Changes in Spinal Alignment of Women Who Underwent Unilateral Mastectomy with Immediate Autologous Breast Reconstruction Compared To Mastectomy without Breast Reconstruction

Sophia Si Ling Heng,1,2,3 Yin Hui Gan,1 Maya Mazuwin Yahya,4 Juhara Haron,5 Wan Azman Wan Sulaiman2,3

Abstract
This study compared the physical impact of mastectomy with and without immediate autologous breast reconstruction on spinal alignment. Autologous breast reconstruction improved spinal alignment in the short and intermediate post-operative period, showing a positive correlation with breast volume. Comparing between types of autologous breast reconstruction, free flaps significantly improved spinal tilt over pedicled flaps.

Introduction: The impact of breast reconstruction on spinal alignment is not well studied, especially in immediate autologous breast reconstruction. Studies on body posture have shown greater asymmetry among those without reconstruction. This study compared the changes in spinal alignment pre- and post-operatively among women who underwent unilateral mastectomy without reconstruction (MA) versus immediate autologous breast reconstruction (IABR).

Methods: A cross sectional, retrospective study analysed MA and IABRs performed from January 2007 to December 2017 and their pre- and post-operative anterior chest radiographs. The change in Cobb’s angle (degrees) less than 1 year, 1 to 2 years, more than 2 years post-operatively were analysed using GE Healthcare Centricity Picture Archive and Communications Systems.

Results: 537 patients underwent mastectomy; 76 fulfilled the inclusion criteria (36 IABR, 40 MA). No significant difference existed between mean pre- and post-operative Cobb’s angle change across all 3 groups, less than 1 year (MA 3.57±3.84, IABR 3.316±2.72, p=0.81), 1 to 2 years (MA 1.84±4.81, IABR -2.68±3.21, p=0.577) and more than 2 years post-operatively (MA -1.14±5.30, IABR -0.94±5.10, p=0.898). However, raw data indicated IABR improved spinal alignment in the short and intermediate period post-operatively. Among IABR, free flap breast reconstruction improved spinal alignment compared to pedicled flaps (free flaps: 2.21±3.28, pedicled flaps: 0.01±3.67 (p=0.027)).

Conclusion: IABR has a positive impact on spinal alignment in early and intermediate post-operative period compared to MA, especially in women with larger breast volume. Physical benefits of IABR should be highlighted to improve patient’s access to breast reconstruction globally.

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Keywords: Breast neoplasms, Cobb’s angle, Mammaplasty, Spine, Reconstructive surgery

Introduction
Despite an improvement in diagnostic techniques over the past decade, the stage at which women are first diagnosed with breast cancer in the Asia-Pacific region varies widely. In Singapore, China,
Immediate Autologous Breast Reconstruction versus Mastectomy Alone

Hong Kong and Malaysia, a higher percentage of patients present at later stages of their disease. As such radical mastectomy remains the mainstay in these regions. Other factors also contribute to the high rates of mastectomy in these regions, namely patient’s choice, lack of qualified surgeons and lack of facilities.

The positive psychosocial impact of breast reconstruction post mastectomy is well studied by many researchers. Positive association of self-image, sexual well-being and general psychological health are critical issues justifying breast reconstruction in women post mastectomy. There has been a rise in breast reconstruction among western populations since enactment of the 1999 Women’s Health and Cancer Rights by the National Institute for Health in the United States. This is seen as well as in the United Kingdom, where Clinical Excellence recommendations are that all women should have post-mastectomy reconstruction made available to them. In Malaysia, the rates of breast reconstruction seem lower however literature is lacking in studies describing the rates of breast reconstruction performed and latest trends of reconstruction.

There are limited studies to date analyzing the physical impact of breast reconstruction. Few studies have been done studying the physical effect of breast reconstruction on women’s body posture and spinal kinematics. Unilateral mastectomy has been found to have a negative impact on body posture due to the loss of 1 side of breast tissue, causing compensation of the contralateral side. Unilateral mastectomy was also shown to have a long-term negative impact on women’s spinal alignment. Post unilateral mastectomy, physical therapy has been shown to improve the symmetry in body posture. An external breast prosthesis, however, did not improve the disturbances in body posture despite its attempt to balance the loss in breast tissue on the amputated side with an externally fitted weight.

Among the limited studies done so far analyzing the physical effects of breast reconstruction, all have shown an improvement in the spinal alignment and body posture in women who had breast reconstruction post unilateral mastectomy. Authors using photogrammetry to analyze body posture post unilateral mastectomy compared their findings in reconstructed and non-reconstructed women and found a reduction in asymmetry in women who have had breast reconstruction regardless of the type of reconstruction.

