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# A Comparison of Capsular Contracture Rates after Immediate Implant-based Breast Reconstruction Using Biologic versus Synthetic Mesh

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**Background:** Capsular contracture is one of the most common reasons for reoperation after implant-based breast reconstruction. Prior investigations have suggested that biologic mesh may mitigate capsular contracture development. This study sought to compare capsular contracture rates between patients undergoing immediate implant-based breast reconstruction with biologic versus synthetic mesh.
**Methods:** A retrospective review was conducted of the senior author's primary implant-based breast reconstructions between 2008 and 2023. Demographics and the incidence of clinically significant Baker grade III or IV capsular contractures were compared between biologic and synthetic mesh cohorts. Univariate and multivariate logistic regressions were then performed to assess potential risk factors for the development of capsular contracture.
**Results:** A total of 772 breasts underwent immediate reconstruction, of which 689 (89.2%) used biologic and 83 (10.8%) used synthetic mesh. Capsular contracture occurred in 15 (2.2%) biologic mesh breasts and three (3.6%) synthetic mesh breasts with no significant difference between the two groups ($P = 0.430$). Logistic regression showed that radiation was a borderline significant risk factor for developing capsular contracture, but the use of either biologic or synthetic mesh was not significant ($P = 0.351$).
**Conclusions:** Biologic and synthetic meshes function as effective tools in prosthetic breast reconstruction. Our long-term data suggest that the risk of capsular contracture with these devices is low, and there does not seem to be a difference between the two materials. However, there does need to be a shift in how capsular contracture is assessed and discussed in the reconstruction population. *(Plast Reconstr Surg Glob Open 2024; 12:e6031; doi: 10.1097/GOX.0000000000006031; Published online 16 August 2024.)*

## INTRODUCTION

In breast implant surgery, capsular contracture is a local complication in which there is tightening of the capsule around the implant. This complication often presents clinically with an excessively firm and painful breast. Baker grade is the most popular classification to quantify capsular contracture and ranges from grade I to grade IV, with higher grades corresponding to more severe contractures.[1] The exact etiology for the development of capsular contracture after implant-based breast surgery is unclear and likely multifactorial. Prior investigations have suggested that subclinical infection, biofilm formation, chronic inflammation, and foreign body reaction to the implant may all play a role in the development of capsular contracture.[2–5]

Capsular contracture is one of the most common postoperative complications in patients who have undergone implant-based breast reconstruction. The incidence of capsular contracture after primary reconstruction ranges from 10.6% to 15.9% and symptomatic management usually requires surgical intervention.[6–8] Due to this need for reoperation, recent research has been focusing on identifying potential risk factors for capsular contracture and developing preoperative and perioperative techniques to mitigate these risks. Some of the proposed techniques include copious antibiotic irrigation of the pocket, the use of either polyurethane-coated or textured implants, submuscular placement of the implant, and careful surgical technique.[2,9,10]

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The use of acellular dermal matrices for soft tissue support in implant-based breast reconstruction is another technique that has been found to be useful in both the primary prevention and treatment of capsular contracture. Acellular dermal matrices is a type of biologic mesh that results in a less-constrictive pattern of collagen deposition and has been shown to have lower long-term rates of capsular contracture when compared with without its use.[10–14] Although not as extensively investigated, recent research has suggested that synthetic mesh may provide the same benefit as its biologic counterpart. Clinical studies investigating the use of synthetic mesh in breast reconstruction patients have found the incidence of postoperative capsular contracture to be lower than in patients who do not have synthetic mesh, and the incidence seems to be similar to that of biologic mesh.[15–18] It should also be noted that at this time, there are no surgical mesh products that have been approved by the Food & Drug Administration for use in either augmentation or reconstruction breast surgery.[19]

Several meta-analyses and systematic reviews have attempted to compare biologic and synthetic mesh use for the prevention of capsular contracture but have found varying results. Some studies have found no difference between the two groups, whereas others have found synthetic mesh to be slightly superior at preventing the incidence of capsular contracture.[20–22] This emphasizes the continued need for clinical investigation with direct comparison between the two materials. The goal of this study is to assess our own reconstruction patient population to compare capsular contracture rates between biologic and synthetic mesh cohorts, as well as to assess for other potential risks that may increase the rate of capsular contracture in this patient population.

