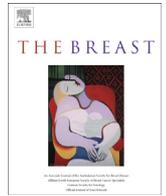




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Original article

An evaluation of resource utilisation of single stage porcine acellular dermal matrix assisted breast reconstruction: A comparative study

Ashley J.R. Kilchenmann ^{a, b, *}, Alessia M. Lardi ^{a, b}, Mark Ho-Asjoe ^b, Klaus Junge ^c, Jian Farhadi ^b^a Department of Plastic, Reconstructive, Aesthetic and Hand Surgery, University Hospital Basel, Petersgraben 4, 4031 Basel, Switzerland^b Department of Plastic and Reconstructive Surgery, Guy's and St. Thomas' Hospital, Westminster Bridge Rd, SE1 7EH London, United Kingdom^c Premier Research Germany Ltd., Europaplatz 5, 64293 Darmstadt, Germany

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ABSTRACT

Objectives: To evaluate resource utilization of single stage porcine acellular dermal matrix (ADM) assisted breast reconstruction compared with tissue expander (TE), latissimus dorsi flap and implant (LD/I) and latissimus dorsi flap and TE (LD/TE) reconstructive techniques.

Materials and methods: Clinical data was collected for length of stay, operative time, additional hospitalisations and operative procedures, and outpatient appointments for 101 patients undergoing unilateral implant based breast reconstruction. Resources utilised by ADM (Strattice Reconstructive Tissue Matrix™) patients were analysed and compared to the resource usage of traditional techniques.

Results: 25 patients undergoing single stage ADM (ADM/I) were compared with 27 having TE, 32 having LD/I and 17 having LD/TE reconstructions. Follow up was 24 months. Compared to TE, ADM/I had similar length of stay and operative time, lower rate and number of additional procedures, fewer, shorter re-admissions ($p < 0.05$) and fewer appointments ($p < 0.05$). Compared to LD/TE, ADM/I had shorter length of stay and operative time ($p < 0.05$), lower rate and number of additional procedures, fewer, shorter re-admissions ($p < 0.05$) and fewer appointments ($p < 0.05$). Compared to LD/I, ADM/I had shorter length of stay ($p < 0.05$) and operative time ($p < 0.05$), fewer appointments, similar rate and number of additional procedures but required more and longer re-admissions.

Conclusion: In our experience, unilateral single stage ADM/I was associated with fewer resources utilised in comparison with two staged TE and LD/TE reconstructions in both complication-free and complicated settings over a 24-month period, despite requiring aesthetic revision in 60.9% of patients. Compared to LD/I, resource utilisation was commensurate in complication-free and complicated settings.

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Introduction

Aesthetic outcomes of implant based breast reconstruction have been improved with the introduction of the Acellular Dermal Matrix (ADM) assisted technique [1–5]. Since the first report of ADM assisted breast reconstruction in 2005 [6], reconstruction with ADM has been globally adopted with constantly increasing case numbers [1, 7–9]. Aside from improved aesthetic outcome, which

is partially attributable to providing better inframammary control [3, 5], ADM assisted breast reconstruction carries many advantages: reduced outpatient visits [10] due to larger intraoperative [3, 10, 11] and subsequently less postoperative expansions [1, 3, 10, 12], and fewer revision surgeries [2, 12–15], partially as a result of a lower capsular contracture rate [1, 2, 4–7, 14–21]. Furthermore, ADM successfully allows single stage reconstruction, eliminating the need for a second stage operation to recreate the breast mound [1, 4, 6–8, 19–23].

Nonetheless, the access and use of ADM remains restricted in various institutions due to the associated high material cost [3, 10, 14, 24]. With, to our knowledge, only eight publications discussing costs of ADM assisted implant based breast reconstruction since 2010 [1, 10, 12–14, 22, 24, 25], there is lack of evidence related to resource utilisation. The purpose of this analysis was to identify and

Abbreviations: ADM, acellular dermal matrix; TE, tissue expander; LD, latissimus dorsi flap; LD/I, LD and implant; LD/TE, LD and tissue expander; LOS, length of stay; FU, follow up; ANC, axillary node clearance.

* Corresponding author. Department of Plastic, Reconstructive, Aesthetic and Hand Surgery, University Hospital Basel, Petersgraben 4, 4031 Basel, Switzerland. Tel.: +41 79 644 32 12.