Our general objective was to compare the spinal changes of patients who had unilateral mastectomy with immediate autologous breast reconstruction to those without breast reconstruction. Specifically, we aimed to evaluate the pre-operative spinal alignment with its post-operative changes in women who had unilateral mastectomy without reconstruction; and then compare those findings to the spinal alignment changes pre-post operatively in women with immediate autologous breast reconstruction. We also sought to evaluate the differences between the spinal alignment changes in diverse types of autologous breast reconstruction.

Materials and Methods

We used non-random sampling, retrospectively selecting women who have had unilateral mastectomy only and unilateral mastectomy with breast reconstruction. All patients above the age of 18 years old were identified using the operating theatre book listing all unilateral mastectomies with and without reconstruction that were performed in Hospital Universiti Sains Malaysia, Kelantan, Malaysia, from January 2007- December 2017. Case files of patients were then traced, retrospectively reviewed and ineligible patients were excluded. Women with pre-existing spine conditions such as scoliosis, women with history of trauma to the spine, those with metastatic spine disease, those with bilateral mastectomy, those without pre- or post-operative chest radiographs and those without traceable case files were excluded.

Data Collection

Pre- and post-surgical anterior chest radiographs of all eligible patients were then assessed using radiological software (GE Healthcare Centricity™ Picture Archive and Communications Systems, Illinois, United States of America) online (PACS) and the Cobb’s angle was measured digitally. Direction of curve was recorded. Cobb’s angle was measured using the PACS measurement tools by extrapolating 2 lines from the caudal and cranial-most vertebral bodies that are most angulated toward each other and then taking the angle of the intersecting 2 perpendicular lines drawn from the aforementioned lines (Figure 1).

Statistical Analysis

Data was entered and analysed using SPSS version 24 Statistical Software (SPSS Chicago, Illinois). Demographic characteristics of the patients were given as means and standard deviations for continuous variables and frequencies and proportions for categorical variables. Differences between mastectomy and reconstructed patients were analysed with background variables such as Body Mass Index (BMI), breast volume and race, whereby continuous data were analysed with independent t-tests and nominal data were analysed with chi-square test. Independent t-tests were used to analyze the mean differences of Cobb’s angle in pre-operative radiographs and post-operative radiographs less than 1 year, 1 to 2 years and more than 2 years between MA and IABR, the mean difference in pre-post Cobb’s angle between the IABR and MA groups, mean difference of Cobb’s angle between background continuous data such as age, body mass index (BMI) and breast volume(ml). Nominal background data were analysed with 1-way ANOVA. The homogeneity of the variances was analysed using Levene’s test for equality of variances. Correlation between direction of spinal tilting between MA and IABR were analysed with chi-square tests and those who had expected cell counts more than 20% were analysed with fisher’s exact test. For non-parametric data, its correlation was calculated with Kendall’s Tau-b test. P value for statistical significance was set as less than 0.05.

Results

Spinal Alignment

A total of 76 patients who underwent unilateral mastectomy and fulfilled the inclusion criteria from 1997 to 2017 were collected. Among those who were included in this study, there was almost equal distribution of those who had unilateral mastectomy only and those who had immediate autologous breast reconstruction with 52.6% (n = 40) of these patients receiving unilateral mastectomy only (MA) and 47.4%(n = 36) received immediate autologous breast reconstruction.
gous breast reconstruction (IABR). Due to our institution's location in Kelantan, Malaysia which has a predominantly Malay Muslim population, our patient demographic (Figure 2) demonstrated that majority of women who underwent mastectomy were Malay at 81.6% (n = 62), then Chinese at 14.5% (n = 11) and others including Indian and Thai nationals at 3.9% (n = 3). There was almost equal distribution with regards to side of surgery with 48.7% (n = 37) involving the left breast and 51.3% (n = 39) involving the right breast. There was a statistically significant difference in the mean age of patients who received MA compared to IABR, with women who received MA only demonstrating a mean age of 55.23±9.03 years; compared to those with IABR who had a mean age of 42.11±8.17 years; t(58)=0.141, p=0.000. The mean difference between these 2 groups was 13.11 years. However, there were no statistically significant differences in BMI, breast volume and weight between MA and IABR groups (Table 1). MA (25.25±5.99) had higher mean BMI than IABR (23.88±3.94), t(70)=1.13, p=0.264. With regards to breast volume, MA had higher mean volume (ml) (292.79±260.83) compared to IABR (284.75±174.65), t(58)=0.141, p=0.888. The mean weight (kg) in the MA group was higher (59.85±13.60) than IABR group (58.07±9.50), t(74)=0.654, p=0.515.

There was a total of 125 post-operative chest radiographs that were collected. These post-operative radiographs were grouped into those taken less than 1 year, 1 to 2 years and more than 2 years (Table 2). Comparing the mean pre-operative Cobb's angle of patients who underwent MA and IABR (Table 3), there was no significant difference of mean pre-operative Cobb's angle, with MA showing a mean of 3.75±2.99 degrees and IABR 4.25±2.72 degrees respectively, t(74)=0.759, p=0.450. Post-operative mean Cobb's angle of all 3 groups of post-operative chest radiographs demonstrated no significant difference between MA and IABR (Table 3).

