

Anatomical Variability of the Infra-mammary Fold and Its Dynamics in Relation to Lejour Mammoplasty

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Background: *The anatomy and tissue components of the infra-mammary fold (IMF) have been a matter of controversy among plastic surgeons and anatomists. This clinical study was done to detect variability in IMF anatomy (position and shape), to identify factors affecting its anatomical landmarks and also the influence of Lejour reduction mammoplasty on its position.*

Patients and methods: *The first part of the study was done on 40 female volunteers examined clinically to define the shape and relations of the IMF to either the rib cage or the intercostal spaces. Data including age, marital status, lactation and breast volume were noted. The second part of the study included 20 cases operated on and followed up for one year after Lejour reduction mammoplasty to evaluate the effect of breast volume change on the position of the IMF.*

Results: *The IMF is not a straight line or a simple curve; its medial end lies between the 5th and 7th rib while the lateral end lies between the 5th and 11th rib. The IMF intersects the breast meridian at the level of the 6th and 8th rib. The effect of breast reduction on the IMF is quite variable, it remained in the same level in 50% and elevated in 50%.*

Conclusion: *IMF is a dynamic structure that undergoes a downward-oriented migration and thus proper positioning and fixation of the IMF on the thoracic wall in breast reduction is a crucial step to achieve the finest results.*

Key words: *Inframammary fold; reduction mammoplasty; breast hypertrophy; breast reduction; breast.*

Introduction:

The infra-mammary fold (IMF) is one of the most important factors in determination of aesthetics of the female breast. Being one of the 2 zones of adherence of the breast; this anatomic landmark is frequently used as a reference point in cosmetic and reconstructive breast surgeries.¹

The anatomy and tissue components of the IMF have been a matter of controversy among plastic surgeons and anatomists. Radiologically, the IMF was found opposite to the 6th rib in most of the cases in one series.² Some have attributed formation of the fold to a distinct ligament,^{3,4} while others described a superficial fascial system.^{5,6} Despite this controversy; most of the plastic surgeons settled on a thought that the preservation of

the integrity of the IMF is an important goal in enhancing the aesthetic result in all breast surgeries.

In aesthetic surgery of the breast it is recommended that all skin marking should be above the IMF as any skin excision or undermining that extends to the area of the IMF will lead to cut off the dermal connection to the skin with loss of the smooth curvature of the lower pole of the breast with less satisfactory results.⁷ In some breast reduction techniques as inferior and central pedicles the fold is not elevated,⁸ however in other techniques the fold is sometimes violated and elevated.⁹ In these situations it should be re-created again through suspension of the pectoral fascia to the dermis of the skin overlying to prevent its descent.

This clinical study was done to detect variability in IMF anatomy (location and shape), to identify factors affecting its anatomical landmarks and also the influence of Lejour mammoplasty on its position.

Patients and methods:

This study was done between June 2011 and December 2012 in the Plastic Surgery Department, Ain Shams University. All patients signed an informed consent.

The first part of the study was done on 40 female volunteers who presented to our outpatient clinic for other procedures. Data including age, marital status, lactation and volume were noted and are summarized in (Table 1). All of them were examined clinically to define the shape and relations of the IMF to either the rib cage or the intercostals spaces at three points;

1- Point A; at the medial most point of the IMF.

2- Point B; at the breast meridian.

3- Point C; at the lateral most point of the IMF.

Each patient underwent bilateral mammogram with the volume of the breasts being calculated using the formula proposed by Kalbhen et al.,¹⁰ because its superiority has been demonstrated in previous studies;

$$\text{Breast volume} = \pi/4 \times (W \times H \times C)$$

Where W= breast width, H= breast height and C= compression thickness in craniocaudal mammography. The measurement was performed using a ruler on the mammography while the compression thickness was measured by the operator.