E-mail address: ashley.kilchenmann@stud.unibas.ch (A.J.R. Kilchenmann).

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compare the resource utilisation of our experience with unilateral single stage porcine ADM assisted breast reconstruction compared to two-staged tissue expander (TE) and Latissimus Dorsi Flap (LD – Implant and TE based) techniques. As the first analysis to solely provide an overview of the resources utilised for single stage ADM BR, we intended to explore whether the cost of ADM justifies its use in implant-based reconstruction compared to traditional techniques.

Patients and methods

We performed a retrospective single centre cohort study of patients who underwent unilateral implant-based reconstruction between 2006 and 2011 at our institution, the NHS Trust of Guy's and St. Thomas'. Patients included in the study were: single stage ADM (ADM/I), non-ADM two staged TE, LD + Implant (LD/I) and LD + TE (LD/TE).

Breast surgeons performed skin- or nipple-sparing mastectomy. Patients were offered single stage ADM if they opted to keep a breast size similar to the preoperative size. The final decision was made intraoperative depending on skin-flap vascularity. ADM reconstruction was performed in accordance with previously explained techniques [26]. The ADM used in this study was Strattice™ Reconstructive Tissue Matrix (LifeCell Corporation, Branchburg, NJ). TE reconstruction involved total or partial muscular coverage with pockets created by the pectoralis major or serratus anterior muscles. LD flaps were raised simultaneously in the lateral decubitus position while mastectomy was performed.

By not focussing on actual costs generated, but by recording and comparing resources utilised, including the initial operation, additional hospitalisations and operative procedures (recorded separately for complications and completion of reconstruction), outpatient appointments, seroma drainages and complication rates, we hope to provide a globally reproducible overview, which is applicable to different countries and institutions. This data, as well as clinical data, was extracted from patient notes and electronic hospital databases. No data was collected on patient satisfaction, quality of life or aesthetic outcome. The patient related variables identified include age, body mass index (BMI), indication for surgery, BRCA status, comorbidities (smoking, diabetes, hypertension, use of systemic steroids/immunosuppression) and adjunctive therapy use (radio- and/or chemotherapy). The follow up (FU) was set at 24 months for all patients. We consider this time period substantial for obtaining long-term results and covering the relevant resource usage for a valid comparison.

Four patients underwent simultaneous contralateral mastectomy and reconstruction. However, the contralateral reconstruction differed from the ipsilateral reconstruction, which led to inclusion in the study. These patients, as well as patients undergoing delayed reconstruction, contralateral augmentation and contralateral flaps were excluded from calculations regarding operating times and length of stay, so as to allow equal analysis. Operating times recorded include the mastectomy time, as it was not possible to distinguish between mastectomy and reconstructive time. Additionally, for calculations regarding length of stay, the groups were divided into two time periods, as in-patient management of ADM patients was modified with increased experience. Initially, ADM patients were hospitalized until all drains were removed. With increased experience in management, patients were discharged with drains in situ and monitored closely until drain removal. *Early patients* include the first 12 months of patients recruited for each reconstructive group. *Late patients* include all the remaining patients.

Outpatient appointments included in this analysis are those attended in the plastics dressing and outpatient clinics. Due to

documentation it was not possible to record expansions separately. ER visits without admission, nipple tattooist visits, oncological and breast surgical FU appointments were not accounted for. No patients were excluded due to incomplete notes/documentation or death prior to the end of FU.

Resource utilisation of single stage ADM assisted breast reconstruction was compared against all other groups. ADM generates an additional acquisition cost, which is not included in the procedure tariff. In this analysis, the only ADM accounted for is that used in the initial operation. Statistical analysis was performed using ANOVA based on ranks, poisson regression, logistic regression and exact logistic regression depending on the type of data. Baseline variables which showed considerable imbalances between reconstruction groups (p -value < 0.10) were used as covariables in the analyses of resource utilization, which were done as multigroup comparisons in a first step. If the overall p -value indicated a trend towards differences between reconstruction groups (p -value < 0.10) pairwise comparisons were performed with a p -value of < 0.05 considered significant. No attempt has been made to adjust p -values for multiple testing. All results are hence considered exploratory. Statistical analysis was performed with the SAS 9.2.

