

Inframammary Fold Reconstruction: A Biomechanical Analysis

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Background: Inframammary fold reconstruction has scarcely been evaluated in literature. No biomechanical analyses have been performed comparing different reconstructive methods. This evaluation compares the gold-standard suture reconstruction with an intrarib anchor system (Micro BioComposite SutureTak, Arthrex).

Methods: Three analysis groups were compared including 8 Sawbone blocks, 22 embalmed cadaver, and 27 regular cadaver specimens (N = 57). Transient mechanical analysis was performed at 5N/s using an Instron 5565 test frame.

Results: Ultimate load favored the anchor system (compared with the gold-standard suture) by a factor of 9.8 ($P < 0.0001$) for the regular cadaver group and a factor of 1.7 ($P < 0.038$) for the embalmed cadaver group. A similar statistically significant benefit was shown for stiffness and load at 2-mm displacement.

Conclusions: This analysis showed an anchor system to be the biomechanically superior fixation method in terms of ultimate load, fixation stiffness, and displacement at failure when compared with the gold-standard suture method in inframammary fold reconstruction. Because of superior stability in every aspect, an anchor system may be considered for inframammary fold reconstruction. (*Plast Reconstr Surg Glob Open* 2016;4:e634; doi: 10.1097/GOX.0000000000000568; Published online 7 March 2016.)

Inframammary fold (IMF) reconstruction plays an important role in plastic and oncoplastic surgery. Several techniques are described in literature,

including lipo-fascial flap creation,¹ de-epithelialized skin flaps,² and a variety of suture techniques, all of which rely on suture material being applied either in a continuous suture manner or in a single suture manner to the epieptoral/thoracic fascia.¹⁻⁷ Available literature, biomechanically comparing techniques, is insufficient at best, and a systematic evaluation of IMF reconstruction is not yet available. Case numbers are commonly low, and prospective randomized trials are missing altogether.

To evaluate different fixation techniques, long-term prospective clinical trials evaluating outcome, postoperative pain, complication rates, and costs need to be performed. Before doing so, however, a biomechanical analysis of the available techniques is necessary. This head-to-head study aimed to evaluate the ultimate strength of a fascial suture in direct comparison to an intrarib, absorbable anchor

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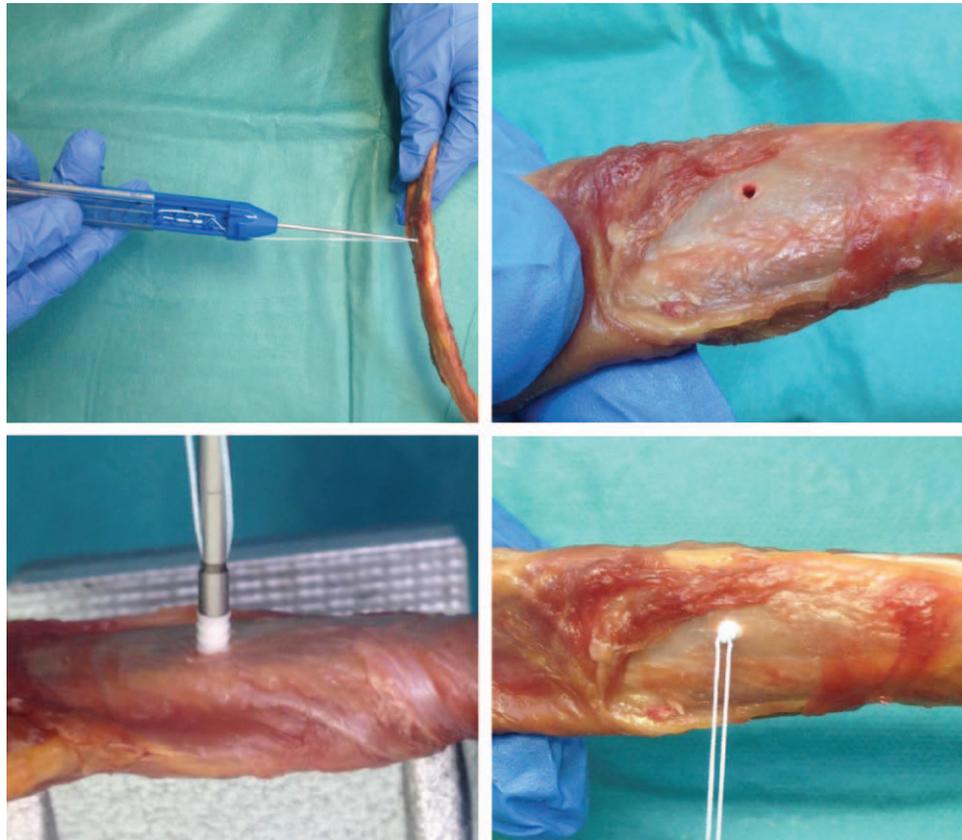


