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Review

# Treatment of breast animation deformity: A systematic review<sup>☆</sup>



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Muscle splitting;  
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## Summary

**Introduction:** Animation deformity (AD) is a known complication of subpectoral implant placement and results from the contraction of the pectoralis major muscle with resultant movement of the underlying implant. This can lead to a poor cosmetic result, with the implant becoming distinctly visible postbreast reconstruction and augmentation. The prevalence and clinical significance of AD remain unclear. To date, there exists no published review outlining the treatment modalities for AD and their effectiveness. The objective of this study is to appraise the effectiveness of various treatment options through a systematic review of the literature.

**Methods:** The MEDLINE search tool was used to carry out a search of the PubMed. Two separate reviewers independently assessed the initial resultant papers based on strict inclusion and exclusion criteria. Factors evaluated included patient demographics, publication information, study design, number of patients, preventative/treatment technique, and type and size of implant.

**Results:** The search strategy yielded 504 articles, of which eight articles met all the inclusion criteria. This represents 214 individual breasts that underwent surgical correction for AD. Of the 214 included breasts, 151 were postmastectomy and reconstruction, while 63 were primary augmentation. Of the reconstructed breasts, 5.6% ( $n=12$ ) received radiation. Overall, interventions for treating AD were successful in all ( $n=214$ ) of the documented cases, with an overall complication rate of 11.6% ( $n=25$ ) reported in the studies after treatment. The techniques used to treat AD included subfascial plane change ( $n=8$ ), prepectoral (subglandular/subcutaneous) plane change ( $n=187$ ), and muscle-splitting techniques ( $n=19$ ).

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**Conclusion:** In conclusion, AD is likely an underestimated complication that is increasing in incidence with the growing number of breast implants being placed in the subpectoral plane. This review successfully identified the highly effective treatment modalities to combat AD. Patient characteristics and surgical technique must be tailored on a case-by-case basis to allow for optimum esthetic outcome given the substantial complication rate of these treatment modalities.

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## Introduction

Breast augmentation is the most commonly performed esthetic procedure in North America.<sup>1</sup> According to the American Society of Plastic Surgery (ASPS), breast augmentation accounted for 300,378 of the 1.8 million cosmetic procedures performed across the United States in 2017.<sup>1</sup> Subpectoral implant placement, also known as the retro- or subpectoral technique, has become widely used and is an appropriate technique for many patients.<sup>2</sup> The advantages of subpectoral implant placement include better soft tissue coverage and lower rates of implant rippling, malpositioning, and capsular contracture, especially with textured implants.<sup>2</sup>

Animation deformity (AD) is a known complication of subpectoral implant placement and results from the contraction of the pectoralis major muscle with resultant movement of the underlying implant.<sup>3,4</sup> This affects patients with breast reconstruction and augmentation and can lead to a poor cosmetic result with the implant becoming distinctly visible.<sup>3</sup> The prevalence and clinical significance of AD remain unclear, although the incidence of some degree of AD has been reported to be as high as 77.5% when implants are placed in the subpectoral position, with a moderate or severe deformity seen in up to 15% of cases.<sup>4</sup>

Some patients may accept some minor distortion of the implant, whereas even minimal movement of the implant during activity may bother other patients.

Although this AD is not uncommon with breast augmentation, in any dual-plane or subpectoral reconstruction, this complication can further be exacerbated and over-emphasized.<sup>5</sup> When the breast tissue is removed in the mastectomy, the thinning skin flap has less tissue to hide the dynamic deformity that occurs underneath. As a result of this and other factors including pain and esthetic considerations, there has been a recent surge in the prepectoral placement of implants during reconstruction.<sup>5</sup> This novel placement has been described to prevent AD deformity; however, the optimal treatment for AD is often debated and not well understood.<sup>6,7</sup>

Despite the high incidence and, at times, significant negative sequelae of AD, there remains a paucity of quality data regarding its treatment. Because of the lack of scientific evidence and objective data, AD often appears as the topic of presentations at surgical conferences and symposia. More recently, AD has taken the spotlight in a variety of editorials and quality of life studies describing its detrimental effects to the patient.<sup>5-7</sup> The purpose of this review is to critically appraise the effectiveness of the various treatment options for AD.