Results

Patient characteristics (Table 1)

101 patients who underwent unilateral implant based breast reconstruction at our institution were included: 25 ADM/I reconstructions, 27 TE reconstructions, 32 LD/I reconstructions and 17 LD/TE reconstructions (Fig. 1). Patient characteristics are summarised in Table 1. Age, BRCA status, BMI and reason for mastectomy did not differ significantly between the groups ($p > 0.10$).

All further procedures and admissions recorded took place within the 24-month FU period, with the exception of 6 patients, who only underwent the planned 2nd stage procedure 25–48 months after initial reconstruction. Admission and procedure details for these 2nd stage procedures were included to permit equal analysis. 11 patients with TE or LD/TE reconstructions did not complete reconstruction: 7 patients declined further surgery, 2 patients suffered implant loss without subsequent reconstruction and 2 died before end of FU.

Further procedures and admissions after initial reconstruction

Table 2 gives an overview of further procedures after the initial reconstruction. Recorded procedures took place in surgery either during an admission or as a day case. 78 patients (78%) underwent 136 further procedures due to complications and for completion of reconstruction.

37 (39.8%) patients had 62 further procedures due to complications. Procedures performed due to complications were defined as: washout/debridement, implant removal, implant replacement, exchange implant for expander with subsequent procedures, flap salvage, haematoma aspiration and VAC application of breast or donor sites. Seroma drainages of the breast and LD donor site performed during outpatient appointments were recorded separately (Table 4), as resource usage is minimal in comparison to procedures in surgery.

64 patients (65.3%) had 74 further procedures for completion of reconstruction. Procedures performed for reconstructive completion were defined as: planned 2nd stage exchange expander for implant or flap reconstruction, exchange of implant, lipofilling, liposuction, fat transfer, nipple-areola-complex reconstruction,

Table 1
Patient characteristics, adjunctive therapies.

	n	ADM + implant	TE	LD + implant	LD + TE	p-value	Method of analysis
N, Overall	101	25	27	32	17	na	
Age, year \pm SD (range)	101	49.5 \pm 9.54 (31–71)	48.6 \pm 9.68 (26–63)	50.2 \pm 9.53 (27–67)	49.2 \pm 11.14 (29–69)	0.9345	ANOVA
BMI, kg/m ² \pm SD (range)	88	24.8 \pm 4.10 (19–35)	26.5 \pm 7.18 (19–46)	26.4 \pm 5.44 (19–39)	27.1 \pm 7.19 (20–46)	0.6828	ANOVA
BRCA % (n)	101	8% (2)	7.4% (2)	6.3% (2)	0% (0)	0.7976	ELR
Comorbidities % (n)	101	12% (3)	40.7% (11)	37.5% (12)	52.9% (9)	0.0318	ELR
Radiotherapy % (n)	101						ELR
Previous		0% (0)	11.1% (3)	21.9% (7)	35.3% (6)	0.0107	
PreOP		0% (0)	0% (0)	3.1% (1)	0% (0)	1.0000	
PostOP		48% (12)	55.6% (15)	12.5% (4)	23.5% (4)	0.0014	
Chemotherapy % (n)	101						ELR
Previous		8% (2)	11.1% (3)	28.1% (9)	41.2% (7)	0.0231	
Neoadjuvant		12% (3)	29.6% (8)	6.3% (2)	0% (0)	0.0127	
Adjuvant		48% (12)	40.7% (11)	15.6% (5)	11.8% (2)	0.0098	
Time point of reconstruction % (n)	101					0.0011	ELR
Immediate		100% (25)	100% (27)	90.6% (29)	70.6% (12)		
Delayed		0% (0)	0% (0)	9.4% (3)	29.4% (5)		
Reason for mastectomy % (n)	91					0.8129	ELR
Cancer		92% (23)	95.8% (23)	92.9% (26)	100% (14)		
Prophylactic		8% (2)	4.2% (1)	7.1% (2)	0% (0)		
Simultaneous ANC % (n)	101	36% (9)	63% (17)	15.6% (5)	23.5% (4)	0.0011	ELR

ANC = Axillary node clearance; ELR = Exact logistic regression; ANOVA = Analysis of variance.

dog-ear excision, contralateral augmentation and mastopexy in context of ipsilateral revisions.