In post-operative radiographs less than 1 year, mean Cobb's angle of those with MA was 3.57±3.8 degrees and those with IABR was 3.32±2.72 degrees, t(37)=0.242, p=0.810. In the group of radiographs taken 1 to 2 years, mean Cobb's angle in MA was 2.00±3.84 degrees compared to IABR with 2.32±2.95 degrees, t(31)= 0.261, p=0.796. In radiographs taken more than 2 years post-operatively, the Cobb's angle in MA was 2.97±5.11 degrees and reconstruction was 3.11±5.54 degrees, t(51)= 0.185, p=0.854.

We compared the mean Cobb's angle pre- and post-operatively between mastectomy and reconstructed patients without accounting for change in direction to analyze the trend of change (Figure 3). Pre-operative mean Cobb's angle among those who received IABR was higher compared to those with MA. Subsequently, the immediate impact of IABR on the spinal alignment in radiographs taken less than 1-year post-surgery is more pronounced than those with mastectomy only, with a lower Cobb's angle value despite a higher
Figure 2  Racial Distribution of Patients.

Table 1  Demographic Characteristics between Mastectomy and Reconstructed Patients

<table>
<thead>
<tr>
<th></th>
<th>MA (mean±SD)</th>
<th>IABR (mean±SD)</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>55.23±9.03</td>
<td>42.11±8.17</td>
<td>0.000</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>59.85±13.60</td>
<td>58.067±9.497</td>
<td>0.515</td>
</tr>
<tr>
<td>BMI (kg/m^2)</td>
<td>25.25±5.99</td>
<td>23.88±3.94</td>
<td>0.264</td>
</tr>
<tr>
<td>Breast volume (ml)</td>
<td>292.69±260.83</td>
<td>284.75±174.65</td>
<td>0.888</td>
</tr>
</tbody>
</table>

Abbreviations: BMI = body mass index; IABR = immediate autologous breast reconstruction; MA = mastectomy only.
* p-value calculated using independent t-test.

Table 2  Distribution of Post-operative Chest Radiographs

<table>
<thead>
<tr>
<th>Duration of post-operative chest radiographs</th>
<th>MA (n = 40)</th>
<th>IABR (n = 36)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (n = 76)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 1 y</td>
<td>14 (11.2%)</td>
<td>25 (20.0%)</td>
</tr>
<tr>
<td>1-2 y</td>
<td>19 (15.2%)</td>
<td>14 (11.2%)</td>
</tr>
<tr>
<td>More than 2 y</td>
<td>35 (28.0%)</td>
<td>18 (14.4%)</td>
</tr>
</tbody>
</table>

Abbreviations: IABR = immediate autologous breast reconstruction; MA = mastectomy only.

Table 3  Mean Pre-operative and Post-operative Cobb’s Angle between Mastectomy and Reconstructed Patients

<table>
<thead>
<tr>
<th>Time of chest radiographs taken</th>
<th>MA (mean±SD)</th>
<th>IABR (mean±SD)</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-operative</td>
<td>3.75±2.99</td>
<td>4.25±2.72</td>
<td>0.450</td>
</tr>
<tr>
<td>Post-operative:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 1 y</td>
<td>3.57±3.84</td>
<td>3.32±2.72</td>
<td>0.810</td>
</tr>
<tr>
<td>1-2 y</td>
<td>2.00±3.84</td>
<td>2.32±2.95</td>
<td>0.796</td>
</tr>
<tr>
<td>More than 2 y</td>
<td>2.83±5.11</td>
<td>3.11±5.54</td>
<td>0.854</td>
</tr>
</tbody>
</table>

Abbreviations: IABR = immediate autologous breast reconstruction; MA = mastectomy only.
* p-value calculated using independent t-test.
pre-operative mean Cobb’s angle. However, when comparing IABR to MA, the mean post-operative Cobb’s angle in radiographs taken 1 to 2 years is higher in those who received IABR. In radiographs more than 2 years post-surgery, the mean Cobb’s angle is similar between the both.

