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Chest and breast MRI: the added value of a fast imaging for a new diagnostic approach in the planning of augmentation surgery in patients with thoracic asymmetries

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Abstract. – OBJECTIVE: In breast augmentation surgery, breast symmetry depends on the breast tissue, implants and chest wall. Any asymmetry of the anterior thoracic wall can influence the breast shape. If breast asymmetry is detected in the preoperative evaluation, a chest wall deformity should be suspected. Until now, very few reports describe the use of MRI to objectively assess breast and chest measurements with the aim of providing customized augmentation. This study describes the use of MRI to evaluate breast and chest wall asymmetry, and considers the feasibility of preoperative measurements which are useful for performing an objective preoperative evaluation.

PATIENTS AND METHODS: Between April 2012 and February 2013, 13 patients underwent chest/breast MRI scan. Scans were performed on a 1.5 T scanner using a single T1 FSE non-suppressed axial sequence, without contrast administration. Acquisitions included the breast and chest wall. Specific measurements were obtained to assess the overall shape of the chest wall and breast, as well as any asymmetry.

RESULTS: All patients showed some degree of left-right side asymmetry on specific thoracic, breast and implant measurements. MRI provided detailed and objective data.

CONCLUSIONS: Preliminary findings revealed the value of breast/chest wall MRI in the planning of augmentation surgery. MRI is a valuable technique in young women because there is no use of ionizing radiation. Scans allow surgeons to determine the best surgical approach and obtain reproducible and better aesthetic results.

Key Words:
Magnetic resonance imaging, Breast implants, Thoracic wall asymmetry, Mammaplasty, Measurements.

Introduction

The symmetry and shape of the human breast depend on two key elements: the breast tissue itself and the underlying chest wall.

In breast augmentation surgery, a third element that contributes to the final appearance of the breast is the type of prosthesis used[1].

Surgeons performing breast augmentation have to carefully consider the first two elements, as well as the prosthetic devices, as part of the surgical approach.

Any asymmetry and variation in the contour of the anterior thoracic wall can influence breast shape and symmetry and lead to a distorted appearance. Therefore, chest wall analysis is a valuable element in the preoperative assessment of patients requesting breast augmentation[2].

Chest wall evaluation may help to predict the surgical outcome and improve the surgical approach; chest wall and breast analysis allow for more reproducible and better aesthetic results, improving patient satisfaction[1-9].

Neglecting the assessment of the thoracic wall in breast augmentation may lead to poor or suboptimal aesthetic and surgical results: breast and chest asymmetries may first become evident postoperatively or even be accentuated by the surgical procedure.

The presence of chest wall abnormality and the preoperative anatomic features play a crucial role in the choice and type of implant, in its placement and in selecting the access site and positioning plane according to the specific needs of the patient[2].

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Rohrich et al[10] quantified the prevalence of breast and chest wall asymmetry by retrospectively examining standardized preoperative photographs of patients who underwent breast augmentation. Their data showed the high prevalence of natural asymmetries among these women and suggested a preoperative breast and chest wall analysis that aids both patient and surgeon satisfaction.

Hirsch and Brody[1] stressed this idea, analyzing standard chest computed tomography (CT) scans and showing the high prevalence of chest wall asymmetries and the associated surgical implications[1].

Chest wall asymmetries are classified into five categories: Poland syndrome, pectus excavatum, pectus carinatum, sternal clefts, and rib and vertebral anomalies[3].

Breast asymmetry is nearly always detected in patients with Poland syndrome and rib anomalies[2].

A condition still frequently misdiagnosed by plastic surgeons is anterior thoracic hypoplasia (ATH) which was defined for the first time by Spear et al[3] as the presence of unilateral chest wall depression combined with hypoplasia of the ipsilateral breast, superior location of the nipple-areola complex when compared with the contralateral side, and normal pectoralis muscles. This thoracic condition is often misdiagnosed or neglected at the preoperative evaluation for breast augmentation, and its presence may only become evident after post augmentation results, because breast implants accentuate this type of deformity.