Table 3 shows details of further admissions, which required overnight stay, after initial reconstruction. 65 patients (66.3%) had 108 further admissions and 417.1 additional days in hospital, for complications and completion of reconstruction combined. 51 (52%) patients required 58 admissions and 203.7 additional days in hospital to undergo procedures for completing reconstruction. 31 patients (32%) required 49 unplanned admissions and 213.4 additional days in hospital due to complications.

Operating times, simultaneous procedures, length of stay and outpatient appointments (Tables 4–6)

When looking at calculations regarding operating times, operative time for ADM/I was insignificantly longer than for TE (mean, 177.9 vs. 164.8 min). ADM/I had significantly shorter operating times than LD/I and LD/TE (172.2 vs. 208.7 and 243.3 min, respectively). During the initial operation, 59 patients had simultaneous procedures ($p = 0.8465$): 11 involved a sentinel node biopsy (SNB) (10.8%), 33 patients underwent ANC (32.4%) and 2 patients had both an ANC and SNB.

Calculations regarding the length of stay for ADM/I show a significant decrease over the two time periods (mean, 9.5 vs. 5.4 days, respectively; $p = 0.0066$). As postoperative inpatient management

of the other groups was not altered over the two time periods, we performed pairwise comparisons of ADM/I LOS late patients with LOS all patients in the remaining reconstructive groups. ADM/I tended towards a shorter length of stay than both TE and LD/TE patients (5.4 vs. 5.6 and 7.3 days, respectively), and had a significantly shorter length of stay compared to LD/I patients (5.4 vs. 7.8 days). On average, ADM/I patients attended fewer outpatient appointments than LD/I (mean, 9 vs. 11.9 appointments) and had a significantly lower number than TE (mean, 13.8 appointments) and LD/TE (mean, 14.5 appointments). See Fig. 2.

Discussion

In the UK, healthcare will account for 33% of total governmental expenditure of its resource budget by 2015; 11% of the total capital budget [27]. Despite an increase in yearly productivity of 0.4% there has been substantial increase in expense, rising from £ 38,229 million in 1995 to £ 113, 594 million in 2010 [28]. The current economic situation makes indispensable for surgeons to evaluate costs of innovative techniques, such as ADM assisted breast reconstruction. On these grounds, we wanted to explore the resource utilisation of 101 patients having undergone unilateral breast reconstruction with the focus on single stage ADM reconstruction. To our knowledge, this is the first analysis distinguishing between operative revisions and re-admissions required for

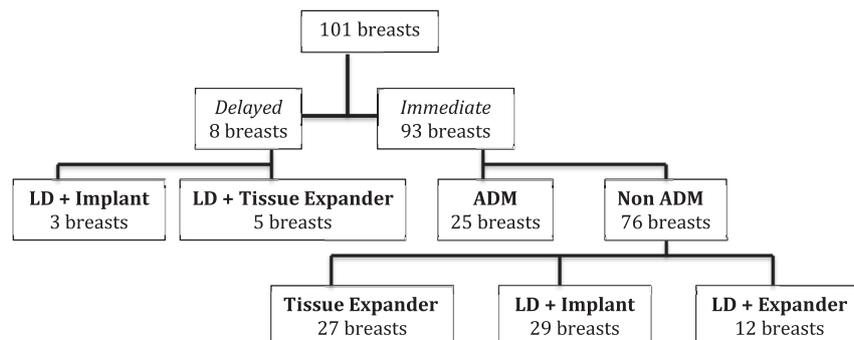


Fig. 1. Distribution of study patients.

Table 2
Further procedures after initial reconstruction.