Mean differences between pre- and post-operative Cobb’s angle (post-operative Cobb’s angle minus pre-operative Cobb’s angle) were analysed and there were no significant differences between those who had mastectomy and reconstruction in all groups (Table 4). Plotting the trend of this data (Figure 4) and considering direction (negative sign designated for Cobb’s angle that shifted to the contralateral side compared to its pre-operative Cobb’s angle), there was a non-statistically significant larger mean difference between pre- and post-operative Cobb’s angle in radiographs of MA patients taken less than 1 year post-operatively compared to patients who received IABR, with mean difference of pre and post-operative Cobb’s angle in MA 0.643±4.30 degrees and IABR -1.28±2.107 degrees, t(37)=1.856, p=0.071. Subsequently there was a negative value in mean difference of pre- and post-operative Cobb’s angle in radiographs taken 1 to 2 years post-operatively in both MA and IABR, indicating a reduction in post-operative Cobb’s angle for both groups which were not statistically significant. This reduction in Cobb’s angle is more in the IABR group compared to the patients who received MA, with the mean difference in degree of Cobb’s angle at -2.68±3.21 degrees for IABR and -1.84±4.81 degrees for MA, t(31)=0.564, p=0.577. In the long run however, when looking at chest radiographs of more than 2 years post-operatively, both MA and IABR groups a have a similar reduction of Cobb’s angle compared to pre-operatively. In MA group, a mean difference of -1.14±5.30 degrees, whereas IABR group had -0.94±5.10 degrees, t(52)=0.129, p=0.898.

Analysing direction of curve using Pearson Chi-Square test, there was no significant difference of direction of spinal tilt in relation to diseased breast side in pre-operative radiographs between mastectomy and reconstruction, X2 (1, N = 121) =0.191, p=0.662. Referring to Table 5, there were a total of 121 radiographs which were tilted pre-operatively. There were 4 radiographs without any spinal tilting (spinal alignment was at midline) and were excluded from the analysis (Figure 5). A total of 24% (n = 29) of mastectomy patients and 18.2% (n = 22) of IABR patients tilted to the same side as their diseased breast. Those whose spinal alignment were tilted to the opposite side compared to their diseased breast were higher in

### Table 4 Mean Difference in Cobb’s Angle Post-operatively compared to Pre-Operatively Between MA and IABR in Each Group

<table>
<thead>
<tr>
<th>Duration of radiographs taken post-surgery</th>
<th>Mean difference in pre- and post-operative Cobb’s angle (mean±SD)</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MA</td>
<td>IABR</td>
</tr>
<tr>
<td>Less than 1 y</td>
<td>0.643±4.30</td>
<td>-1.28±2.107</td>
</tr>
<tr>
<td>1-2 y</td>
<td>-1.84±4.81</td>
<td>-2.68±3.21</td>
</tr>
<tr>
<td>More than 2 y</td>
<td>-1.14±5.30</td>
<td>-0.94±5.10</td>
</tr>
</tbody>
</table>

Abbreviations: IABR = immediate autologous breast reconstruction; MA = mastectomy only.

* P-value calculated using independent t-test.
Immediate Autologous Breast Reconstruction versus Mastectomy Alone

Figure 4: Mean Differences of Pre- and Post-operative Cobb’s Angle in those with MA and IABR.

![Graph showing the mean differences of pre- and post-operative Cobb’s Angle between MA and IABR.](image)

- For the MA group, the mean Cobb’s Angle was significantly lower than in the IABR group post-operatively.
- The differences were most pronounced within the first year post-operation, with a trend suggesting a recovery of alignment over time.

Figure 5: Demographic of Radiographs with Spinal Alignment at Midline.

![Bar chart showing the distribution of midline spinal alignment by post-operative time.](image)

- Among patients with less than 1 year post-operation, 2.7% (n = 1) were IABR at midline.
- Among those 1 to 2 years post-operation, 3.6% (n = 1) were MA at midline.
- Among those more than 2 years post-operation, 8.3% (n = 5) were IABR at midline.

Post-operatively, there was also no significant difference in the direction of curve (Table 6) between mastectomy and reconstruction for all groups. Again, those who were at midline were excluded.

(Figure 5), where among those less than 1 year there was only 2.7% (n = 1) IABR at midline; among those 1 to 2 years there was 1 (3.6%) MA at midline; among those more than 2 years there was 5 (8.3%) IABR at midline. Fisher’s exact test was used for both post-operative groups of less than 1 year, with \( p = 0.292 \); and in those 1 to
Assessing Types

Among those more than 2 years, applying Pearson Chi-Square test, X² (1, N = 55) =1.461, p=0.227. Pre-operatively there were 4 patients with Cobb’s angle more than or equals to 10, 1 patient was in the mastectomy group, and 3 were in the reconstruction group. Post-operatively, in the group of less than 1 year there was 1 patient that progressed to 15 from 3 degrees with mastectomy and 1 that remained static at 10 degrees post breast reconstruction. Whereas in the group of more than 2 years, there were 3 patients that had significant scoliosis, 2 patients post breast reconstruction progressed from 3 degrees to 11 and 10 degrees to 21; whereas 1 patient with mastectomy only progressed from 15 to 18 degrees.