In the evaluation of patients seeking primary breast augmentation or secondary correction, plastic surgeons at our institution take special care to recognize patients with ATH in order to provide a tailored primary augmentation or correction for each side, as suggested by Spear[3].

In ATH it is very difficult to objectively and precisely quantify the discrepancy of chest and breast asymmetry with clinical evaluation alone.

Although there are studies concerning the use of CT to objectively assess breast and chest measurements to provide customized breast augmentation, we found very few reports that describe the use of magnetic resonance imaging (MRI) for such assessments[11-13]. This study describes the use of MRI as a feasible, fast and safe technique to evaluate chest wall asymmetry.

In collaboration with the plastic surgeons, we describe chest and breast MRI as a valuable tool for the assessment of the degree of correction between the two hemithoraxes in the preoperative analysis of secondary augmentation and implant replacement, in patients with unsatisfactory primary augmentation mammoplasty.

MRI scan of the chest wall can help surgeons plan primary and secondary breast augmentation and predict postoperative results. We believe MRI would be an invaluable imaging technique in the management of patients with thoracic and breast asymmetries, especially in particular chest wall and breast conditions such as ATH.

Patients and Methods

Our study is based on the concepts and analysis that emerged from the work of Hirsch and Brody[1]. In agreement with the surgeons at our hospital, considering that all the patients were female and mainly of a young age, we judged MRI a better option for the evaluation of chest asymmetries.

Between April 2012 and February 2013, 13 patients underwent chest/breast MRI scan. All patients were female. The average age was 38.5 years. Exclusion criteria were standard MRI exclusion criteria and previous major thoracic surgery or thoracic trauma.

Previous breast surgery and augmentation mammoplasty were not considered exclusion criteria because this study describes an analysis of chest and breast asymmetries which is not dependent on previous surgical procedures of the breast.

Informed consent, including potential risks and benefits of the procedure, was obtained from all patients.

The protocol of this study was approved by our Institutional Review Board.

All patients showed some degree of breast/chest wall asymmetry on clinical examination.

All the patients were subjected to a careful palpation of the chest wall by the surgeons, with particular attention to the comparison of the thorax shape on each side and the evaluation of the nipple-areola position, and all of them received a preoperative diagnosis of ATH.

Of the 13 patients with ATH evaluated with chest/breast MRI, 10 underwent bilateral breast augmentation. In one patient, the augmentation was unilateral; 2 of them had had no previous breast surgery. The patients with ATH who underwent previous augmentation were not satisfied with the first postoperative aesthetic results and were seeking corrective surgery.

Given the difficult and complex preoperative evaluation of the asymmetries in ATH[3], we chose MRI imaging together with the surgeons for the evaluation of this condition.

MRI is a panoramic examination, and it can assess the degree of thoracic depression and breast hypoplasia and provide objective evaluation of the breast and implant diameters. It gives precise information about thoracic wall conditions which may be otherwise very difficult or not possible with preoperative inspection.

All scans were performed on a 1.5 T MRI scanner (Signa Excite; GE Medical System, Milwaukee, WI, USA). Patients were placed in a prone position and examined using bilateral breast surface coils. MRI protocol involved a single T1 FSE axial sequence, without fat tissue signal suppression, therefore making the examination very fast. The duration of this axial sequence is about 3 minutes and 30 seconds. No contrast was administered during the evaluations. For all patients the scan included the breast and chest wall, up to the vertebral column.

For each patient, measurements were taken at a plane passing through the nipple to assess the overall shape of the chest wall and to establish the presence of asymmetry. The maximum transverse thoracic diameter (lateral thoracic width, LW) was measured between the most lateral internal points of the thoracic cage (Figure 1a).

On each side of the chest, the maximum anterior-posterior diameter (AP) was also measured between the most anterior and the most posterior point of the thoracic cage, at a plane passing through the nipples (Figure 1a).