	<i>n</i>	ADM + implant	TE	LD + implant	LD + TE	<i>p</i> -value overall	Method of analysis
Further procedures due to complications	93						
Procedure rate % (<i>n</i>)		44% (11)	44.4% (12)	37.5% (9)	29.4% (5)	0.8640	LR
Number of procedures, mean ± SD (range)		0.6 ± 0.91 (0–3)	0.7 ± 0.99 (0–4)	0.6 ± 0.88 (0–3)	0.8 ± 1.6 (0–6)	0.6111	PR
Total number of procedures	16		19	14	13	na	na
Further procedures for completion of reconstruction	98						
Procedure rate % (<i>n</i>)		60.9% (14) ^a	74.1% (20) ^{a,d}	54.8% (17) ^d	76.5% (13)	0.0572	LR
Total number of procedures	15		23	19	17	na	na
Further procedures due to complications and for completion of reconstruction	100						
Procedure rate % (<i>n</i>)		72% (18)	85.2% (23)	71% (22)	88.2% (15)	0.3776	LR
Number of procedures, mean ± SD (range)		1.2 ± 1.13 (0–4)	1.6 ± 1.09 (0–5)	1.1 ± 0.93 (0–3)	1.8 ± 1.48 (0–6)	0.1504	ANOVA based on ranks
Total number of procedures	31		42	33	30	na	na

Pairwise comparisons with statistically significant *p*-values < 0.05: a) ADM/I vs. TE; b) ADM/I vs. LD/I; c) ADM/I vs. LD/TE; d) TE vs. LD/I; e) TE vs. LD/TE; f) LD/I vs. LD/TE. LR = Logistic regression; PR = Poisson regression; ANOVA = Analysis of variance.

complications and completion of reconstruction post ADM assisted breast reconstruction.

Analysis of single stage ADM vs. tissue expander (±LD flap) based reconstructions

Our results suggest single stage ADM is associated with lower resource utilisation compared to TE and LD/TE in non-complicated as well as complicated scenarios, thus potentially providing an economical advantage to the payer. Regarding the reconstructive procedure, an advantage of ADM/I is to be expected over LD/TE, due to tendency towards a shorter length of stay and significantly shorter operating times. Longer operative times do not only have a direct economical effect for the payer increasing OR costs, but also indirectly as OR space is blocked, potentially reducing the operative turnover. No disadvantage would result over TE as operating times and length of stay do not differ significantly, which is interesting, as many surgeons, contrary to our findings, consider ADM/I placement to take longer than TE placement. These results, regarding the pairwise comparison of ADM/I vs. TE, mirror Johnson's findings [22].

We previously found ADM/I being subject to a learning curve [26], explaining why our operating times are longer than in recent reports [22], as patients included portray the beginning of this curve. This being said, one can further expect costs regarding the reconstructive procedure to decrease, as times will reduce with increased experience. Modified postoperative inpatient management of ADM/I led to a significant decrease in length of stay from 9.5 to 5.4 days (*p* = 0.0066), additionally suggesting hospitalisation costs will decrease with increased experience.

Similar to Jansen and Macadam, comparing costs of single stage ADM vs. two staged TE [12], Johnson, comparing costs of single stage ADM with two staged TE and LD reconstructions [22], and De Blacam, comparing costs in a decision analytical model of single stage ADM, two staged ADM and two staged TE [24], our results suggest that single stage ADM assisted reconstruction is associated with lower resource usage, subsequently generating lower costs, than TE and LD/TE, in complicated settings. In comparison to TE and LD/TE, ADM required significantly fewer admissions and additional days in hospital with a tendency towards a lower procedure rate and number. The complication rates >3 months were, however, higher for both TE and LD/TE patients than for ADM/I, explaining the

Table 3
Further admissions after initial reconstruction.