The second part of the study included 20 cases who presented to our hospital for breast reduction surgery. They all had breast reduction by superior pedicle technique described by Lejour, 1996¹¹ operated by the same team and followed up for one year. All patients were reassessed to evaluate the effect of breast volume change on the same 3 points as in the first part of the study. Patients' demographic including age, marital status, lactation and volume are presented in **Table (2)**.

Surgical technique:

- Pre-operatively with the patient standing marking of the sternal notch, the chest midline, the breast meridian (not necessarily crossing the nipple) and the IMF were done with the new nipple position marked according to the patients' degree of ptosis.

- Next, the standard keyhole and its arms pattern were marked to form a curve 4 cms above the inframammary fold. Then a superiorly based vertical pedicle was marked extending to 2 cms below the nipple areola complex (NAC). Lastly, the periareolar area 4.5-5 cms in diameter was marked.

- Intra-operatively with patients in the supine position and the arms extended at 90 degrees; the skin on the pedicle was de-epithelised. Subsequently, skin flaps were undermined and thinned starting from the lower pole followed by lower medial and finally lower lateral areas.

- At the end of undermining, the NAC was transposed to its new position and closed with 3/0 and 4/0 PDS followed by suturing of a 7cms medial and lateral pillars using 2/0 PDS interrupted sutures, then the skin flaps were closed together centrally in a 7cms vertical scar pattern with the whole inferior margin fixed to the pectoral fascia at the new mammary crease position through 5-6 2/0 PDS dermal suture and then the area below this point was closed with 2/0 PDS pursing sutures and also fixed to the pectoral fascia. Lastly the vertical incision was closed with 3/0 PDS sutures and one suction drain was placed in each breast and removed within 3-5 days of operation.

Documentation was done by measurements with registration in the patient's file and medical photography. Breast volume was measured also by means of mammography as described former.

Statistical analysis:

Statistical presentation and analysis of the present study was conducted, using the mean, standard deviation and range for quantitative variables, unpaired student t-test to compare between two groups in quantitative data, Paired t-test used to compare between related

sample and linear correlation coefficient tests used for detection of correlation between two quantitative variables in one group by SPSS V17, Chicago, USA; a value of $P < 0.05$ was considered significant.

Results:

This study was done on 60 female patients to investigate variability in the anatomical location of the IMF and in response to breast reduction surgery.

In the first part of the study, the anatomical relation of the IMF and the rib cage was assessed in 40 cases (80 breasts). The mean age of patients was 30.25 ± 7.26 (range, 19 to 48 years). Of these, 28 patients were married (70%) and 12 were single (30%). History of lactation was evident in 27 patients. 13 breasts were hypoplastic, 3 were average in size and 24 were hyperplastic; the mean volume of breast was 755.47 ± 485.94 (range, 100 to 1629.9).

The IMF is not always a straight line or a simple curve; its medial end lies between the 5th and 7th rib space while the lateral end lies between the 5th and 11th rib (right side) or 10th intercostals space (left side). The IMF intersects the breast meridian at the level of the 5th and 8th rib **Figure (1)**.

Regarding the effect of the demographic variants on the IMF position; only the volume of the breast was found to be independent and significant predictor for the change in the IMF position at the 3 points of study (P -value $< 0.001^*$), while the marital status, age and lactation showed no significant difference **Tables (3-5)**.

In the second part of the study, the variability in the anatomical location of the IMF in response to breast reduction surgery was assessed in 20 cases. The mean age of patients was 33.15 ± 7.956 (range, 23 to 49 years). History of lactation was evident in all patients except for 3 patients. The mean volume of breast was 1044.9 ± 250.8 (range, 699 to 1988). As in the first part of the study only the pre-surgical volume of the breast was found to be independent and significant predictor for the change in the IMF position at the 3 points of study **Table (6)**.

The effect of breast reduction on the medial end of the IMF is quite variable, in all the patients the infra mammary crease was elevated in the early postoperative period however at the end of the 1 year follow-up period it retained its preoperative level in 10 cases (50%), and stayed elevated in 10 cases (50%). The mean pre-surgical volume of the breast which descended was 1271.68 (range, 940 to 1988), while the mean volume of those who remained at the early postoperative level was 818.05 (range, 699 to 993).