These three measurements were helpful to define the overall thoracic shape.

Three internal thoracic angles were also calculated.

The anterior thoracic angle (A) was helpful to evaluate lateral width asymmetry. For each side this angle was measured from the most lateral

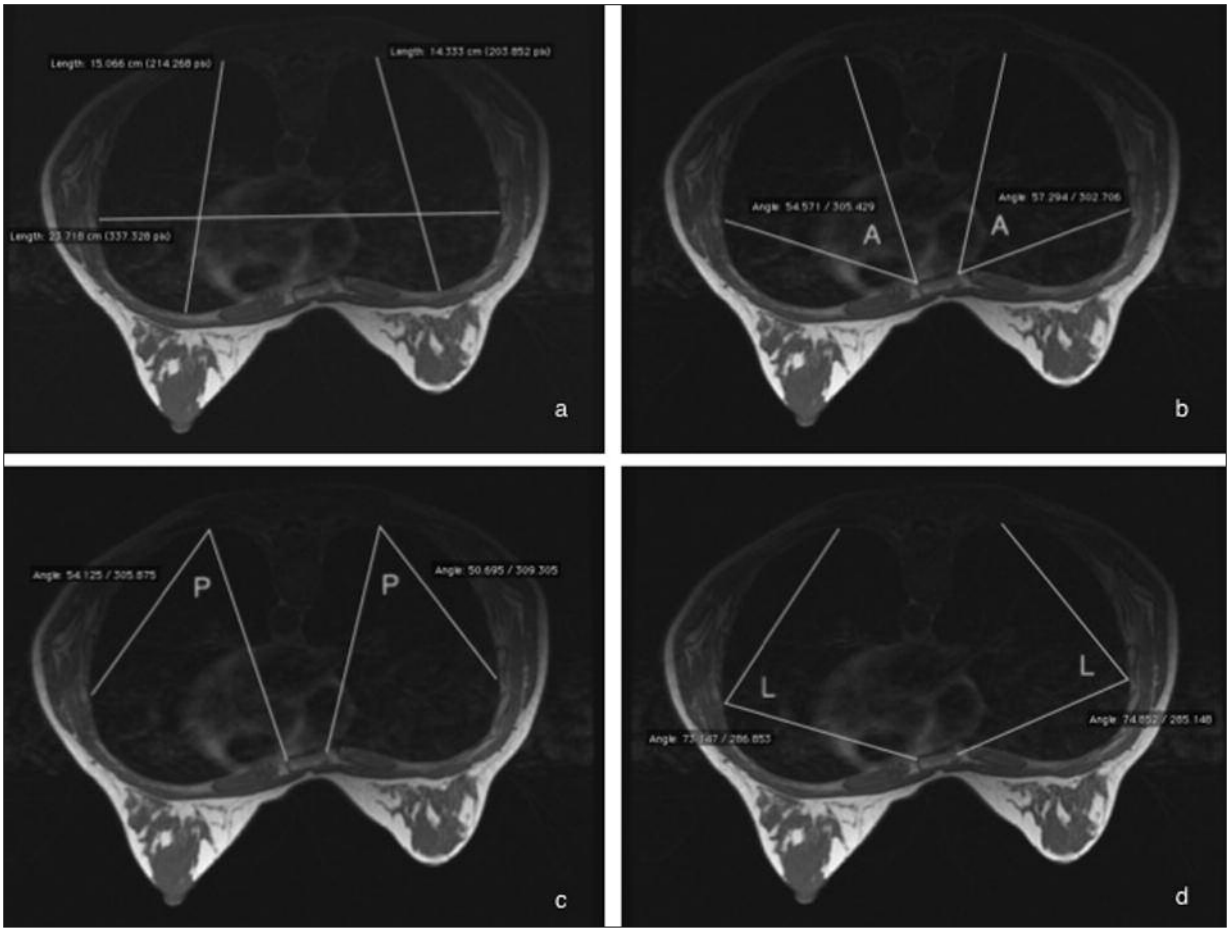

Figure 1. ***a,*** Thoracic transverse diameter (Lateral thoracic width) and anterior-posterior diameters. ***b,*** Anterior thoracic angle (A). ***c,*** Posterior thoracic angle (P). ***d,*** Lateral thoracic angle (L).

point on the thoracic cage to the ipsilateral side of the sternum to the most posterior point of the thoracic cage (Figure 1b).