	<i>n</i>	ADM + implant	TE	LD + implant	LD + TE	<i>p</i> -value overall	Method of analysis
Further admissions due to complications	97						
Admission rate % (<i>n</i>)		30.4% (7)	37% (10)	23.3% (7)	41.2% (7)	0.3376	LR
Number of admissions, mean ± SD (range)		0.5 ± 0.85 (0–3)	0.7 ± 1.48 (0–7)	0.3 ± 0.65 (0–3)	0.6 ± 0.87 (0–3)	0.1439	PR
Total number of further admissions	11		20	9	10	na	na
Additional days in hospital, mean ± SD (range)		1.8 ± 3.41 (0–11)	3.4 ± 8.04 (0–40)	0.7 ± 1.55 (0–6)	3.4 ± 6.71 (0–23)	0.3099	ANOVA based on ranks
Further admissions for completion of reconstruction	98						
Admission rate % (<i>n</i>)		56.5% (13) ^{a,b}	66.7% (18) ^{a,d}	22.6% (7) ^{b,d,f}	76.5% (13) ^f	0.0003	LR
Total number of further admissions	15		22	7	14	na	na
Additional days in hospital, mean ± SD (range)		1.2 ± 1.37 (0–5) ^{a,c}	3.1 ± 3.06 (0–11) ^{a,d}	0.5 ± 0.94 (0–3) ^{d,f}	4.4 ± 4.91 (0–21) ^{c,f}	0.0000	ANOVA based on ranks
Further admissions for complications and completion	98						
Admission rate % (<i>n</i>)		69.9% (16)	85.2% (23) ^d	35.3% (11) ^{d,f}	88.2% (15) ^f	0.0016	LR
Number of admissions, mean ± SD (range)		1.1 ± 1.18 (0–4) ^{a,c}	1.6 ± 1.53 (0–8) ^{a,d}	0.5 ± 0.81 (0–3) ^{d,f}	1.4 ± 1.0 (0–4) ^{c,f}	0.0002	ANOVA based on ranks
Total number of further admissions	26		42	16	24	na	na
Additional days in hospital, mean ± SD (range)		3 ± 4.03 (0–12) ^{a,c}	6.6 ± 8.76 (0–45) ^{a,d}	1.2 ± 1.88 (0–6) ^{d,f}	7.8 ± 8.44 (0–28) ^{c,f}	0.0000	ANOVA based on ranks

LR = Logistic regression; PR = Poisson regression; ANOVA = Analysis of variance.

Pairwise comparisons with statistically significant *p*-values < 0.05: a) ADM/I vs. TE; b) ADM/I vs. LD/I; c) ADM/I vs. LD/TE; d) TE vs. LD/I; e) TE vs. LD/TE; f) LD/I vs. LD/TE.

Table 4
Operating times for initial reconstruction, simultaneous procedures.

	<i>n</i>	ADM + implant	TE	LD + implant	LD + TE	<i>p</i> -value overall	Method of analysis
Operating time in mins, mean ± SD (range) – all patients	65	177.9 ± 35.27 (100–251) ^{b,c}	164.8 ± 36.88 (108–277) ^{d,e}	208.7 ± 38.49 (150–287) ^{b,d}	243.3 ± 31.37 (190–275) ^{c,e}	0.0063	ANOVA based on ranks
Simultaneous procedures % (<i>n</i>) [*]	101	60% (15)	77.8% (21)	50% (16)	41.2% (7)	0.7641	LR

ANOVA = Analysis of variance; LR = Logistic regression.

Pairwise comparisons within the row, with statistically significant *p*-values < 0.05: ^{a)} ADM/I vs. TE; ^{b)} ADM/I vs. LD/I; ^{c)} ADM/I vs. LD/TE; ^{d)} TE vs. LD/I; ^{e)} TE vs. LD/TE; ^{f)} LD/I vs. LD/TE.^{*} Axillary clearance, sentinel node biopsy, contralateral mastectomy, contralateral non-autologous reconstruction, contralateral augmentation, contralateral mastopexy, contralateral flap, contralateral flap removal, Strattice banking in groin, nipple reconstruction.

slightly higher, yet insignificant re-admission rates for complications. Mirroring Johnson's findings [22], both TE and LD/TE patients attended significantly more outpatient appointments than ADM/I, attributable to the expansion process. However, he also recently documented [22], 0% of single stage ADM patients, 30% of TE patients and 50% of LD/I patients had to undergo unplanned surgeries for aesthetics and complications. Despite our similar trend regarding TE, these numbers largely differ from our findings: Johnson did not account for the planned 2nd stage exchange procedure, his cohort was smaller and FU was set to 180 days [22].

Nevertheless, when assuming the patient suffers no complications, our results still support that ADM/I is associated with lower resource usage, with significantly fewer admissions, days in hospital, outpatient appointments and procedures for completion of reconstruction compared to TE. Despite finding no difference in cost between single staged- and two staged ADM, Colwell postulated that if one takes outpatient appointments into account, single stage ADM would yield less costly [13], which reflects results presented here. Fewer clinic visits provide a point of reduced resource utilisation for ADM/I reconstruction by increasing direct medical costs, creating transport costs and increasing time off work, indirectly generating additional costs. When analysing the complication free scenario, compared to LD/TE, ADM/I tended towards fewer admissions and procedures, had significantly fewer outpatient appointments and additional inpatient days for completion of reconstruction, also suggesting ADM/I is associated with reduced resource usage. The high material price is additionally offset by these findings.