Fig. 2. Top left, Micro BioComposite SutureTak by Arthrex system. A resorbable anchor tip is attached to 2 sutures as seen in the images on the bottom. Top right: Initially, a 2-mm diameter hole was introduced into the anterior rib surface allowing the simple placements of the anchor using the applicator. This is shown in the bottom left. After grip removal, the anchor remains firmly in place allowing for inframammary fold reconstruction using the 2 available sutures, which is shown in the bottom right.

Table 1 shows an overview of sample distribution. The gold-standard IMF reconstruction was represented by monofilament, absorbable sutures (poly-*p*-dioxanone 2/0 MonoPlus, Braun, Melsungen, Germany). These were compared with suture-linked anchors system, ie, Micro BioComposite SutureTak 2/0 FiberWire with a 2.4×6.5-mm anchor system (Arthrex), which could be placed within the bone structure as shown in Figure 2 after drilling a 2-mm hole. Recorded parameters were ultimate strength (newton) and displacement at failure (millimeters). These resulted in calculated parameters such as stiffness (newton per millimeter) and load at 2mm displacement. The latter result is considered as fixation failure in biomechanical evaluations because stability may be lost as dehiscence exceeds 2mm.⁸⁻¹²

Procedure

Sutures were placed on remaining fascia tissue on both embalmed cadaver and regular cadaver ribs. They were embedded over a length of 5mm of fascia, thereby providing a strong point of fixation. The an-

chor group required removing fascia and connective tissue from the anterior costal surface. The appropriate anatomical anchor location (rib 5–8) depends on the position of the desired IMF. A 2mm (diameter) × 5-mm (depth) hole was then drilled into the anterior surface of the rib allowing for anchor placement. The posterior costal surface was not damaged. The dermal fixation point would be the same for both methods and, therefore, would not impact the results of these tests. Herein, sutures were attached to the Instron testing frame. Clinically, depending on the remaining skin thickness, a sturdy subdermal tissue layer is chosen as a fixation point. Application of the gold-standard suture was timed at approximately 1 minute, whereas anchor placement requires approximately 5 minutes.

Statistics

Statistical analysis was performed using the VassarStats (Vassar College, Poughkeepsie, N.Y.) statistics program. Analysis of variance (ANOVA) and *t* tests were used to evaluate significances when appropriate.

Ethics Committee Approval

This study was conducted in accordance with institutional review board standard operating procedures. An ethics committee vote was initiated but deemed unnecessary by the “Ethikkommission der Aerztekammer Nordrhein.” A written statement to this extent is available.

RESULTS

Ultimate Load

Both evaluated anchor models showed similar ultimate loads with 64.4 N (Sawbone) and 67.3 N (Regular Cadaver). The embalmed cadaver yielded only 18.7N because of the inferior bone quality. (A summary is shown in Fig. 3.) ANOVA showed that the Sawbone and the regular cadaver model did not differ significantly. However, both differed significantly from the embalmed cadaver. Ultimate loads for tested suture material did not differ between the embalmed and the regular cadaver samples. Ultimate anchor load exceeds ultimate suture load in both embalmed cadaver and regular cadaver studies. Anchors were able to withstand 1.8 times the load of the gold-standard sutures in the embalmed cadaver group. These results were superseded in the regular cadaver group where 6.9 (suture) and 67.3N (anchor) showed an improvement of a factor of 9.8.

Displacement at Failure

No statistically significant difference (ANOVA analysis) could be shown for the anchor subgroup

in the category: displacement at failure; Sawbone (4.7 mm), embalmed cadaver (5.8 mm), regular cadaver (6.4 mm). The same holds true for the suture comparison between embalmed cadaver (5.8mm) and regular cadaver (9.1 mm). Furthermore, intra-group comparison did not differ although a trend favoring the anchor regular cadaver samples (6.4mm) versus suture regular cadaver (9.1 mm) is apparent.

Stiffness

A measure of stiffness may be deduced from the slope of the elastic region of stress/strain or load/displacement diagrams. Units for evaluated overall stiffness were newton/millimeter. An ANOVA showed significant differences among all 3 evaluation groups with respect to stiffness. As expected, Sawbone samples showed the highest stiffness (18.3N/mm) followed by regular cadaver ribs (11.4N/mm) and embalmed cadaver ribs (4.9mm). All results differ significantly. (A summary is shown in Fig. 4.) More interestingly, intragroup analysis again showed anchors to display a higher stiffness in direct comparison to their individual suture counterparts. For embalmed cadaver specimens, anchors increased overall stiffness by a factor of 2.6. Regular cadaver analysis shows a stiffness increase of a factor of 10.4 from 1.1 (suture) to 11.4N/mm (anchor). All differences are significant (Table 1).