## Methods

### Data sources and search strategy

A systematic literature search adhering to the PRISMA guidelines was performed.<sup>8</sup> The MEDLINE search tool was used to carry out a search of the National Library of Medicine (PubMed) database using the following keywords “Sub-muscular” or “Sub-pectoralis,” or “Pectoralis,” or “Retro-muscular,” or “Muscle,” or “Pectoralis Muscles” [Mesh] or “Breast Augmentation”. These keywords were combined with “Breast,” or “Breast Reconstruction,” or “Mammoplasty,” or “Mammoplasty” [Mesh], or “Breast Implant,” or “Implant”. Finally, results were combined with “Animation,” or “Distortion,” or “Animation Distortion,” or “Dynamic Distortion,” or “Muscle Contraction.” The search was confined to the English language and limited to humans. All articles were considered regardless of the date of publishing.

### Study selection and data extraction

Two separate reviewers independently assessed all papers based on strict inclusion and exclusion criteria. Inclusion criteria included subpectoral implant placement, graded or documented AD, and patients having undergone a treatment or intervention for implant distortion. Exclusion criteria included any patient who did not have a graded animation before intervention or who underwent nonsurgical interventions. Retained papers were assessed for data availability. Case reports were excluded to limit publication bias. Factors evaluated included patient demographics, study design, number of patients, treatment technique, and type and size of implant.

### Grading classifications

Two common grading systems were encountered in the various studies reviewed. Pelle-Ceravolo et al. and Spear et al. both described scales to grade AD. Spear et al. described a 4-point grading scale that emphasizes the degree of distortion, with a focus on patient satisfaction.<sup>4</sup> Pelle-Ceravolo et al. however, developed a 3-point grading scale that concentrates on breast shape deformity and its resulting esthetic outcome.<sup>9</sup> In the current review, AD was defined as grade 3 or 4 using the Spear et al. scale, a grade 3 using the Pelle-Ceravolo et al. scale, or simply described as having a positive deformity by the author.<sup>4,9</sup> The full Spear and Pelle-Ceravolo grading scales can be found in Appendix A.

### Quality assessment

Articles were assigned a level of evidence and risk of bias using the American Society of Plastic Surgery (ASPS) critical appraisal check sheet.<sup>10,11</sup>

## Results

The search strategy yielded 504 articles, 8 of which met all the inclusion criteria and were included in this review<sup>12-20</sup> (Figure 1). Study publication dates ranged from 2003 to 2018.

### Patient demographics

The included studies (7 retrospective<sup>12,14-20</sup> and 1 prospective<sup>13</sup>) represent 214 individual breasts that underwent surgical correction for AD. Of the 214 included breasts, 151 were postmastectomy and reconstruction, while 63 were primary augmentation. Of the reconstructed breasts, 5.6% ( $n=12$ ) received radiation. Overall, interventions for treating AD were successful in all ( $n=214$ ) of the documented cases, with an overall complication rate of 11.6% ( $n=25$ ) reported in the studies after treatment.<sup>12-20</sup>

The mean age of all patients ( $n=163$ ) at the time of surgery was 49.4 years (Range: 31-77 years), and the mean follow-up time was 38.2 weeks ( $n=184$ , range: 8-192 weeks). The most commonly used implants were smooth silicone ( $n=220$ ), followed by smooth saline ( $n=2$ ) and textured silicone ( $n=2$ ). The mean size of implant was 589.1 cc ( $n=117$ , range: 380-800 cc). Individual study demographics are presented in Table 1.

### Treatment techniques

The techniques used to treat AD included subfascial plane change ( $n=8$ ), prepectoral (subglandular/subcutaneous) plane change ( $n=187$ ), and muscle-splitting techniques ( $n=19$ ). The specific interventions employed by each study are listed in Table 2. All techniques employed in the included manuscripts were successful at eliminating the deformity.<sup>12-20</sup> The reported complication rates for these techniques were 87.5% ( $n=7$ ), 9.1% ( $n=17$ ), and 0.0% ( $n=0$ ), respectively. The overall complication rate was 11.6% ( $n=25$ ). Acellular-dermal matrices (ADM) were used in 66.8% of subglandular plane changes ( $n=125$ ), and fat grafting was employed 21 times in the same cohort for an average volume of 110.9 cc.