Discussion:

The IMF is a defining element in the shape and structure of the female breast. It is undetectable before puberty and defines the inferior extent of the breast with the onset of puberty.⁶ Because of its aesthetic significance, several techniques were described for recreation of the IMF after mastectomy with or without reconstruction as well as breast reduction and augmentation.

The anatomic components of the IMF have been a matter of controversy among plastic surgeons and anatomists. Blunt dissection techniques and gross observations described a ligament while histological studies did not detect any ligamentous structure in this area. Millard and Garey³ described a crescent shaped ligamentous band stretching from the anterior surface of pectoralis major muscle to the inframamary skin fold to be inserted slightly inferior to the inframamary crease. They called it the prepectoral ligament and suggested that it is responsible for the formation of the fold by supporting the breast as a sling.

Garnier et al.,² described histologically fibres passing from the deep prepectoral fascia to the superficial fascia and did not find any connection between the superficial fascia and the dermis. Radiologically, the IMF was found opposite the 6th rib in most of the cases. Bayati and Seckel⁴ carried out an anatomical study on the relation between the IMF and the underlying soft tissue structures along the rib cage. They described the inframamary crease ligament extending from the periosteum of the 5th rib medially to

the fascia between the 5th and 6th ribs laterally and inserts into the deep dermis of the IMF. They considered that this fold creates and defines the IMF and contributes to the breast shape particularly with ptosis and aging.

Muntan et al.,⁶ could not demonstrate ligamentous structure of dense connective tissue in their histological study. Instead, they found either fusion of the superficial & deep fascia and the dermis or fibrous insertion of the superficial fascia and the dermis at the level of the IMF. Pectoralis major, rectus abdominis and serratus anterior muscles were always present between the IMF and the rib cage.

According to Lockwood, 1991¹² the topographic landmarks of the human body are largely the result of the superficial fascial system and its relationship to fat and muscle fascia. Zones of adherence of the superficial fascial system to the underlying muscle fascia or periosteum form creases of the skin whereas areas with least adherence and localized fat deposits form bulges. The upper and lateral borders are relatively mobile while the medial and lower borders are fairly fixed zones of adherence¹³. Hall-Findlay, 2010¹⁴ described the breast as a subcutaneous structure having 4 footprint borders on which the breast shape is located as a third dimension. The lower border, the IMF, represents a zone of adherence, like many other areas in the body where the skin attached through fibres that prevents descent of the breast caudally. The IMF fibres are skin/fascial structures, not skin structures.

The ideal IMF is located at or above the

6th rib but it is quite variable from person to person.¹⁴ Nava et al., 1998 stated that it is situated at 5th - 6th rib with the inferior margin extending to the 6th intercostals space. Muntan et al.,⁶ found variability in the position of the IMF in relation to the rib cage being located superficial to the 5th, 6th, 7th, or 8th rib. The medial end was mostly at the level of the 5th or 6th costal cartilage while the lateral extent was mostly to the level of the 7th or 8th rib near the anterior axillary line. At the mid-clavicular point below the nipple-areola, the IMF was found over the 6th or 7th rib. There was no predictable relationship between the inferior & lateral borders of pectoralis major muscle and the IMF. In our study, we found that the IMF is not a straight line or a simple curve with the medial and lateral ends lying at the same level in relation to the rib cage, the lateral end tends to be lower. The lateral end of the IMF may reach a lower level than that described by Muntan et al.,⁶ (11th versus 8th rib).