## Takeaways

**Question:** Is there a difference in the incidence of capsular contracture between patients undergoing immediate implant-based breast reconstruction using biologic versus synthetic mesh?

**Findings:** A total of 772 breasts underwent primary reconstruction. Capsular contracture occurred in 2.2% of biologic mesh breasts and 3.6% of synthetic mesh breasts with no significant difference between the two groups.

**Meaning:** Biologic and synthetic mesh both function as effective tools in prosthetic breast reconstruction and result in a low incidence of postoperative capsular contracture.

## METHODS

### Patients and Data

After institutional review board approval, a retrospective chart review was performed of consecutive immediate implant-based breast reconstructions performed by the senior author that used either biologic or synthetic mesh. All operations occurred between 2008 and 2023 in a hospital setting. Patient demographics, operative data, and follow-up information were all assessed. This included patient age, body mass index (BMI), tobacco history, diabetes history, American Society of Anesthesiologists (ASA) classification, radiation history, chemotherapy history, laterality of breast reconstruction, implant size, implant surface texture, and use of either biologic or synthetic mesh. Postoperative complications were recorded, including incidence of wound dehiscence, seroma requiring drainage, hematoma, infection requiring admission or IV antibiotics, and wound necrosis requiring sharp debridement. Length of follow-up and incidence of postoperative capsular contracture were also recorded. Capsular contracture was assessed by the senior author via physical examination during routine postoperative follow-up visits and recorded in the medical record. Contracture was graded according to the Baker classification, with grade III patients having firmness and visible distortion of the breast while grade IV patients had grade III plus pain. Only patients with Baker grade III or IV capsular contracture were considered clinically significant and thus positive for capsular contracture. Patients with grades I or II were considered negative for capsular contracture. Patients with 1 month or less of follow-up and those who had documented capsular contracture before scaffold insertion were excluded from the study.

### Surgical Technique

All patients underwent two-stage tissue expander to implant reconstruction. At the time of mastectomy, tissue expanders were placed in a subpectoralis position. Mesh was used to reinforce the lower pole of the breast and was sutured to the inferolateral edge of the pectoralis muscle and the inframammary fold. The tissue expander was then exchanged for a permanent implant, generally either 3 months after the index operation, or 6 months after completion of radiation in cases where that was needed. However, although these were the routine time points, the exact timing of the second stage did slightly vary on a case-by-case basis depending on the timing of adjuvant chemotherapy and radiation.

### Scaffold Materials

Biologic mesh: AlloDerm (LifeCell Corporation, Branchburg, N.J.) is a regenerative, human acellular dermal matrix that is derived from donated cadaveric dermis.[23] FlexHD (Musculoskeletal Transplant Foundation, Edison, N.J.) is an acellular dermal matrix that is derived from human tissue.[24] AlloMax (Bard Davol, USA), which was sold and rebranded as Cortiva (RTI Surgical, Deerfield, Ill.), is an acellular dermal matrix derived from human skin and processed to remove noncollagenous elements.[25,26]

Synthetic mesh: GalaFLEX (Galatea Surgical, Inc., Lexington, Mass.) is a synthetic mesh comprised of high-strength, resorbable poly-4-hydroxybutyrate monofilament fibers that are knitted into a microporous scaffold.[27,28] SeriScaffold (Sofregen Medical, Framingham, Mass.) is a long-term, bioabsorbable synthetic mesh. It is a silk-derived material that is composed of purified silk

fibroin knitted into a tear-resistant mesh.[29,30] SeriScaffold was found to have a high incidence of late-presenting complications and Food & Drug Administration–reported adverse events, and it is no longer clinically available as of December 31, 2021.[31,32] DuraSorb (Integra LifeSciences, Princeton, N.J.) is a resorbable polydioxanone mesh with a monofilament and microporous design.[31,33]

### Statistical Analysis

Baseline demographics and capsular contracture rates were compared between the two groups. A chi squared test was used to compare categorical data. A two-sided *t* test or Wilcoxon signed rank test was used to compare numerical data as appropriate. Both a univariate and multivariate logistic regression analysis were then performed to assess potential risk factors for the development of capsular contracture. Statistical significance was set as a *P* value less than 0.05. Statistical analysis was performed in RStudio, version 1.4.1717.[34,35]