With regards to breast volume of the patients and difference in pre-post Cobb’s angle, Kendall’s tau-b we ran to determine the correlation in this non-parametric data. We found a strong, positive correlation between breast volume and difference in pre-post Cobb’s angle in MA which was statistically significant (τb = 0.251, p = 0.015). There was no statistically significant correlation between breast volume and Cobb’s angle pre-post difference in those who underwent IABR (τb = 0.122, p = 0.220).

Types of Immediate Breast Reconstruction

Among the patients we collected, there were a total of 36 patients who underwent immediate autologous breast reconstruction with 66.7% (n = 24) free flaps and 33.3% (n = 12) pedicled flaps. Assessing the distinct types of reconstruction, most of the patients received deep inferior epigastric artery perforator flap reconstruction with 47.2% (n = 17), followed by ipsilateral transverse rectus abdominis muscle flap at 19.4% (n = 7), and closely by contralateral transverse rectus abdominis flap, latissimus dorsi flap and others, respectively at 8.3% (n = 3), 11.1% (n = 4) and 13.9% (n = 5).

Using independent t-tests, we found a statistically significant difference of the mean pre-post difference in Cobb’s angle between those who had IABR with pedicled flap compared to a free flap with free flap having a greater improvement in mean pre-post Cobb’s angle of 2.21±3.28 degrees compared to pedicled flaps with 0.01±3.67 degrees, t(58)=2.265, p=0.027.

There were no statistically significant mean differences of pre-post Cobb’s angle between types of autologous IABR as determined by one-way ANOVA [F(4,55)=0.735, p=0.572]. Comparing between groups, the ‘other’ group had a mean difference of 2.13±3.04 degrees (p=0.220), a greater mean difference than all the other groups especially the latissimus dorsi flap. The latissimus dorsi flap demonstrated a negative change in Cobb’s angle indicating a worsening of post-operative angle (A mean pre-post Cobb’s angle of -0.38±1.66). The deep inferior epigastric artery perforator flap had the second highest improvement in mean pre-post Cobb’s angle at 2.10±3.62 degrees compared to latissimus dorsi (p=0.154). Third in place is the contralateral transverse rectus abdominis with a mean pre-post Cobb’s angle of 1.75±3.30 degrees (p=0.374), and fourthly is the ipsilateral transverse rectus abdominis flap with a mean of 0.86±4.07 (p=0.506).

Using independent t-tests, we found a statistically significant difference between breast volume (ml) and type of pedicled or free flap, where those with higher breast volume at a mean of 310.90±166.98 ml (p=0.009) having free flaps compared to those with pedicled flaps with a mean breast volume of 189.95±93.24.

Discussion

Our institution located in Kelantan, Malaysia, has a demographic of 95% ethnic Malay Muslim patients which reflects the local population in Northeast Malaysia. This presents with a unique clinical setting in breast reconstruction; whereby due to cultural beliefs, women are restricted from choosing implant-based breast reconstruction. Also, many of our patients live in rural locations. Low socioeconomic status and the difficulty of access to healthcare are factors that deter women from choosing breast reconstructive techniques that require multiple hospital visits. As a result, we exclusively perform immediate autologous breast reconstructions. This allows us to compare the impact of immediate autologous breast reconstruction to those without reconstruction. Our study aimed to supplement the paucity of data regarding the physical effects of IABR (immediate autologous breast reconstruction) versus

<p>| Direction of Pre-operative Spinal Tilt in relation to Side of Operation in MA and IABR |
|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|</p>
<table>
<thead>
<tr>
<th><strong>Direction of spinal tilt</strong></th>
<th><strong>Number of radiographs (%)</strong></th>
<th><strong>Total</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ipsilateral</td>
<td>29 (23.2%)</td>
<td>22 (17.6%)</td>
</tr>
<tr>
<td>Contralateral</td>
<td>37 (29.6%)</td>
<td>33 (26.4%)</td>
</tr>
<tr>
<td>Midline</td>
<td>2 (1.6%)</td>
<td>2 (1.6%)</td>
</tr>
</tbody>
</table>

Abbreviations: IABR = immediate autologous breast reconstruction; MA = mastectomy only.

| Direction of Spinal Tilt Compared to Side of Resected Breast in Post-operative Radiographs (Excluding midline spinal alignments) |
|---------------------------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| **Duration post-surgery** | **Direction of spinal tilt** | **MA** | **IABR** | **Total** |
|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| Less than 1 y | Ipsilateral | 3 (8.3%) | 11 (30.6%) | 14 (38.9%) |
| Contralateral | 9 (25.0%) | 13 (36.1%) | 22 (61.1%) |
| 1-2 y | Ipsilateral | 6 (22.2%) | 6 (22.2%) | 12 (44.4%) |
| Contralateral | 10 (37.0%) | 5 (18.5%) | 15 (55.6%) |
| More than 2 y | Ipsilateral | 12 (21.8%) | 6 (10.9%) | 18 (32.7%) |
| Contralateral | 27 (49.1%) | 10 (18.2%) | 37 (67.3%) |