Interestingly, we found direct to implant reconstruction is only single stage in 39.1% of patients, with 60.9% undergoing 15 elective procedures for aesthetic completion. In terms of reconstructing the breast mound, it is single stage in all patients. However, 1.2 additional days in hospital were required per patient for procedures to

achieve the desired aesthetic result. Regardless, resources used to complete reconstruction can still be expected to lie below those of traditional tissue expander based techniques.

Analysis of single stage ADM vs. LD + implant reconstruction

Our results demonstrate that ADM/I is associated with tantamount of resource utilisation as LD/I reconstruction in complicated as well as non-complicated scenarios. After having adapted inpatient management, ADM/I patients required 2.4 days less in hospital after the initial reconstructive procedure (*p* < 0.05). Furthermore, ADM/I not only presented with significantly shorter operating times but also with significantly lower complications rates <3 months, attributable to absent donor site morbidity. Combined, these results suggest ADM/I is associated with reduced resource usage for the initial reconstructive procedure. Johnson's conclusions [22], stating short-term (180d FU) single stage ADM is less costly than LD/I, are similar.

However, when additionally exploring long-term resources used (24 months), we found no difference in the association of resources utilised in complicated settings. Johnson did not explore costs generated outside the 180d FU in his smaller cohort. Compared to ADM/I, LD/I patients required a similar number of additional procedures but tended towards fewer re-admissions and inpatient days (*p* > 0.05). On average, LD/I patients attended 2.9 more outpatient appointments than ADM/I patients (*p* > 0.05) and suffered more complications >3 months. Although LD/I required 1.8 additional days in hospital less than ADM/I, the initial length of stay was 2.4 days longer (*p* < 0.05), offsetting the reduced number of additional days as well as, depending on local tariffs, the high material cost.

When analysing under the assumption that the patient suffers no complications, we found LD/I had a significantly lower re-

Table 5
Outpatient appointments, seroma drainages, implant loss and complication rates.

	<i>n</i>	ADM + implant	TE	LD + implant	LD + TE	<i>p</i> -value overall	Method of analysis
Outpatient appointments, mean ± SD (range)	95	9.0 ± 5.92 (0–24) ^{a,c}	13.3 ± 5.58 (5–25) ^a	11.9 ± 9.24 (1–54) ^f	14.5 ± 6.70 (0–27) ^{c,f}	0.0038	ANOVA based on ranks
Breast seroma drainages % (<i>n</i>)	101	20% (5)	11.1% (3)	6.3% (2)	11.8% (2)	0.2490	LR
LD-donor site seroma drainages % (<i>n</i>)	101	0% (0)	0% (0)	15.6% (5)	23.5% (4)	0.6337	LR
Implant Loss* % (<i>n</i>)	101	12% (3)	25.9% (7)	6.3% (2)	11.8% (2)	0.5444	LR
Complication** rates < 3 months post BR % (<i>n</i>)	100	48% (12) ^b	48.1% (13) ^d	80.6% (25) ^{b,d}	76.5% (13)	0.0417	LR
Complication** rates > 3 months post BR % (<i>n</i>)	101	24% (6)	48.1% (13)	31.3% (10)	35.3% (6)	0.7033	LR

^{*}Patients who did not have immediate replacement of an implant after its removal (due to a complication, primarily infections) and patients who lost an implant due to rupture; not included as part of the overall complication rate.^{**}Complications defined as, but not limited to: infection, breast seroma, breast haematoma, wound dehiscence, LD-donor site seroma and haematoma, skin necrosis, capsular contracture and scar hypertrophy requiring revision.

