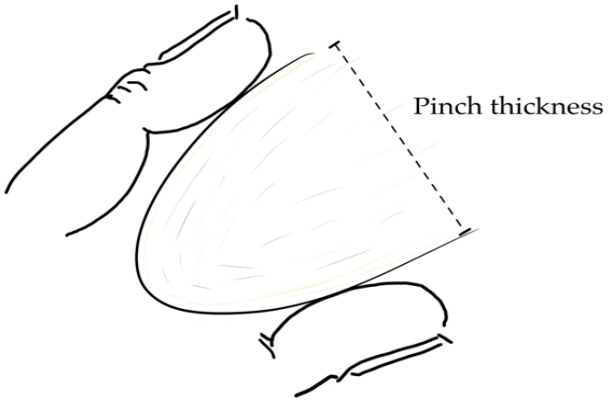

Figure 2: Skin pinch is a quick clinical measurement as half of skin pinch ("half skin pinch") is the local tissue thickness. The half skin pinch is measured at both medial and lateral extents of the breast. The sum of these values is the tissue contribution to the breast width. Subtracting this tissue contribution from the measured breast width is the maximum allowable width/diameter of a breast prosthesis.

3. Once the shape and base dimensions have been decided, then choosing either the projection or the volume completely specifies the implant. Tebbetts[16] described a clinical method to estimate the implant projection in aesthetic breast surgery by anterior translation of the NAC. However, the senior author (M.C) finds some elements of this method unreliable and prefers instead to list a range of options of implant volume and projection for the patient. The patient tries out these different sizers in clinic (and possibly at home too, using a fillet made by pouring a known volume of rice in a plastic bag- the "rice-bag test").

Once chosen, the implant is placed so that an ideal NAC (constructed later, using local flap, or tattooing) is positioned in the breast meridian and that approximately 60% of the resultant volume is below the NAC[17] (Figure 3).

Pros and Cons of implant based breast reconstruction: Implant based breast reconstruction is sometimes considered a short, quick-fix operation but it poses more issues in the long term. If the patient needs radiotherapy, there is higher risk of skin break down and adverse capsule formation. The already thin skin and an adverse capsule can compromise the aesthetic outcome. Even in best of situations, the breast reconstructed with implants looks different from contralateral, has limited ptosis and does not droop over time as the contralateral one thus leading to increasing asymmetry. There are further concerns about risk of implant rupture and BIA-ALCL[16]. At the end of all this, it only provides volume symmetry for the patient, which may appear acceptable in clothes.

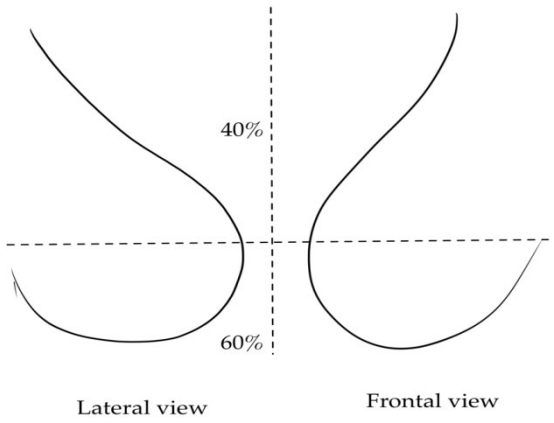

Figure 3: 40% of breast tends to be above the nipple and approximately 60% is below it. Although there is discrepancy as to whether it means volume or height of the breast (The ratio was first measured as height on photographs, but more recently has been used to describe volume as well). Sometimes an alternative ratio of 45:55 is used instead. In practice, the difference is only a few millimeters.

CONCLUSION

In our opinion, breast reconstruction surgery needs to be individualized to the patient by offering all modern surgical options. While implant based breast reconstruction is suitable for some patients, it is just one tool in the surgeon's toolbox and should not be considered as the only solution for every patient.

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Author Affiliations: Department of Plastic Surgery University Hospitals Birmingham, UK

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