The proper size of the breast is about 400 gm. Macromastia is considered when at least 200 gm of tissue are removed from at least one breast during operation, i.e breast volume at least 600 gm.¹⁵ The breast size is an important determinant of the breast shape, the third breast dimension.¹⁴ In our study, for the determination of breast volume we have chosen mammography as it is convenient, has a considerable cost, offers a high level of accuracy and reproducibility although it is associated with poor patient tolerability.¹⁶

The incidence of noticeable breast asymmetry ranges between 4% and 10% in

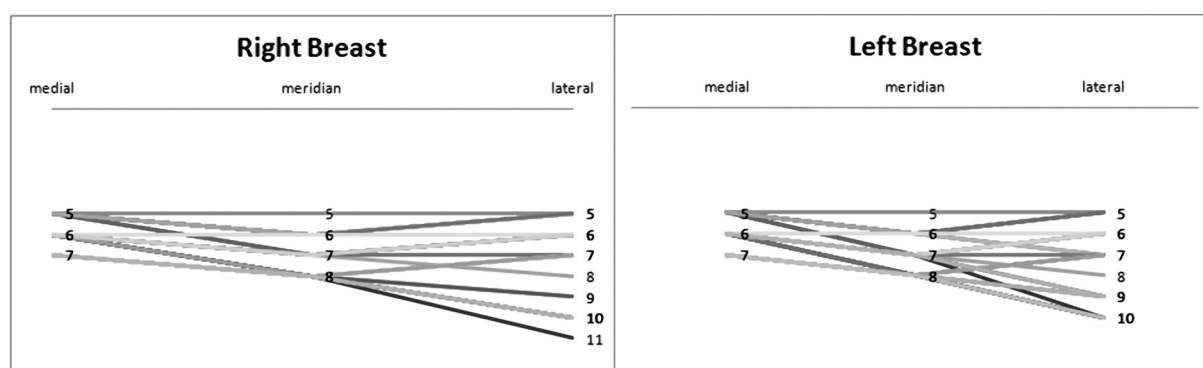


Figure (1): The shape of the IMF

Table 1:

Case number	Age	Marital status	Lactation	IMF				Volume
					Medial	Meridian	Lateral	
1	25	Single	No	Right	7r	8	11r	1472.2
				Left	6	7	10	966.4
2	19	Single	No	Right	5	6	5	837.9
				Left	5	6	5	837.9
3	20	Single	No	Right	5	6	5	371.1
				Left	5	6	5	371.1
4	32	Married	Yes	Right	5	7	6	145.8
				Left	5	7	6	145.8
5	26	Married	Yes	Right	6	8r	7	471.5
				Left	6	8r	7	471.5
6	21	Married	Yes	Right	6	8r	9	873.4
				Left	6	8r	9	837.9
7	27	Single	No	Right	7r	8r	10	1423.5
				Left	7r	8r	10	1314.8
8	20	Single	No	Right	7r	8r	10	953.2
				Left	6	7	9	802.4
9	37	Single	No	Right	6	8r	9	1314.8
				Left	6	8r	9	1314.8
10	39	Married	Yes	Right	6	8r	10	1503.3
				Left	6	8r	10	1503.3
11	23	Single	No	Right	5	7	6	651.6
				Left	5	7	6	651.6
12	26	Married	Yes	Right	6	7	8	1399
				Left	6	7	8	1455.5
13	30	Married	Yes	Right	6	7	7	1044.1
				Left	6	6	7	972
14	44	Married	Yes	Right	6	7	7	525.1
				Left	6	6	6	376.5
15	30	Single	No	Right	6	7	7	618.3
				Left	6	7	7	618.3
16	34	Married	Yes	Right	6	8r	10	1416.9
				Left	6	8r	10	1563.3
17	38	Married	No	Right	6	8r	10	1590
				Left	6	8r	10	1479.1
18	48	Married	Yes	Right	6	7	7	994.34
				Left	6	6	7	708.15
19	28	Married	Yes	Right	7r	8r	7	1629.9
				Left	7r	8r	7	1485.7