Reported complications included capsular contracture ( $n=11$ ), hematoma ( $n=4$ ), seroma ( $n=2$ ), suture erosion ( $n=2$ ), skin necrosis ( $n=2$ ), red breast syndrome ( $n=1$ ), wound dehiscence ( $n=1$ ), and new-onset stretch marks ( $n=1$ ). A list of complications by study is found in Table 2.

All included manuscripts were assigned a Level of Evidence of III ( $n=8$ ).

### Subfascial plane

Originally described by Graf et al., subfascial implant placement has been shown to yield less capsular contracture than subglandular placement and avoids the AD seen from subpectoral placement.<sup>19</sup> This technique is thought to maintain a better breast structure due to the preservation of Cooper's ligaments normally dissected during a subglandular approach.<sup>19</sup> This technique has also been described to

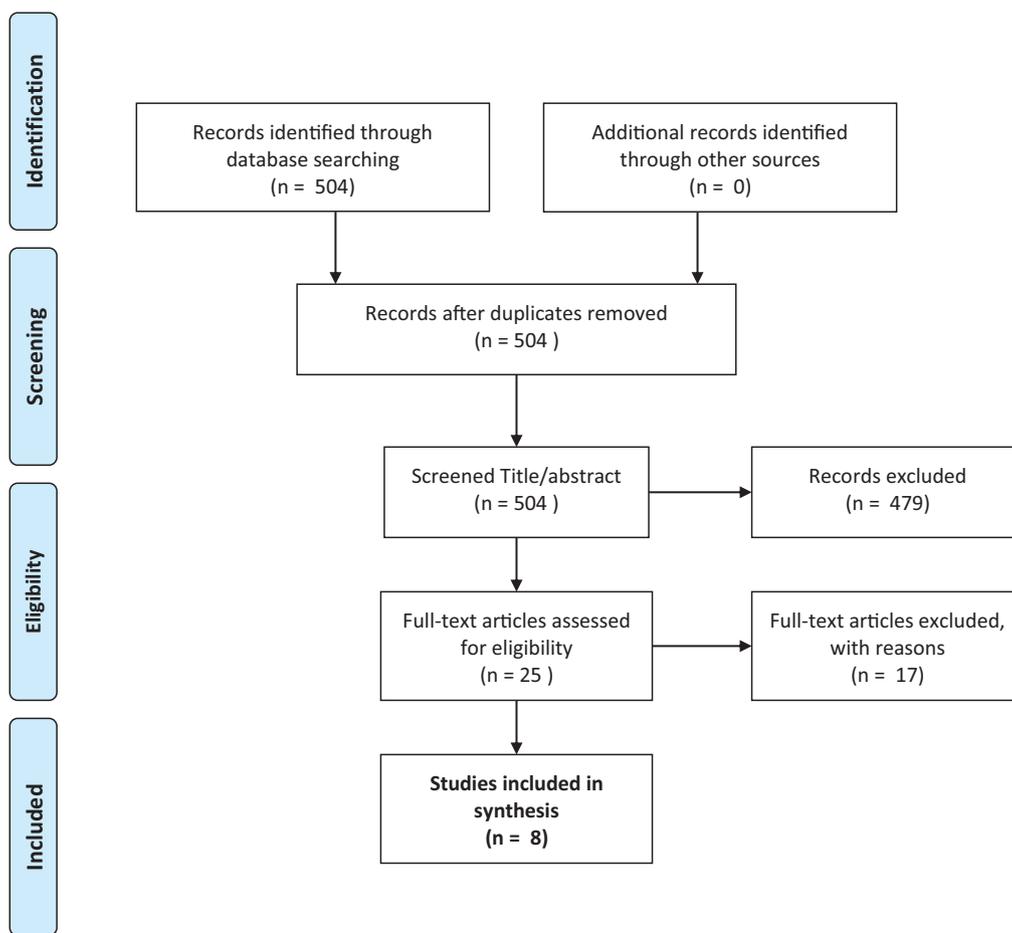


Figure 1. PRISMA search strategy.

Table 1. Individual study demographics.