DISCUSSION

This basic analysis of a novel IMF reconstruction technique on a cadaver model showed that an an-

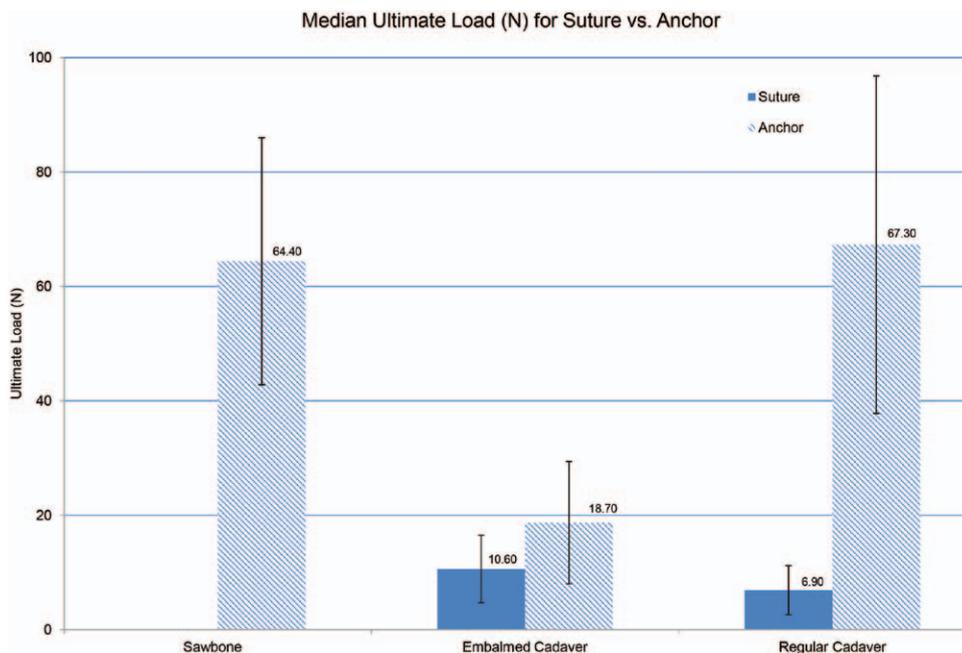


Fig. 3. Median ultimate loads for all 3 evaluated test subjects. Error bars indicate SD.

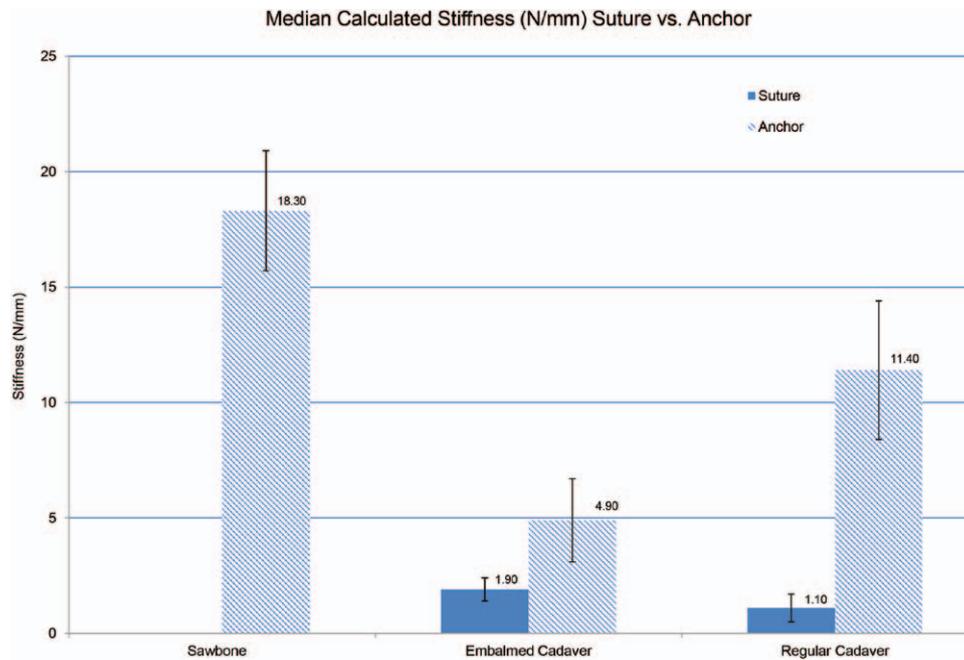


Fig. 4. Median ultimate loads for all 3 evaluated test subjects. Error bars indicate SD.