The posterior thoracic angle (P) was helpful to evaluate the degree of vertebral body-sternum alignment. For each side this angle was measured from the most lateral point to the most posterior point on the thoracic cage to the ipsilateral side of the sternum (Figure 1c).

The lateral thoracic angle (L) was used to evaluate overall shape and anterior-posterior deformity. This angle was measured bilaterally from the lateral border of the ipsilateral side of the sternum to the most lateral point on the thoracic cage to the most posterior point of the internal posterior wall (Figure 1d).

These measurements were described for the first time by Hirsch and Brody[1] to quantify overall chest wall asymmetries and to outline the role of the chest wall in the final outcome of breast augmentation surgery.

In agreement with the plastic surgeons of our hospital and the clinical needs, we made additional measurements. These further analyses were particularly useful in evaluating thoracic asymmetries and objectively quantifying the degree of asymmetries in patients with a diagnosis of ATH who had already undergone primary breast augmentation.

In patients who already had primary breast augmentation surgery, we measured the anterior-posterior diameter of the breast, excluding the implant (Breast Anterior-Posterior diameter, BAP). This measurement was helpful to quantify the degree of breast hypoplasia (Figure 2a).

The maximum transverse diameter of the breast at the nipple level (Breast Lateral diameter, BL) was measured to quantify the width of already placed implants, and to plan the shape and dimension of future implants prior to augmentation (Figure 2b).

Furthermore, for each side, the anterior-posterior diameter from the most posterior point of the thoracic cage to the apex of the nipple was also measured (Thorax-Breast Anterior-Posterior diameter, TBAP) (Figure 2c).

This last measurement was useful to evaluate the postoperative final assessment between the two sides, because the difference in projection of the breast perceived by the observer depends on both the depression of the chest and the volume of the gland, examined at the nipple level, which is the maximum projection point of the breast (Figure 3).