Case number	Age	Marital status	Lactation	IMF				Volume
					Medial	Meridian	Lateral	
20	48	Married	Yes	Right	6	7	6	1361.45
				Left	6	7	6	1361.45
21	27	Married	Yes	Right	5	6	6	1192.9
				Left	5	6	6	1301.6
22	25	Married	Yes	Right	5	6	6	965.45
				Left	6	6	6	965.45
23	28	Single	No	Right	5	6	6	525
				Left	5	6	6	971.25
24	23	Single	No	Right	5	6r	5	294
				Left	6	7	6	553
25	32	Married	Yes	Right	6	7	6	866
				Left	6	7	7	884
26	39	Married	Yes	Right	7r	8r	7	751.3
				Left	7r	8r	9	604.9
27	31	Married	Yes	Right	5r	5	5r	100
				Left	5r	5	5r	104
28	29	Married	Yes	Right	5	6	5	113
				Left	5	6	5	120
29	36	Married	Yes	Right	6r	7	6	279
				Left	6r	7	6	308
30	32	Married	Yes	Right	7r	8r	7	800
				Left	7r	8r	7	863
31	23	Married	Yes	Right	7r	8r	7	316
				Left	7r	8r	7	330
32	26	Single	No	Right	6r	6	6r	240
				Left	6r	6	6r	244
33	22	Single	No	Right	5r	6	6r	192
				Left	5r	6	6	409
34	40	Married	Yes	Right	6r	6	6r	273
				Left	6r	6	6r	287
35	26	Married	Yes	Right	6r	6	6r	139
				Left	6r	6	6r	132
36	32	Married	Yes	Right	6r	6	6	130
				Left	6r	6	6	144
37	28	Married	Yes	Right	6	7	6	106
				Left	6	7	6	106
38	30	Married	Yes	Right	6r	7	6	200
				Left	6r	7	6	200
39	30	Married	Yes	Right	7r	8r	10	1324
				Left	7r	8r	10	1314

Case number	Age	Marital status	Lactation	IMF				Volume
					Medial	Meridian	Lateral	
40	36	Married	Yes	Right	7r	8r	10	1053
				Left	6	7	9	902

(*) r= rib

Table 2: Patients' data:

Case number	Age	Marital status	Lactation	IMF (pre-operative)				Volume	IMF (post-operative)			
					Medial	Meridian	Lateral			Medial	Meridian	Lateral
1	28	Married	Yes	Right	7r	8	10	1429.9	Right	7r	8	10
				Left	7r	7	10	1385.7	Left	7r	7	10
2	28	Married	Yes	Right	7r	8	7	940	Right	7r	8	7
				Left	7r	8	9	940	Left	7r	8	9
3	38	Married	Yes	Right	7r	8	9	980	Right	7r	8	9
				Left	7r	8	9	980	Left	7r	8	9
4	45	Married	Yes	Right	7r	8	10	1370	Right	7r	8	10
				Left	7r	8	10	1370	Left	7r	8	10
5	26	Married	Yes	Right	7r	8	10	1539	Right	7r	8	10
				Left	7r	8	10	1532	Left	7r	8	10
6	23	Single	No	Right	7r	7	7	857	Right	5	6	6
				Left	7r	7	7	857	Left	6	6	6
7	34	Married	Yes	Right	7r	8	7	1988	Right	7r	8	7
				Left	7r	8	7	1988	Left	7r	8	7
8	28	Married	Yes	Right	6	7	7	816	Right	5	6	6
				Left	6	6	7	816	Left	5	6	6
9	29	Married	Yes	Right	7r	8	10	1024	Right	7r	8	10
				Left	7r	7	9	1150	Left	7r	7	9
10	37	Married	Yes	Right	6r	7	6	807	Right	5	6	5
				Left	6	7	6	807	Left	5	6	5
11	49	Married	Yes	Right	7r	7	8	1300	Right	7r	7	8
				Left	7r	7	8	1500	Left	7r	7	8
12	30	Married	Yes	Right	6	7	7	770	Right	5	6	6
				Left	6	6	7	770	Left	5	6	6
13	26	Single	No	Right	5	7	6	777	Right	5	6	5
				Left	5r	7	6	770	Left	5	6	5
14	37	Married	Yes	Right	6	7	7	704	Right	5	6	5
				Left	6	6	6	704	Left	5	6	5
15	32	Married	Yes	Right	6r	7	6	993	Right	5	6	6
				Left	6	7	6	910	Left	5	6	6