## RESULTS

Of the 772 breasts undergoing primary reconstruction, 689 (89.2%) breasts had biologic mesh inserted with 185 (26.9%) AlloDerm, 13 (1.9%) AlloMax/Cortiva, and 491 (71.3%) FlexHD. Of the 83 breasts that had synthetic mesh inserted, 76 (91.6%) used DuraSorb, two (2.4%) used GalaFLEX, and five (6.0%) used SeriScaffold. The average patient age was 46.3 years (SD = 10.2), and the average BMI was 25.6 (SD = 5.4). Patients in the biologic mesh group were followed up for an average of 54.7 months (range 2–165 months, SD = 40.5), whereas those in the synthetic mesh group were followed up for an average of 18.8 months (range 2–120 months, SD = 19.6). There was a significant difference in follow-up between these two groups, with biologic mesh being followed up for a significantly longer period ($P < 0.001$). Twenty-seven patients were diabetic and 116 patients were current or former smokers. A breakdown of ASA classifications resulted with class I in 41 patients, class II in 325 patients, and class III in 66 patients. All patients underwent immediate implant-based breast reconstructions. Five (0.7%) breasts received neoadjuvant radiation, 122 (16.9%) breasts received postmastectomy radiation, and 303 (42.0%) breasts were in patients who received chemotherapy. Six hundred and fifty (90.0%) breasts were in patients undergoing bilateral reconstruction. Average implant volume was 510.8 mL (SD = 152.8), 53 (8.4%) breasts had textured implants placed, and 661 (91.6%) breasts had smooth implants placed.

Analysis between the biologic and synthetic mesh patients showed that patients with biologic mesh were more likely to be older ($P = 0.001$), have a larger implant volume ($P = 0.030$), undergo postmastectomy radiation ($P = 0.025$), undergo chemotherapy ($P = 0.012$), and have textured implants placed ($P = 0.003$). There was no significant difference in BMI, history of tobacco use, ASA class, incidence of neoadjuvant radiation, or laterality of mastectomy between the two groups (Table 1). An assessment of the overall complication profile showed 5.2% dehiscence, 5.1% seroma, 1.0% hematoma, 3.5% infection, and 4.4% necrosis. A breakdown of complications between biologic and synthetic mesh can be seen in Table 2.

**Table 1. Patient Demographics and Outcomes**

| | Biologic Mesh (n = 689) | Synthetic Mesh (n = 83) | Significance (*P*) |
|---|---|---|---|
| Mean age (y) | 46.7 | 43.1 | **0.001** |
| Mean BMI (kg/m²) | 25.6 | 24.9 | 0.303 |
| Implant volume (cc) | 514.9 | 476.9 | **0.030** |
| History of tobacco use | 173 (25.1%) | 22 (26.5%) | 0.886 |
| Diabetes | 34 (4.9%) | 7 (8.4%) | 0.278 |
| ASA class | | | 0.072 |
| Class I | 65 (10.2%) | 5 (6.0%) | |
| Class II | 473 (74.0%) | 71 (85.5%) | |
| Class III | 101 (15.8%) | 7 (8.4%) | |
| Neoadjuvant radiation | 5 (0.7%) | 0 | 0.957 |
| Postmastectomy radiation | 116 (16.8%) | 6 (7.2%) | **0.035** |
| Chemotherapy | 281 (40.8%) | 22 (26.5%) | **0.017** |
| Bilateral mastectomy | 567 (82.3%) | 72 (86.7%) | 0.567 |
| Adjuvant interventions at TE exchange | | | |
| Fat grafting | 474 (69.8%) | 44 (54.3%) | **0.008** |
| Capsulotomy | 593 (87.3%) | 68 (84.0%) | 0.384 |
| Capsulorrhaphy | 138 (20.3%) | 24 (29.6%) | 0.062 |
| Myotomy | 148 (21.8%) | 0 | **<0.001** |
| Surface | | | **0.012** |
| Textured | 53 (8.4%) | 0 | |
| Smooth | 578 (91.6%) | 83 (100.0%) | |
| Length of follow-up (mo) | 54.7 | 18.8 | **<0.001** |
| Capsular contracture | 15 (2.2%) | 3 (3.6%) | 0.664 |

Boldface values indicate statistical significance.