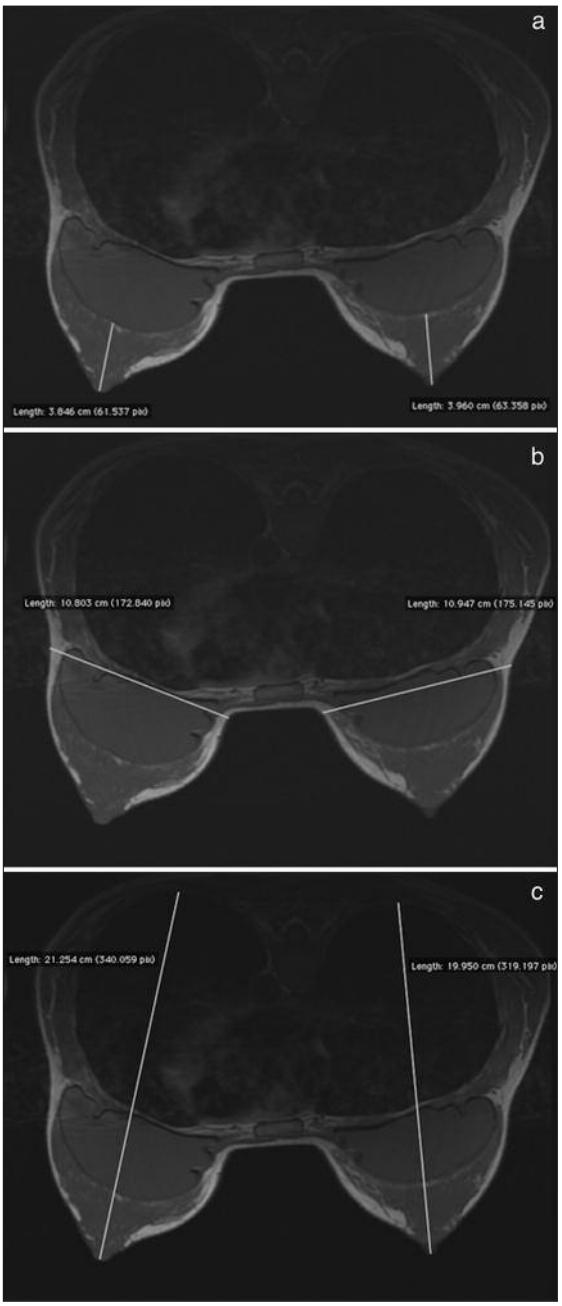

Figure 2. ***a,*** Anterior-posterior diameter of the breast, excluding the implant (*Breast Anterior-Posterior diameter*). ***b,*** Maximum transverse diameter of the breast at the nipple level (*Breast Lateral diameter*). ***c,*** Anterior-posterior diameter from the most posterior point of the thoracic cage to the apex of the nipple (*Thorax-Breast Anterior-Posterior diameter*).

Results

MRI scan demonstrated a certain degree of asymmetry between the right and left sides of the thorax in all patients as detectable by the thoracic anterior-posterior diameter (AP).