Study	Type of study	No. of breasts	Implant type	Implant size cc	Follow-up months (n)	Mean age (n)
Leasavoy (2010)	Retrospective	36	Smooth silicone (34/36) Saline (1/34) Textured silicone (1/34)	-	20 (36)	39 (n = 36)
Hammond (2015)	Retrospective	19	Smooth silicone (19)	512 (n = 19)	13.8 (19)	54.5
Sbitany (2014)	Retrospective	8	-	-	9 (8)	-
Khan (2012)	Retrospective	10	Smooth silicone (5/10) Textured silicone (1/10) Nonspecified (4/10)	380 (n = 6)	1 (10)	31 (n = 6)
Khan (2009)	Retrospective	9	-	-	4-36 (9)	-
Hunstad (2010)	Prospective	8	Smooth silicone (60/61), Saline (1/61)	-	2-24 (41)	-
Lentz (2017)	Retrospective	22	Smooth Silicone (22/22)	-	-	-
Gabriel (2018)	Retrospective	102	Smooth Silicone (102/102)	603 (n = 102)	16.7 (n = 102)	53.2 (n = 102)

help protect from implant edge visibility in patients with minimal soft tissue coverage.<sup>19</sup>

Factors to be considered when employing this technique are the increased operative time (75 min compared to 45 min for dual-plane implant placement<sup>21</sup>), technically

challenging dissection (pectoralis fascia measuring approximately 1 mm<sup>21</sup>), and decreased upper pole coverage in thin patients.<sup>21</sup> This technique showed the highest reported rate of complications at 87.5% (n = 7), although it had the smallest sample size of eight patients.

**Table 2.** Study results and technique.

Study	No. of breasts	Surgical technique	Clinical results	Complications	Level of evidence
Leasavoy (2010)	36	Prepectoral change (no ADM)	100% resolution of animation deformity (36/36)	Hematoma (1/36) Capsular contracture (2/36)	3
Hammond (2015)	19	Prepectoral change (fat grafting)	100% resolution of animation deformity (19/19)	Capsular contracture (4/19) Seroma (1/19), Suture erosion (1/19) Hypertrophic Scar (1/19)	3
Lentz (2017)	22	Prepectoral change (15 with ADM; 7 plane change alone)	100% resolution of animation deformity (22/22)	Hematoma (1/22) Capsular contracture (1/22)	3
Sbitany (2014)	8	Prepectoral change (8 with ADM)	100% resolution of animation deformity (8/8)	Red breast syndrome (1/8)	3
Khan (2012)	10	Muscle splitting - dual plane	100% resolution of animation deformity (10/10)	-	3
Khan (2009)	9	Muscle splitting - dual plane	100% resolution of animation deformity (9/9)	-	3
Hunstad (2010)	8	Subfascial plane	No animation deformity reported (both by clinician and by patient) (8/8)	Capsular contracture (4/61) Hematoma (2/61) New-onset stretch mark (1/61)	3
Gabriel (2018)	102	Prepectoral change (ADM)	100% resolution of animation deformity (102/102)	Seroma (2/102) Skin necrosis (3/102) Wound dehiscence (1/102)	3

### Prepectoral (subglandular/subcutaneous) plane

The prepectoral plane (subglandular/subcutaneous plane) is a technique that places the implant above the undisturbed pectoralis either with or without the use of an overlying ADM. Prepectoral placement was employed for the correction of AD in both primary augmentation and reconstruction patients. In this review, prepectoral implant plane change was effective in all cases. Of note, authors of the original manuscripts felt that fat grafting and/or ADM was necessary to limit implant visibility and prevent capsular contracture.<sup>12,14,15,18,20</sup> Additionally, careful patient selection was employed in all studies. Gabriel et al. included only patients with a pinch test greater than 2 cm and excluded patients with uncontrolled diabetes, poor skin perfusion using a PDE Fluorescence Imaging System (Hamamatsu Mitaka USA, Denver, CO), smokers, and patients who underwent prior radiation. All studies emphasized proper patient selection in terms of comorbidities and flap perfusion, given the high cost of ADM, the potential repeated need for the patient to return for fat grafting, and the potentially high rates of complications.<sup>12,14,15,18,20</sup> Finally, the size of the implants is limited by the size of the prepectoral pocket. Stretching the skin envelope by inserting too large of an implant can risk skin flap necrosis and implant visibility.