**Table 2. Complication Profile**

| | Biologic Mesh (n = 689) | Synthetic Mesh (n = 83) | *P* |
|---|---|---|---|
| Dehiscence | 37 (5.4%) | 3 (3.6%) | 0.792 |
| Seroma | 38 (5.5%) | 1 (1.2%) | 0.111 |
| Hematoma | 8 (1.2%) | 0 (0.0%) | 1.000 |
| Infection | 26 (3.8%) | 1 (1.2%) | 0.347 |
| Necrosis | 31 (4.5%) | 3 (3.6%) | 1.000 |

Capsular contracture occurred in 18 (2.3%) total breasts. Contracture occurred in 15 (2.2%) biologic mesh breasts and three (3.6%) synthetic mesh breasts with no significant difference between the two groups ($P = 0.430$). Nine (60%) of the biologic mesh breasts that developed capsular contracture had AlloDerm inserted, and the other six (40%) had FlexHD inserted. The three capsular contractures that occurred in synthetic mesh breasts occurred with DuraSorb. Of patients who developed capsular contracture, the average age was 49.9 (SD = 13.4), average BMI was 25.5 (SD = 4.9), and average follow-up was five years (mean = 61.3 months, range = 2–150 months, SD = 49.3). Average time to capsular contracture was 16.7 months (range = 2–74 months, SD = 21.9).

Logistic regression analysis was performed to identify risk factors for the development of capsular contracture. Upon univariate analysis, radiation was a borderline significant risk factor for developing capsular contracture.

**Table 3. Capsular Contracture Univariate Analysis**

| | Capsular Contracture (n = 18) | No Capsular Contracture (n = 754) | Significance (*P*) |
|---|---|---|---|
| Mean age (y) | 49.9 | 46.2 | 0.201 |
| Mean BMI (kg/m$^2$) | 25.5 | 25.6 | 0.685 |
| Implant volume (cc) | 465.8 | 511.8 | 0.228 |
| History of tobacco use | 4 (22.2%) | 191 (25.3%) | 1.000 |
| Diabetes | 1 (5.6%) | 40 (5.3%) | 0.076 |
| ASA Class | | | 0.390 |
| Class I | 0 | 70 (9.9%) | |
| Class II | 14 (93.3%) | 530 (75.0%) | |
| Class III | 1 (6.7%) | 107 (15.1%) | |
| Neoadjuvant radiation | 0 | 5 (0.7%) | 1.000 |
| Postmastectomy radiation | 6 (33.3%) | 116 (15.4%) | 0.050* |
| Chemotherapy | 5 (27.8%) | 298 (39.5%) | 0.465 |
| Bilateral mastectomy | 13 (72.2%) | 626 (83.0%) | 0.216 |
| Adjuvant interventions at TE exchange | | | |
| Fat grafting | 10 (55.6%) | 508 (68.5%) | 0.305 |
| Capsulotomy | 15 (83.3%) | 646 (87.1%) | 0.719 |
| Capsulorrhaphy | 1 (5.6%) | 113 (15.2%) | 0.499 |
| Myotomy | 4 (22.2%) | 144 (19.4%) | 0.764 |
| Surface | | | 0.354 |
| Textured | 2 (11.8%) | 51 (7.3%) | |
| Smooth | 15 (88.2%) | 646 (92.7%) | |

**Table 4. Risks for Capsular Contracture in Primary Reconstruction**

| | OR | 95% CI | *P* |
|---|---|---|---|
| Biologic versus synthetic mesh | 1.017 | 0.982–1.053 | 0.351 |
| Age | 1.001 | 0.999–1.002 | 0.157 |
| BMI | 0.999 | 0.998–1.002 | 0.991 |
| Implant volume | 0.999 | 0.999–1.000 | 0.488 |
| History of tobacco use | 1.000 | 0.975–1.026 | 0.995 |
| Diabetes | 0.978 | 0.931–1.028 | 0.384 |
| ASA class | 0.999 | 0.974–1.024 | 0.913 |
| Neoadjuvant radiation | 0.973 | 0.852–1.111 | 0.688 |
| Postmastectomy radiation | 1.023 | 0.989–1.058 | 0.188 |
| Chemotherapy | 0.980 | 0.956–1.005 | 0.108 |
| Bilateral mastectomy | 0.994 | 0.962–1.028 | 0.740 |
| Surface (textured versus smooth) | 1.003 | 0.956–1.053 | 0.901 |

None of the other recorded patient demographics were risks for developing capsular contracture (Table 3). A multivariate regression was then performed and showed that neither biologic nor synthetic mesh were significant risk factors ($P = 0.351$). None of the other recorded demographic data were a significant risk factor for developing capsular contracture, including age, BMI, diabetes, history of tobacco use, ASA class, neoadjuvant radiation, postmastectomy radiation, chemotherapy, laterality of mastectomy, implant volume, or implant surface texture (Table 4).