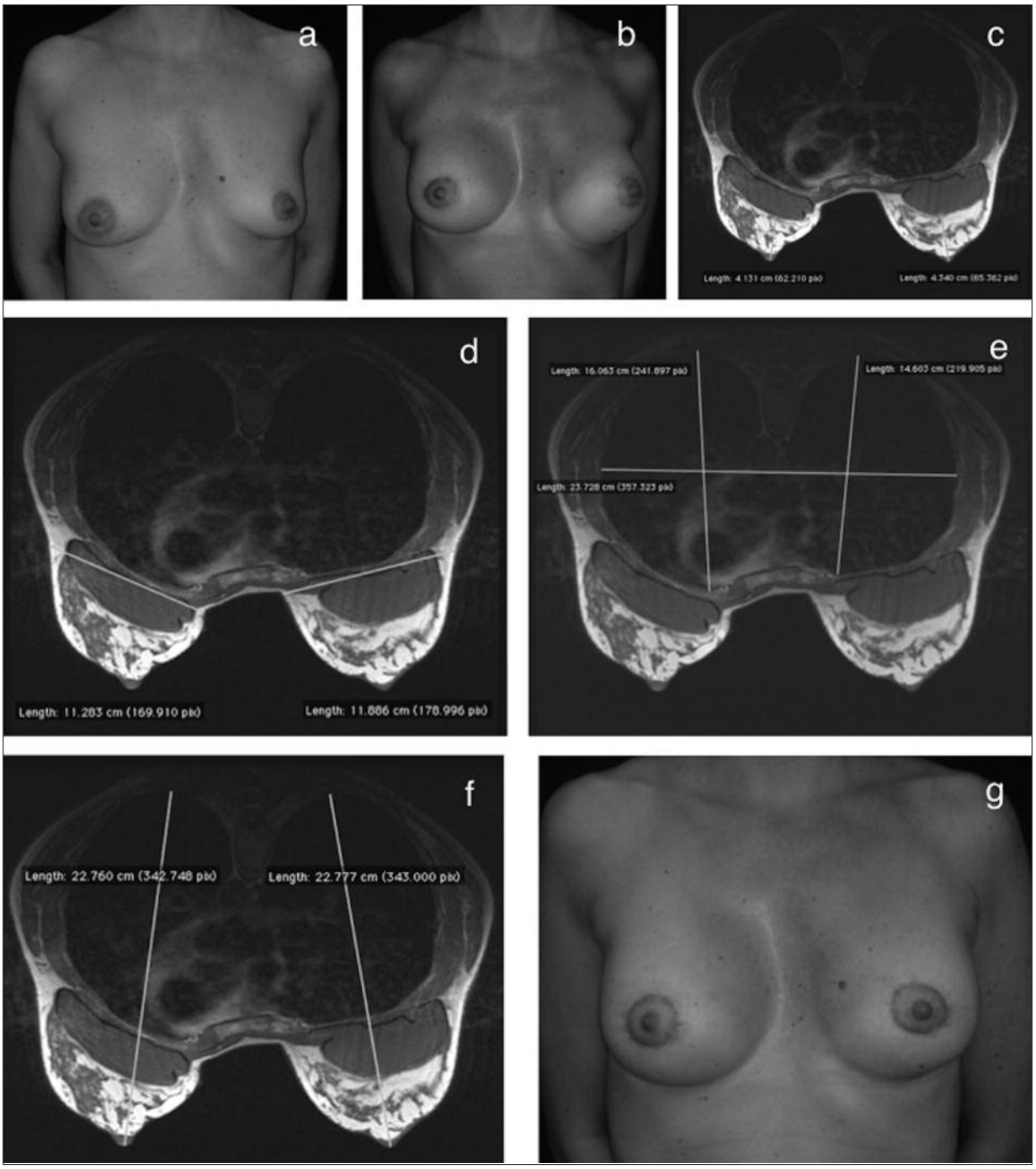

Figure 3. ***a,*** Example of a patient with breast asymmetry. Preoperative photo showing breast asymmetry. ***b,*** Postoperative photo of the same patient. The outcome was sub-optimal: the left breast projects laterally and the left inframammary fold is more caudal compared to the right side. Corrective surgery was therefore performed after an MRI analysis of the breast and chest wall ***(c, d, e, f)***. Preoperative MRI measurements were helpful to customize the surgical approach. ***g,*** The same patient after corrective surgery: the left breast projection and the level of the left inframammary fold were corrected.

MRI evaluation also showed that the values for the breast anterior-posterior diameter (BAP) and breast maximum transverse diameter at the nipple level (BL) were different for all the patients, showing differences in breast tissue between the right and left sides.

In this paper we decided to report only a summary of the measurements and data that emerged in our study, which outlines the differences between the right and left sides of the chest and breast (Tables I, II).

For all the patients who underwent primary breast augmentation, the values of the TBAP diameters and the values for the difference between the two TBAP diameters, which shows whether the choice of implant was effective to balance the differences in the AP diameters of the chest and breast projection, were helpful to assess the postoperative results.

Even though the number of patients was smaller than the series of Hirsch and Brody[1], our preliminary data confirm the previous observations: all patients have some degree of right-left asymmetry in the three angular measurements and in the anterior-posterior chest diameter.

This data/trend was also confirmed by the novel additional measurement we made in agreement with our plastic surgeons.

The surgical approach could be tailored for each single patient according to the magnitude of the chest wall defect and breast asymmetry that emerged from the preoperative scan, and the selection of the type and size of the prosthesis could also be customized.

Discussion

The findings emerging from this preliminary study revealed the value of breast and chest wall MRI scan in patients presenting with suspected chest wall asymmetry.

Often preoperative recommendations regard generic groups of malformations of the anterior chest wall.

Thoracic and breast MRI scan prior to primary or secondary mammoplasty will allow plastic surgeons to achieve more predictable and reproducible postoperative results. MRI evaluation is particularly valuable in the anatomical and clinical condition of ATH.

Even now, this clinical entity is rarely discussed by many surgeons; performing correction of breast hypoplasia in this kind of patient without a careful and precise preoperative assessment of the chest wall and breast glands can lead to very poor aesthetic and surgical results. The treatment planning of these entities, which are characterized by chest wall depression and breast asymmetry, and the choice of prosthesis are completely different for each patient.