chor fixation will be a more stable and stiffer, but also a slightly more time-consuming, approach. Before further discussion of these results, we must ask ourselves whether this method is of testing adequate. To our knowledge, this is the first biomechanical analysis of inframammary tissue loads. Nonetheless, a plethora of literature is available on evaluating novel surgical approaches via their biomechanical properties. Especially orthopedic and trauma surgery often relies on biomechanical analysis before the introduction of a new method into clinical trials.^{3,11,13,14} Although this has not yet been done in oncoplastic breast surgery, we find it important to create a solid, quantitative foundation for future work. Although we understand that not every surgical approach may undergo a prior biomechanical analysis, it seems prudent to attempt preclinical evaluation whenever possible. In addition, our analysis also provided data whether embalmed cadaver testing may be a suitable substitute for regular cadaver testing.

The main endpoint of method superiority yielded a simple answer. The anchor system is superior in both implant stiffness and overall load-bearing capacity. In fact, it was shown that, based on superior stability, 1 anchor may replace several sutures. The authors are well aware of the fact that the placement of several sutures, or the implementation of a continuous suture,¹⁵ may lead to a nonlinear ultimate load increase. Suture thickness and type may also play an important role in a biomechanical analysis. Naturally a monofilament, absorbable

2/0 suture may be less sturdy than a 1/0 braided suture. However, because absorbable 2/0 sutures are used for IMF reconstructions in the hospitals represented by these authors, we chose these to be our baseline. Therefore, when compared with a single 2/0 absorbable suture, anchors showed to be far superior with respect to their load-bearing capacity. Also, the stability achieved by implementing this anchor is an immediate one. Although scar tissue formation will result in the ultimate long-term stability, short-term postoperative stability is much higher in this rigid fixation method.

Fixation failure generally occurred between 5 and 9 mm of displacement. Because this was unrealistic, the overall stiffness was calculated from the slope of the stress-strain diagram to determine a load of failure at a 2-mm gap. This value is often used in orthopedic surgery as dehiscence should not exceed 2 mm without impairing, for example, osteosynthesis stability.^{8,11,14} As one would expect, 2-mm displacement loads also favor anchor implementation by a factor of approximately 10. This again was to be expected because a 2-mm displacement load is a calculated value directly proportional to stiffness. Overall, results indicate that the placement of 2 anchors, for example, in the midclavicular and anterior axillary line may more than compensate the requirement of placing several sutures in an attempt to permanently re-create an IMF. However, the optimal balance between stability and aesthetic outcome might be achieved by using either method.

Clinical Considerations

Although surgical reconstruction of the IMF is generally possible using a standard suture technique, our method may be considered when the surrounding tissue does not allow for the use of regular suture fixation. Rather than replacing the standard technique entirely, inframammary reconstruction using an anchor system may simply represent an additional option. Especially when insufficient tissue on the ventral rib surface is available, as it is often the case in irradiated patients, finding the rib surface and using this method may be a suitable option.

Complication Rates

Obviously, introducing an anchor into the ventral rib surface also introduces the risk of creating a pneumothorax. Although this complication is generally reported within incidence of less than 1% during standard breast surgery, this value may increase as secondary, and more complicated, interventions occur.¹⁶ Nonetheless, the use of drill-guidance systems may help address this issue because it prevents exceeding the desired depth. Such a system is provided by the manufacturer.

Financial Considerations

It should be noted that introducing the anchor system will result in a slightly higher cost because an individual anchor is priced at approximately €200. This exceeds suture prices significantly. Although medical professionals are used to the concept of improving surgical outcomes with innovative techniques, the notion of drastically increasing material costs in IMF reconstruction may delay the implementation of this approach. Although superior stability may be helpful, long-term results regarding the aesthetic outcome will decide whether this method should be used in an oncoplastic reconstruction scenario.

Furthermore, surgical duration, postoperative pain, and complication rates are clinical factors that will have to be evaluated in subsequent prospective randomized patient trials.

CONCLUSIONS

This biomechanical analysis showed the Micro Bio-Composite Suture-Tak 2/0 FiberWire anchor system (Arthrex) to be a superior fixation method in terms of ultimate load, fixation stiffness, and displacement at failure when compared with the gold-standard

suture method in IMF reconstruction. This study will be the foundation of subsequent clinical trials.

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