Abbreviations: IABR = immediate autologous breast reconstruction; MA = mastectomy only.
Immediate Autologous Breast Reconstruction versus Mastectomy Alone

MA (mastectomy only). Specifically, our goal was to fill the gaps in knowledge by comparing the spinal alignment changes among women who had immediate autologous breast reconstruction and those who did not. Previous studies demonstrated the preservation of central spinal alignment in group of breast reconstruction techniques that were mixed with autologous, implant-based and tissue expander base. The post-operative changes in spinal alignment were also only analysed by Jeong JH et al once and included a heterogeneous group of spinal alignment assessment ranging from 1 month to 2 years after surgery. To understand how immediate autologous breast reconstruction improves spinal alignment, our study analysed the short, intermediate, and long-term changes post-operatively.

Our findings showed that IABR in the early and intermediate post-operative period had a positive impact on preserving spinal alignment compared to those who had MA. Despite the lack of statistical significance (due to a small sample size), the raw data shows that in the early post-operative period, IABR improved the spinal alignment whereas MA worsened the spinal tilting. In the intermediate post-operative period, both MA and IABR patients showed an improvement in spinal alignment, with IABR having an improvement of tilt up to almost 1 degree more than MA. However, in the long-term post-operative period, both IABR and MA settled to a similar degree of tilting. There was a positive correlation between breast volume and improvement of spinal alignment when comparing IABR vs. MA that was statistically significant. When comparing between types of IABR, free flaps significantly improved spinal alignment when compared to breast reconstruction with pedicled flaps.

Our hypothesis that IABR would improve spinal alignment was proven in the early and the intermediate period. The positive physical impacts of breast reconstruction is not well highlighted due to the paucity of data. The outcome of this study reinforces breast reconstruction as pertinent for preservation of spinal alignment and should be made available to all women post mastectomy not just for aesthetic and psychosocial benefits.

**Spinal Alignment**

The 3rd edition of Malaysian clinical practice guidelines (CPG) of breast cancer management, 2019 recommends all practitioners to offer breast reconstruction to all women who undergoing mastectomy. Studies cited by the Malaysian CPG indicate an improvement of quality of life for those who have breast reconstruction. With regards to immediate versus delayed breast reconstruction, 2 studies were cited by the CPG with positive findings of improved quality of life. It however, is still doubtful when it comes to recommending immediate breast reconstruction in women who will require post-mastectomy radiation, women with high BMI and smokers. Studies quoted by the CPG indicate an elevated risk of post-operative complications in these group of women. The 2-year results of Michigan breast reconstruction outcome study published in 2002 showed that immediate breast reconstruction had higher complication rates compare to delayed. Women with higher BMI also had an association with higher complications. These recommendations for breast reconstruction, however, remain purely as guidelines and are not enforced on healthcare providers or for insurance coverage in Malaysia. This contrasts with the United States of America, where it was mandated in the Women’s Health and Cancer Rights Act of 1998, that all health care plans had to cover for breast and nipple reconstruction in the case of breast cancer. No longer was breast reconstruction confined to a solely aesthetic procedure but was finally recognized as an inherent step in breast cancer recovery. This change was triggered by a multitude of preceding research proving significant psychosocial and quality of life improvements in those who have had breast reconstruction.

Thus far, the necessity of breast reconstruction has been well justified through its psychosocial, sexual, emotional, and quality of life improvements. Comparing types of reconstruction, Sgarzani et al found that patient satisfaction and quality of life were significantly higher in the group who had autologous free DIEAP (deep inferior epigastric artery perforator) flap breast reconstruction compared to those with an implant based reconstruction. Cha et al found no significant difference between patient satisfaction when comparing types of breast reconstruction but found an overall good to very good scores of satisfactions in all the patients who have had reconstruction. It is as early as 3 weeks where we can see an improvement of patient satisfaction, sexual well-being and psychosocial improvement post-breast reconstruction. However, there is a deterioration of well-being with regards to the donor site area of abdominal flap detectable at 3 months post-surgery.

Despite these overwhelming psychosocial benefits proving that breast reconstruction is a necessary component in breast cancer management, the number of women who have had breast reconstruction remains low in Asia. As Shameem et al demonstrated in Malaysia, only 36.8% of women with breast cancer were offered reconstruction. To complicate matters further for patients, the myriad of available options for breast reconstruction (immediate vs. delayed breast reconstruction, implant based versus autologous breast reconstruction); makes it difficult for them to navigate their options, especially during the traumatic initial period of accepting their diagnosis. Breast reconstruction post-mastectomy has yet to be mandated in the legislation in Malaysia, therefore whether a woman will be able to receive breast reconstruction or not rests in the hands of the surgeons of their respective hospitals. In Asia, each healthcare framework differs from country to country, with countries such as in Malaysia providing universal healthcare where private and national healthcare co-exist together. In Malaysia’s public healthcare, breast reconstruction is offered as an option for patients who will undergo mastectomy only in centers with qualified reconstructive surgeons and adequately trained staff. Women are referred to hospitals according to the area of which they reside in, and not whether the hospital has a reconstructive surgeon. It is only when the patient specifically requests breast reconstruction then would the general surgeon refer her to a reconstructive surgeon.