It is of great value to understand the asymmetry and the variations in the chest wall prior to breast augmentation because the breast projection and degree of symmetry vary postoperatively, and can even be accentuated.

Chest and breast MRI preoperative analysis in augmentation surgery can be used to avoid subjective assessment and guarantee more reproducible evaluation compared to visual review, and provide more detailed information compared to chest scanning using optical imaging techniques[4,14,15].

Table I. Values of thoracic measurements.

#Patient	Age	LW	(R) AP	(L) AP	(R) A	(L) A	(R) L	(L) L	(R) P	(L) P
1	46	23.81	14.05	14.86	57.65	55.76	73.7	74.09	49.61	51.34
2	48	26.88	13.69	13.62	42.32	46.65	76.76	73.86	60.34	59.51
3	29	23.74	11.92	13.21	40.43	41.8	76.09	83.27	63.16	54.48
4	41	23.53	14.81	15.73	40.9	40	83.7	87.19	55.79	52.63
5	42	26.86	12.66	13.63	40.83	48.11	70.74	71.46	67.94	60.58
6	33	23.59	15.1	14.51	45.48	49.99	85.11	84.48	49.39	45.91
7	33	21.91	13.93	13.68	32.27	31.17	86.86	85.47	60.88	63.31
8	29	22.3	15.45	14.79	31.5	32.75	90.84	88.9	57.32	58.22
9	35	21.08	13.03	13.46	42.26	39.67	84.61	83.46	53.19	56.71
10	55	23.72	13.58	14.65	72.6	53.46	61.19	70.01	46.26	55.88
11	40	25.24	14.89	15.07	39.23	34.93	82.9	85.02	58.32	60.36
12	31	23.89	14.84	14.67	40.86	39.18	84.14	87.83	55.16	52.77
13	32	23.56	11.77	12.72	41.34	43.87	77.65	74.86	60.74	60.4

Values of maximum thoracic transverse diameter (*Lateral thoracic width, LW*), and right (R) and left (L) side maximum anterior-posterior diameter (AP), anterior thoracic angle (A), lateral thoracic angle (L), posterior thoracic angle (P). Values are expressed in centimetres (cm) for the diameters, and degrees for the angles.

Table II. Values of thoracic and breast measurements.

#Patient	Age	(R) BL	(L) BL	(R) BAP	(L) BAP	(R) TBAP	(L) TBAP
1	46	9.22	8.76	–	–	20.84	21.74
2	48	8.28	5.53	–	–	19.1	20.07
3	29	10.94	10.80	3.96	3.84	19.95	21.25
4	41	11.88	11.28	4.34	4.13	22.77	22.76
5	42	11.81	11.01	1.82	1.80	19.18	19.40
6	33	10.39	10.62	4.54	3.99	24.00	24.22
7	33	9.02	9.54	2.05	2.26	19.68	20.17
8	29	11.71	11.40	3.13	2.76	20.95	20.91
9	35	9.69	8.00	3.11	4.37	21.56	19.52
10	55	11.02	10.08	3.58	–	20.43	19.39
11	40	12.27	12.89	2.90	3.06	22.23	23.04
12	31	10.40	11.43	2.70	2.82	22.26	21.94
13	32	9.96	8.45	3.85	3.70	19.53	20.82

Values of right (R) and left (L) maximum transverse diameter of the breast (*Breast Lateral diameter, BL*), anterior-posterior diameter of the breast, excluding the implant (Breast Anterior-Posterior diameter, BAP), anterior-posterior diameter from the most-posterior point of the thoracic cage to the apex of the nipple (*Thorax-Breast Anterior-Posterior diameter, TBAP*). BAP measurements were not obtained in breasts without implants. Values are expressed in centimetres (cm).

It is also difficult to accurately quantify the magnitude of breast and chest asymmetry with physical evaluation alone.