Case number	Age	Marital status	Lactation	IMF (pre-operative)			Volume	IMF (post-operative)				
					Medial	Meridian		Lateral		Medial	Meridian	Lateral
16	39	Married	Yes	Right	6	7	6	880	Right	5	6	5
				Left	6	7	6	863	Left	5	6	5
17	41	Married	Yes	Right	6r	7	6	931	Right	5	6	6
				Left	6	7	7	931	Left	5	6	6
18	44	Married	Yes	Right	7r	8	10	972	Right	7r	8	10
				Left	7r	7	9	983	Left	7r	7	9
19	25	Married	Yes	Right	6	7	7	699	Right	5	6	6
				Left	6	7	7	699	Left	5	6	6
20	24	Single	No	Right	7r	8	7	1030	Right	7r	8	7
				Left	7r	8	7	1032	Left	7r	8	7

Table 3: Shows no significant differences concerning the marital status in relation to the variation of IMF location.

	Marital status							
	Single			Married			T-test	
	Mean	±	SD	Mean	±	SD	T	P-value
Right								
Medial	5.75	±	0.87	6.04	±	0.64	-1.165	0.251
Meridian	6.83	±	0.94	7.11	±	0.88	-0.888	0.380
Lateral	7.17	±	2.21	7.11	±	1.59	0.096	0.924
Left								
Medial	5.67	±	0.65	6.04	±	0.58	-1.786	0.082
Meridian	6.75	±	0.75	6.96	±	0.92	-0.708	0.483
Lateral	7.08	±	1.88	7.14	±	1.58	-0.103	0.918

Table 4: Shows no significant differences concerning lactation in relation to the variation of IMF location.

	Lactation							
	No			Yes			T-test	
	Mean	±	SD	Mean	±	SD	T	P-value
Right								
Medial	5.77	±	0.83	6.04	±	0.65	-1.114	0.272
Meridian	6.92	±	0.95	7.07	±	0.87	-0.497	0.622
Lateral	7.38	±	2.26	7.00	±	1.52	0.638	0.527
Left								
Medial	5.69	±	0.63	6.04	±	0.59	-1.699	0.098
Meridian	6.85	±	0.80	6.93	±	0.92	-0.268	0.790
Lateral	7.31	±	1.97	7.04	±	1.51	0.481	0.634

Table 5: Shows no significant differences concerning age of the patient in relation to the variation of IMF location and also shows that the volume of the breast was found to be independent and significant predictor for the change in the IMF position at the 3 points of study (P-value <0.001*).

	Age		Volume	
	R	P-value	R	P-value
Right				
Medial	0.204	0.207	0.516	<0.001*
Meridian	0.180	0.266	0.609	<0.001*
Lateral	0.126	0.437	0.717	<0.001*
Left				
Medial	0.221	0.170	0.410	0.009*
Meridian	0.069	0.674	0.499	<0.001*
Lateral	0.153	0.347	0.657	<0.001*

Table 6: Shows that only the pre-surgical volume was found to be independent and significant predictor for the change in the IMF position at the 3 points of study (P-value <0.001*).

	Volume	
	r	P-value
Right		
Medial pre	0.645	0.002*
Meridian pre	0.515	0.020*
Lateral pre	0.650	0.002*
Medial post	0.224	0.342
Meridian post	-0.051	0.831
Lateral post	-0.013	0.956
Left		
Medial pre	0.673	0.003*
Meridian pre	0.751	0.004*
Lateral pre	0.544	0.013*
Medial post	0.212	0.369
Meridian post	0.045	0.851
Lateral post	0.109	0.649

the literature.¹⁷ Our study showed that more than half of the female-population is affected by minor degrees of asymmetry. Asymmetry was not the presenting complaint probably because only major variations may present significant physical, social, and psychological concern.¹⁸

Great variability was observed in the three reference points of the IMF; this variability correlates with breast volume, pregnancy and

lactation, probably due to laxity and stretch of the fold of the superficial fascial system although some authors stated that breastfeeding does not worsen breast ptosis.¹⁹ In our study, variability of the IMF is more pronounced at the lateral end (point c), that reached the 9th - 11th rib in 21 out of 80 hyperplastic breasts (26.2 %).