In effort to further boost the proven benefits of breast reconstruction and improve awareness, the physical benefits of breast reconstruction have also been studied, albeit much less than that of psychosocial ones. A unilateral mastectomy alone has been shown to have negative impact on the shoulder girdle kinematics, resulting in altered motor patterns. With regards to changes in body posture and spine alignment, the normal aging population of women will
experience a deterioration of muscle strength where significant changes in body posture occurs over 60 years old. This deterioration of spinal alignment such as deepening of kyphosis worsens the gait of women and increases the abnormalities of balance and risks of fall. In another study researching osteoporosis and lung function, they found significant association with degree of hyper-kyphosis and poor functional vital capacity postulated to be due to restriction of thoracic cage. Cobb’s angle measured at the coronal plane reflects the degree of scoliosis which invariably impacts body posture and spine alignment. Cobb’s angle of more than 10 degrees has been used as a cut-off for the minimal degree of tilting to diagnose adolescent scoliosis. This seemingly arbitrary plotting of a cut-off point has however been challenged by other researchers, with huge variations in prevalence of scoliosis if 10 degrees as a cut-off point is used, thus prompting other classifications to be formulated. However, many still use 10 degrees as the minimal value to begin closer monitoring of patients’ spinal alignment. Using 10 degrees as a value of defining scoliosis, the prevalence of scoliosis in the aging population (more than 45 years old) was found to be ranging from 30% - 68% with no sexual predilection. In a study investigating specifically scoliosis in post-menopausal women, a prevalence of 12.9% was reported among women more than 50 years old. Despite this variation, a recent systemic review indicates that studies show that a smaller lumbar Cobb’s angle (less than 30) show negative association with curve progression. In view of this, studies analysing body posture and spinal alignment have used Cobb’s angle as a measure of degree of spinal malalignment in the coronal plane, for example in investigating augmentation mammoplasty and scoliosis. In our data, we had 4 patients out of 76 with pre-operative Cobb’s angle of more than or equal to 10 (5.26%) which is within the prevalence among normal elderly that was previously reported and agrees with studies which found no difference in the prevalence of lumbar scoliosis among women with breast cancer compared to the normal population. In view of demonstrable negative effects of abnormal spinal alignment, Serel et al analysed the spinal alignments of women who have had unilateral mastectomy before and 12 months after. They found a significant deviation of spinal alignment post unilateral mastectomy. When comparing between those who had breast reconstruction and those who only had unilateral mastectomy, Ciesla et al using photogrammetric examination, determined that women who had immediate breast reconstruction manage to maintain the normal body posture. Conversely, those with unilateral mastectomy had the most postural changes. Peres et al however, managed to demonstrate a significant difference only in the change of vertical alignment of the trunk in the lateral view of the patients who had unilateral mastectomy only compared to those with breast reconstruction. There was, however, no comparison with healthy subjects or those who had immediate breast reconstruction. Another study comparing healthy women with those who had mastectomy using Moire topography as a photogrammetric analysis of body posture, reported a statistical significance of trunk inclination among other items and the older the women operated on, the more frequently their trunks deviated to the right. A recent paper published performed a direct comparison of chest radiographs of those who had mastectomy only and those who had immediate breast reconstruction, wherefore there was a statistically significant difference of Cobb’s angle in those who had immediate breast reconstruction. There was however, a very heterogeneous duration post-surgery that was included, ranging from 1-month post-surgery to 2 years. This wide variation in post-surgical chest radiographs makes it difficult to form a uniformed basis to analyze the Cobb’s angle as immediate post-surgical changes effects such as pain or could affect the Cobb’s angle.

It is with this in mind that we divided our patients into short-term (less than 1 year), intermediate (1 to 2 years) and long term (more than 2 years) groups and analysed each group individually. Also, the study grouped all types of reconstruction together (including tissue expander insertion and autologous breast reconstruction) and analysed their radiographs as 1 group. Unlike autologous breast reconstruction, the procedure of tissue expander insertion does not create a donor site and requires a second surgery to insert the implant, which was not taken into account for in that particular study.