### Muscle-splitting biplane

The muscle-splitting biplane technique involves splitting the pectoralis major in a line parallel to its obliquely running fibers, starting from the middle and lower third of the

sternum and finishing superior and lateral to the anterior axillary fold.<sup>17</sup> The superior portion of the implant lies on the chest wall beneath the muscle, while the inferior pole lies above the muscle in a subglandular position.<sup>17</sup> This technique allows for better upper pole coverage while limiting implant movement during pectoralis contraction, as only part of the implant is underneath the muscle.<sup>17</sup> The positioning of the lower pectoralis muscle behind the implant allows adequate filling of the lower pole of the breast.

Baxter first described a variation of this technique emphasizing the importance of upper pole implant coverage by the pectoralis major.<sup>22</sup> The authors claim that the partial coverage of the prosthesis by the superomedial muscle creates and maintains a proper 3-dimensional shape and decreases deformation with physical activity.<sup>22</sup>

Critics have argued that any technique that splits the muscle is excessively destructive and can cause depression or thinning in the inferior pole, especially in thin patients.<sup>4</sup> Moreover, very large implants (greater than 400 cc.) may lead to bottoming out or a potential “double bubble” deformity due to migration of the implant inferiorly. This migration, in turn, can lead to excessive lower pole stretching.<sup>21</sup> Even with the higher likelihood of “double bubble” deformity, this technique has been shown, by the authors, to result in less intraoperative bleeding, less postoperative pain, and faster recovery than traditional subpectoral placement.<sup>17</sup>

The relatively low complication rate can potentially be explained by a relative short follow-up period of 10 months

( $n = 19$ )<sup>16,17</sup> that would mask the development of certain complications such as capsular contracture.

## Discussion

This study highlights the different forms of surgical treatment for AD. Overall, interventions for treating AD were successful in 100% ( $n = 214$ ) of documented cases, with an overall complication rate of 11.6% ( $n = 25$ ) reported in the studies after treatment.<sup>12-20</sup> One possible factor contributing to the elevated complication rate is the fact that AD correction is a secondary surgery and requires extensive dissection through previously formed scar tissue. Additionally, the study with the highest number of patients had the lowest number of complications<sup>20</sup>. This in part can be due to the stringent patient selection, including prior radiotherapy, which can create and exacerbate AD with the fibrosis of the muscle. The most common complication experienced following prepectoral plane change was capsular contracture ( $n = 11$ ). Capsular contracture has long been known to be a complication of prepectoral implant placement; however, rates been hypothesized to be decreased with the introduction of ADMs and fat grafting.<sup>23,24</sup>

The treatment of AD is so important, given that it has been shown to have severely bothersome effects on the patient. A study investigating the impact of AD on quality of life in patients who underwent postmastectomy found that 80% of patients were bothered by AD and 45% of those patients were bothered to a significant degree ( $\geq 6$  out of 10).<sup>25</sup> In addition, 48% of patients felt that the AD interfered with their daily life and 28% of patients underwent or were scheduled to undergo revision of their reconstruction at the time of interview.<sup>25</sup> A similar study performed by Nigro and Blanchet showed through a retrospective chart review that 84 of 108 patients (77.8%) reported having symptoms of AD.<sup>26</sup> All of the included patients underwent subpectoral, implant-based breast reconstruction using an ADM in the lower pole.<sup>26</sup>

It has been hypothesized that patients with increased pectoralis strength may have higher grades of AD and that the incidence of AD, if pooled, would be highest in parts of the world with the most active habitants.<sup>4</sup> Included articles made no mention of variations because of differences in pectoralis strength (activity level). Although not an objective measure, it is important to elicit the activity level and hobbies of the patient to gauge the potential for pectoralis hypertrophy post AD correction. Additionally, given the large mean implant volume of 589.1 cc, there may be a correlation with stretching of the sarcomeres and degree of AD. Although no study to date has measured the degree of pectoralis stretch with hypertrophy and subsequent animation, there have been studies analyzing the growth of sarcomeres postexpansion<sup>27</sup>. One study in rats showed that the average number of sarcomeres in a muscle fiber postexpansion remained the same; however, the sarcomere length and fiber length were significantly greater in the expanded muscle<sup>27</sup>. The act of tissue expansion on pectoralis has not shown to have any effects on actual physical performance or strength<sup>28</sup>. Only one retrospective chart review showed no significant difference in age, athleticism, BMI, and