## DISCUSSION

Capsular contracture is one of the most common postoperative complications observed in both reconstructive and aesthetic breast surgery. The incidence of capsular contracture after primary augmentation ranges from 8.8% to 14.8%, whereas the rate after primary reconstruction is slightly higher at 10.6%–15.9%.[6–8] Capsular contracture is likely more common in the reconstructive population, given the hypovascular field and natively tight implant pocket innate to the requirements of performing an oncologically sound mastectomy. Many reconstruction patients also require radiotherapy with or without chemotherapy treatment, which potentially compromises skin integrity and perfusion. This may negatively affect wound healing and make the breast more prone to infection.[36–38]

Although biologic mesh has been found to be a useful tool in the treatment of capsular contracture, there is a paucity of investigations assessing the long-term impact of synthetic mesh on capsular contracture. This investigation found the rates of capsular contracture after primary reconstruction with either biologic or synthetic mesh to both be low at only 2.2% and 3.6%, respectively. This is lower than the 10.6%–15.9% rates that have been published in breast-implant trials for primary breast reconstruction patients that did not have internal support. These findings support existing published research that use of mesh may lower capsular contracture rates.

The exact etiology for how biologic and synthetic mesh mitigate capsular contracture is not well defined, but potential causes include a reduction in periprosthetic myofibroblasts and a less-constrictive pattern of collagen deposition. A study by Tevlin et al conducted a histologic analysis of samples from reconstructed breasts and found that biologic mesh resulted in thinner capsules with significantly fewer myofibroblasts.[10,39]

In addition to assessing the incidence of capsular contracture with internal support, this study also aimed to compare capsular contracture with the use of biologic versus synthetic mesh. There are limited data directly comparing biologic and synthetic mesh and whether one material is superior in its ability to prevent capsular contracture. This investigation used the senior author's patient population to directly compare capsular contracture rates between the two materials. By providing comparisons by a single surgeon, it allowed for better control of potential confounders and improved the comparability between the two groups.

Upon comparison, there was no significant difference in the rate of capsular contracture between the biologic and synthetic mesh cohorts ($P = 0.430$). This aligns with two previously published meta-analyses by Murphy et al and Choi et al; both studies found no significant difference in the incidence of capsular contracture when comparing biologic versus synthetic mesh.[21,22] Because biologic and synthetic mesh seem to be similarly effective tools in implant-based breast reconstruction, plastic surgeons can turn to other metrics to decide between which internal support material to use during a primary reconstruction. This may include specific patient needs, cost of the material, concern for other postoperative complications, and surgeon preference.

It should be noted that there were several differences in demographic data between the biologic and synthetic mesh cohorts in this study. Patients who had biologic mesh

inserted were more likely to be older, have larger volume implants, undergo postmastectomy radiation, undergo treatment with chemotherapy, undergo concurrent fat grafting or myotomy at time of TE exchange to permanent implants, and have textured implants. However, the univariate and multivariate regression analyses that were performed showed that radiation was only a borderline significant risk factor for the development of capsular contracture, and that none of the other demographics were significant risk factors in this group of patients. This signifies that none of these differing demographics likely affected the outcomes of this study. It should also be noted that although none of the other demographics were significant risk factors for developing capsular contracture upon either univariate or multivariate regression, there were only 18 patients who developed capsular contracture, and the statistical analysis is limited by this small number. This small sample size means that there may not be enough power in this investigation to identify true statistical significance, potentially leading to a type II error.