In our results, there was no significant difference in pre-, post and pre-post mean difference of Cobb’s angle between patients who had mastectomy or immediate autologous breast reconstruction whether short-term, intermediate or in the long-term. However, plotting the raw data (Figure 4), we can see that in the short term (less than 1 year) those who received autologous IABR had an improvement in their spinal tilting whereas those who received MA worsened. In the intermediate term (1 to 2 years) both MA and IABR groups had an improvement in spinal tilting with IABR demonstrating at least 1 degree more improvement than MA. And in the long term (more than 2 years), both MA and IABR’s previously achieved improvement in spinal tilting reduced and settled at an almost similar degree of reduction in Cobb’s angle. Additionally, there was no significant difference in the direction of curve between MA and IABR whether pre or post-operatively. There was a positive linear correlation of breast volume and pre-post Cobb’s angle change in MA patients whereas there was no significant correlation in patients who received IABR. This was similar to Jeong et al’s findings, and this greater improvement of alignment seen could be due to the larger the size of a diseased breast removed, the more relief is afforded to a woman that allows them to assume a closer to midline alignment post-operatively. There were no significant difference in the direction of tilting between MA and IABR either pre or post-operatively.

Types of Reconstruction

Our population of data from purely autologous immediate breast reconstruction differs from current available literature, and indicates that there could be other factors affecting the improvement in spinal alignment other than purely reconstructing ones missing breast. The presence of a donor site and its location is a factor that needs to be considered. Comparing different types of immediate autologous breast reconstruction, between free and pedicled flaps, we demonstrated a statistically significant greater improvement of spinal alignment in those who received reconstruction with free flaps than pedicled flaps. This could be due to a larger number of the myocutaneous latissimus dorsi flap among the pedicled flap pool of patients, where harvesting the latissimus dorsi muscle and creating an ipsilateral donor site posteriorly could compound the tilt of the spinal
alignment. Transverse rectus abdominis muscle myocutaneous flap also involves removing the abdominal muscle that also play a role in maintaining a balanced spinal alignment. There are however, to the best of our knowledge, no studies to date that compare the impact of these types of autologous breast reconstruction on spinal alignment. Analysing different types of autologous breast reconstruction, we did not find a significant difference between their change in Cobb’s angle pre and post-operatively comparing the myocutaneous latissimus dorsi flap, transverse rectus abdominis and deep inferior epigastric perforator flap. However, due to our small sample size in each type of reconstruction, deep inferior epigastric artery perforator flap reconstruction with 47.2% (n = 17), followed by ipsilateral transverse rectus abdominis muscle flap at 19.4% (n = 7), and closely by contralateral transverse rectus abdominis flap, latissimus dorsi flap and others, respectively at 8.3% (n = 3), 11.1% (n = 4) and 13.9% (n = 5), this non-significance could be a prematurely derived conclusion. Further analysis with a larger sample size would be a better representation of the data. Understanding the effect that each type of autologous reconstruction has on a patient’s spinal alignment would aid in the choice of type of autologous breast reconstruction especially in patients with pre-existing problems of spinal alignment to prevent further deterioration and morbidity.

**Limitations**

Our sample size is an important limiting factor. Another limitation of our study is the bane of most retrospective studies, which is the lack of complete documentation. With regards to our data collection method, 1 of the main limitations is the inherent issues of measuring Cobb’s angle which includes a reported range of 2-7 degrees of measurement error, intra-observer variation of 5-10 degrees with higher values in inter-observer variation, and a diurnal variation of 5 degrees.26 Having said that, standardizing the software used for measurement helps to reduce some of these errors.

**Conclusion**

The physical benefits of breast reconstruction are an important aspect that is still not well studied. Our study indicates that immediate autologous breast reconstruction has a positive impact on spinal alignment in the early and intermediate post-operative period, especially in women with larger breast volume. IABR with free flaps compared to pedicled flaps significantly preserves spinal alignment. Autologous breast reconstruction is not merely for aesthetic or psychosocial benefits, but a crucial step in restoring a woman’s physical balance. Immediate autologous breast reconstruction improves spinal alignment, and its physical benefits should be highlighted to improve patient’s access to breast reconstruction globally.

**Clinical Practice Points**

- The positive psychosocial effects of autologous breast reconstruction have been well studied. However, there are limited studies on the physical effects of breast reconstruction.
- Previous studies showed women who had breast reconstruction have better posture and spinal kinematics compared to those with mastectomy only. These studies, however, did not differentiate between those with autologous versus implant-based reconstruction.
- We studied the impact of autologous breast reconstruction (IABR) on the spinal alignment of patients and compared it to those who had mastectomy only (MA) during the short, intermediate and long-term post-operative period. We found that IABR improved spinal tilting in the short and intermediate post-operative period compared to those with MA, especially in women with larger breast volume.
- Among IABR techniques, free flap reconstruction significantly improved spinal alignment compared to pedicled flaps. This finding could be due to the pedicle tethering and limiting the range of spinal movement.
- The physical effects of various types of breast reconstruction need to be taken into account during decision-making. IABR improves spinal alignment post-operatively and the physical benefits of breast reconstruction should be highlighted.

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