implant size between patients who had AD vs. those who did not.<sup>4</sup>

In addition to activity level, multiple individual patient factors such as tissue coverage, prior radiation, and body mass index (BMI) need to be assessed when choosing a corrective procedure for AD to limit complications and optimize patient satisfaction. Tissue coverage is the most important factor to be considered. One example, as seen in the articles included in this review, is that patients with thin tissue coverage and low BMI were described as poor candidates for the subfascial or the prepectoral plane on the grounds that the soft tissue envelope may not offer adequate implant coverage<sup>13,18,20</sup>. Flap perfusion but not thickness, which is described by the original articles in this review, has proven to be the main factor contributing to obtain a favorable reconstruction. A visible dermis in any patient's flap is considered to be a contraindication for a subglandular reconstruction or plane change.<sup>27</sup> Even further, as seen in this review, surgeons performed this technique only on patients with a pinch test greater than 2 cm, thus ensuring optimal flap thickness, which was regarded as a surrogate for flap perfusion.<sup>19</sup> Additionally, one study employed the use of skin perfusion imaging to ensure adequate skin flap perfusion. Interestingly, this study had the lowest rate of complications at 4.9% ( $n = 5$ ), with the largest patient set<sup>20</sup>.

Moreover, oncologic considerations also exist when considering plane change.<sup>26</sup> Patients with a tumor invading the chest wall or that comes within 0.5 cm of the pectoralis major muscle are described as having contraindications for subglandular/prepectoral plane change. It is said that these patients may have a higher risk for future chest wall tumor recurrence and would benefit from undergoing some form of submuscular reconstruction, which would allow for easier detection and surveillance.<sup>29</sup>

As mentioned earlier, specific patient characteristics, habits, and comorbidities that may compromise skin flap vascularity must be identified and controlled before treatment, which include tobacco use, uncontrolled diabetes with an HbA1c  $>7.5\%$ , and radiation.<sup>30,31</sup> These factors can impede wound healing, infection, and flap vascularity. Given the already increased complication rate seen in this review for secondary procedures, they must be controlled to ensure the best surgical result.

In addition to a change of plane for the treatment of AD, there have been case reports of nonsurgical and intraoperative prophylactic interventions at the time of initial surgery to avoid AD. These studies were not included in the results in accordance with the inclusion criteria. One study describes cutting the medial pectoral nerve for the avoidance of the dynamic deformity.<sup>31</sup> There are also two cases in the literature of AD corrected using botulism toxin injected into the pectoralis major muscle. By 3 weeks postinjection, no tethering was detected and both patients said they would elect to have more injections.<sup>32,33</sup> Finally, similar to the first study, there is a case report of a surgeon ablating the medial and lateral pectoral nerves by electrocautery<sup>34</sup>. The patient subsequently had an excellent postoperative course, although further electromyography or nerve conduction studies are required.<sup>34</sup>

## Limitations

Eight articles from the initial search results were included. One limitation is the fact that most articles in the literature discussed AD as a secondary endpoint (adverse event) and not as the primary focus of treatment in the study, which was part of the inclusion criteria that were set forth in this review. Second, included articles used different AD grading systems that mostly relied on patient-centered subjective grading. This, in turn, limited the ability to compare different techniques to their alternatives, with no objective measure of comparing the severity of patients experiencing AD. Finally, all the articles except one<sup>13</sup> were retrospective chart reviews, and thus lower quality of evidence. Further studies employing prospective clinical trials comparing different techniques on functional and esthetical outcome are needed.

## Conclusion

In conclusion, AD is likely an underestimated complication that is increasing in incidence, with the growing number of breast implants being placed in the subpectoral plane. This review delineates the paucity of evidence regarding this morbid complication. It also represents the first comprehensive review discussing several different surgical interventions for the correction of AD. Patient characteristics and surgical technique must be tailored on a case-by-case basis to allow for optimum esthetic outcome given the substantial complication rate of these treatment modalities. Surgeons need to be aware of the potentially detrimental effects AD can have on their patients and be familiar with the different surgical modalities of treating this complication. In the future, high-quality studies are required to consolidate treatment options for this condition.

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None.

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## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.bjps.2019.02.025](https://doi.org/10.1016/j.bjps.2019.02.025).

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