Although differing demographics were not significant risks for capsular contracture, it is important to recognize that there was a longer follow-up period in the biologic mesh cohort when compared with the synthetic mesh cohort (54.7 months versus 18.8 months, $P < 0.001$). The majority of capsular contracture occurs within the first 2 years after surgery.[40,41] In our study, the average time to diagnosis of capsular contracture was 16.7 months. This is within the time frame of follow-up of our synthetic mesh cohort, and thus we believe our follow-up period is adequate to have captured the true incidence, but it is nevertheless a potential limitation of our study. Furthermore, three different synthetic meshes were included in this study, and each one has been found to have a slightly different time for complete absorption. DuraSorb has been found to be fully absorbed by around 9 months,[31] GalaFLEX has been found to be fully absorbed between 18 and 24 months,[42] and SeriScaffold has been reported to be fully absorbed by 24 months, although some studies have found that the true time to complete absorption of Seri may be even longer.[43,44] With these different absorption times of the synthetic meshes used, and follow-up of only 18.8 months, it is possible that the true capsular contracture rate for the synthetic mesh cohort could be slightly higher than what was reported in this study.

This investigation ultimately found that both biologic and synthetic mesh had lower rates of capsular contracture when compared with historical rates without internal support, and there was no difference between the two materials. However, the main limitation of this study is the inherent difficulty in distinguishing the natural firmness of a reconstructed breast from true fibrosis of the implant capsule. In aesthetic cases, capsular contracture is easy to identify, as a soft and pliable breast will suddenly become firm. However, in reconstruction cases, the breast is typically firm to begin with, so clinically identifying true capsular contracture becomes much more difficult.

There are several confounding factors associated with breast reconstruction that may contribute to this initial firmness. After mastectomy, there is a tight implant pocket and thin tissue overlying the implant, resulting in a much firmer feel. Breasts may also undergo radiotherapy, which compromises tissue integrity and perfusion. This may cause layers superficial to the implant capsule to become tight, thereby mimicking the clinical findings of capsular contracture.[45–48] The use of biologic mesh may also make a breast feel firm, as it is a thick and stiff material. Additionally, a 6×16 cm piece of mesh was generally used and contoured to the breast. To get a lamellar fit, the surgeon relied somewhat on the stretch of the pectoralis muscle with some inherent stretch in the mesh. It is possible that some of the tightness seen with lower grade capsular contracture may just be tighter fit of the implant dimensions. Because no histologic analysis of the capsule was performed, it is also possible that the tightness associated with capsular contracture could be a function of the mesh itself becoming consolidated and dense or the muscle interface tightening to some degree. This highlights the inherent limitations in the way clinically diagnosed capsular contracture conflates what may be separate histopathologic processes. In all discussions of capsular contracture in reconstruction, these confounding factors should temper the analysis and results.

Because reconstructed breasts may feel firm for reasons unrelated to the capsule, the use of Baker classification may not be suitable for this patient population. For this reason, in 1995, Baker and Spear reclassified reconstructions using the Baker-Spear classification and suggested that only a grade IV capsular contracture be considered a poor outcome.[49] Similar questions regarding the validity of Baker scoring in reconstructed breasts have been raised by other plastic surgeons. Hirsch et al[50] discussed the need to differentiate irradiated from nonirradiated breasts when clinically describing capsular contracture. A more recent study published by Mohan et al discussed how Baker classification is problematically subjective and does not consider other variables that may impact breast stiffness and discomfort. They concluded that Baker classification should continue to be used as an easy clinical tool, but that research investigations should use additional methods to assess for contracture, including ultrasound, magnetic resonance imaging, or histology.[51] Based on the outcomes of our study, it is easy to agree with the findings of Mohan et al. Although we did calculate capsular contracture rates with biologic and synthetic mesh, we recognize that it is necessary to address the issues surrounding Baker classification and clinical assessment of contracture in the reconstruction population.

Other limitations of this study include the retrospective nature, heterogeneity in the types of mesh used, and the lack of nonmesh control. It is possible that certain properties of meshes prevent capsular contracture, and in the future, these materials can be harnessed for prevention of this complication. Future work should identify the inherent properties of mesh that prevent capsular contracture to design a mesh that ultimately reduces rates of surgical reoperation.

## CONCLUSIONS

Biologic—and now synthetic—mesh has shown increased utility in prosthetic breast reconstruction.

Studies have reported a lower risk of capsular contracture with mesh reconstruction vis-à-vis historical controls without mesh. Our study shows no significant difference in the incidence of capsular contracture between biologic and synthetic mesh in primary breast reconstruction.

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## DISCLOSURES

*John Y.S. Kim is a patent and equity holder for Surgical Innovation Associates and EDGe Surgical and receives book royalties from Springer. All the other authors have no financial interest to declare in relation to the content of this article.*

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