According to Hall-Findlay, 2010,¹⁴ an implant tends to lower the IMF even without

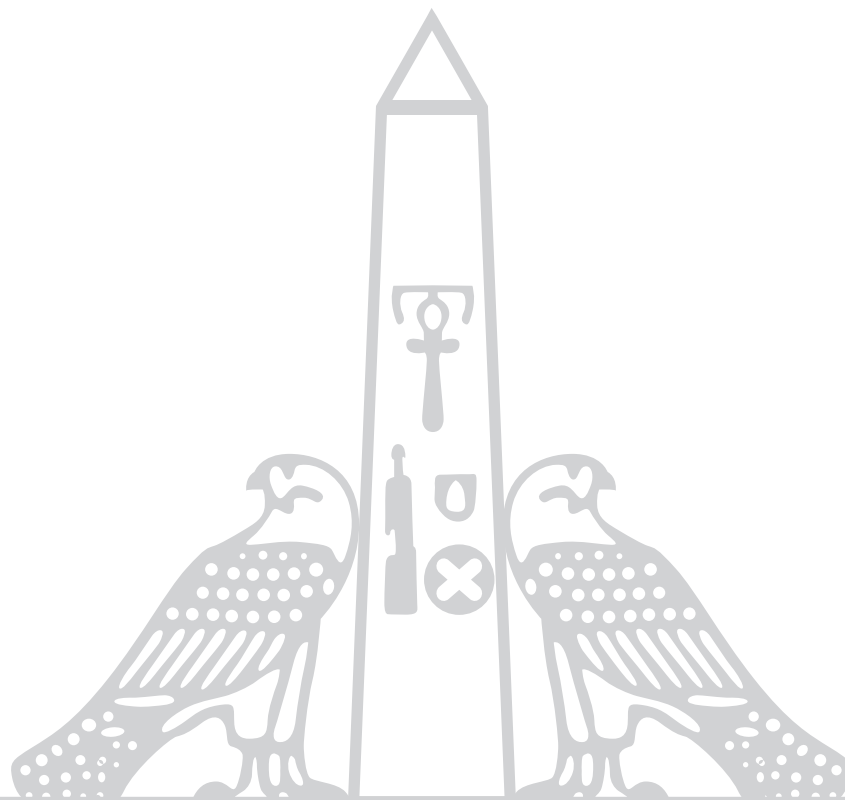
violation of its fibres. Breast reduction leaving the weight of the remaining breast tissue inferiorly or compression of the breast tissue by tight skin brassier closure also lowers the IMF. It can be elevated by removing breast tissue above the fold from the lower part of the breast as in superior or superomedial pedicle techniques or by liposuction. In our study, reduction mammoplasty by the superior pedicle technique tends to elevate or at least preserve the level of the IMF in 50% of cases after a period of 1 year. This is due to resection of the lower part of the breast parenchyma which tends to gravitate inferiorly with the inferior pedicle technique,^{11,20} and so we recommend that the patients be informed about this probability of IMF descent in addition to the usual complications of reduction mammoplasty.

The mean pre-surgical volume of the breasts with elevated IMF (818.05) was much less than the breast that retained the pre-surgical level (1271.68) and so to avoid this bottoming out we recommend that more elevation of the IMF (>4cms) with extra fixation at the new level should be done in breasts with high mean pre-operative volume (>820). We think that more studies with larger number of patients are needed to detect the critical pre-operative volume at which post-operative IMF descent might occur.

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