The data obtained from the scans help physicians to easily determine the implant and surgery type and to eliminate the majority of postoperative complaints and patient dissatisfaction, ensuring that the best aesthetic results are obtained for each patient.

In agreement with the plastic surgeons at our hospital, we judged MRI scan an optimal technique because, as pointed out by Hirsch and Brody[1], in these young female patients the same information provided by CT scan can be obtained without the use of ionizing radiation.

All the useful information for the preoperative workup of breast implant surgery could be achieved with a very fast examination using a single T1 FSE sequence, without fat tissue signal suppression.

A significant point is that there was no need for intravenous contrast administration.

In addition, MRI provides excellent soft tissue contrast and multiplanar imaging.

MRI scan was also recently suggested as a valuable imaging technique in the preoperative workup for pediatric patients with pectus excavatum[16-18].

MRI provides a less subjective approach towards patients seeking breast augmentation.

MRI examination, together with the clinical features, allows surgeons to make easier diagnoses of thoracic hypoplasia and other clinical conditions, and in case of any abnormality, measurements obtained by MRI scans help to quantify the degree of breast and chest wall discrepancies.

MRI evaluation of thoracic measurements can help to predict the difference of implant projection between the two sides.

Preoperative MRI can make definitive diagnosis of ATH by comparing the values between the two sides, in addition to the clinical criteria.

MRI scans help quantify breast and chest asymmetries and predict whether they are correctable by implants, or whether the use of a flap or a customized/prefabricated chest implant or flaps is required.

It is our belief that an increasing number of plastic surgeons will request this type of measurement to be performed by radiologists in the preoperative planning of breast augmentation or reconstruction surgery in order to achieve an objective and reproducible evaluation of the patients' breast and chest shape and consequently obtain a predictable surgical outcome.

With chest wall and breast MRI, radiologists can play a crucial role as consultants in the preoperative workup in breast surgery providing more reproducible and easily achievable data compared to other non-radiological imaging techniques (e.g. optical imaging).

One limitation of our study could be, given the particular clinical condition considered, the rela-

tively low number of participants. Therefore, further research is needed. In particular, it would be useful to include a broad group of thoracic asymmetries in further studies.

Another commentary, as also mentioned by Hirsch and Brody[1], is that it is not easy to determine the clinical implications of the measured asymmetries, and the clinical significance will vary from patient to patient. Precisely for this reason we think an unbiased evaluation like MRI, with its possibility of precise and objective measurements, conveys useful information to the surgeon.

Given these factors, it is important to consider a chest MRI scan in women presenting breast asymmetry with a clinical suspicion of thoracic asymmetry before breast augmentation to achieve an optimal result with a highly customized surgical approach.

The use of a preoperative MRI evaluation could have considerable positive medico-legal implications. For example, in specific groups of patients with chest or breast abnormalities (like ATH condition), the possibility of doing an easier and confident preoperative diagnosis and obtaining a consequent surgical planning, could give both the surgeon and the patient a realistic post-surgical outcome: this could avoid an unrealistic aesthetic expectation in these groups of women thus reducing medico-legal litigation. Another positive implication that could reduce medico-legal issues is that objective preoperative measurements give the surgeon the possibility of a more broad and precise shared planning with the patient about the selection of the shape and type of the implants, and about the customized surgical approach.

Conclusions

Familiarity with and understanding of these preoperative measurements by radiologists is essential to provide detailed and objective data in breast surgery, whether in primary and secondary breast augmentation, in breast reconstruction and in follow-up examination.

Considering the high prevalence of asymmetry and the range of variation in the chest wall, strengthening the collaboration between radiologists and plastic surgeons in this field can greatly improve surgical outcome and patient satisfaction.

Conflict of Interest

None of the authors have any potential conflicts of interest. In particular none of the authors have any employment, consultancies, stock ownership, honoraria, patent applications/registrations, and grants or other funding, financial or personal relationships with people or organizations that could inappropriately influence this work.

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