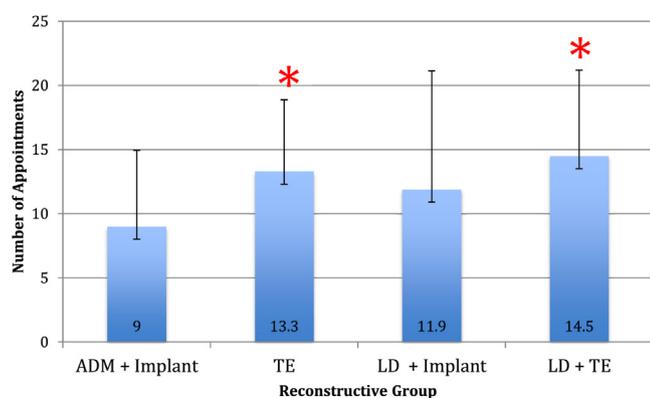
ANOVA = Analysis of variance; LR = Logistic regression.

Pairwise comparisons within the row, with statistically significant *p*-values < 0.05: ^{a)} ADM/I vs. TE; ^{b)} ADM/I vs. LD/I; ^{c)} ADM/I vs. LD/TE; ^{d)} TE vs. LD/I; ^{e)} TE vs. LD/TE; ^{f)} LD/I vs. LD/TE.

Table 6
Length of stay and drainage duration for initial hospitalization.

	n	ADM + implant	TE	LD + implant	LD + TE	p-value overall	Method of analysis
LOS in days, mean ± SD (range) – all patients	76	6.7 ± 3.20 (3–15)	5.6 ± 2.50 (1–10)	7.8 ± 2.99 (4–19) ^a	7.3 ± 2.50 (5–13)	0.1465	ANOVA based on ranks
LOS in days, mean ± SD (range) – early patients		9.5 ± 4.14 (5–15)	4.7 ± 2.57 (1–9)	9.0 ± 4.94 (6–19)	10.0 ± 2.65 (8–13)	0.1483	ANOVA based on ranks
LOS in days, mean ± SD (range) – late patients		5.4 ± 1.56 (3–9) ^{a,b}	6.7 ± 2.00 (4–10)	7.5 ± 2.19 (4–12) ^b	6.0 ± 0.89 (5–7)	0.0262	ANOVA based on ranks
Breast drainage duration, days, mean (range)	79	6.8 ± 3.96 (2–17)	6.3 ± 3.97 (2–19)	6.8 ± 2.24 (3–13)	6.4 ± 1.91 (4–12)	0.4738	ANOVA based on ranks

ANOVA = Analysis of variance.

Pairwise comparisons with statistically significant *p*-values < 0.05: a) ADM/I late vs. LD/I all b) ADM/I late vs. LD/I late.* *p* < 0.05 in pairwise comparison with ADM/I**Fig. 2.** Outpatient appointments.

admission rate, tended towards fewer additional inpatient days, required a similar number of procedures for completion of reconstruction and necessitated more outpatient appointments than ADM/I. Similar to the complicated setting, this lower long-term resource usage of LD/I compared to ADM/I is offset by the significantly longer length of stay and operating times. Thus, when comparing LD/I and ADM/I in a non-complicated setting, results demonstrate no associated difference in resource utilisation over a period of 24 months.

This study carries the limitations of a non-randomized retrospective single-centre study. Our institution is a university hospital, with results representing teaching hospital outcomes. Despite using regression models, the small sample size and discrepancy between the cohorts regarding baseline variables, especially comorbidities, prevented us from achieving causal-interference. Further research is needed to confirm our findings. Additionally, further prospective research is needed to evaluate patient satisfaction and quality of life after single stage reconstruction with ADM. Paired with costs, the result would yield a cost-utility analysis, similar to Krishnan's concerning two-staged ADM [25]. Currently, there are two on going prospective randomised controlled trials comparing single stage ADM respectively two-staged ADM with two-staged non-ADM reconstruction [29, 30], whose results will grant such analyses.

Conclusion

In our experience, unilateral ADM assisted single stage reconstruction was associated with reduced resource utilisation and thus has a potential economical benefit in comparison with two staged TE and LD/TE reconstructions in complication-free as well as

complicated settings over a 24 month period, despite requiring aesthetic revision in 60.9% of patients. Compared to LD/I reconstruction, the tendency towards higher long-term resource utilisation of single stage ADM was offset by the fewer clinic visits, significantly shorter length of stay and operating times, resulting in commensurate resource utilisation, for both complication free and complicated settings.

When consulting patients on unilateral immediate implant based reconstruction, where eligible, single stage ADM assisted breast reconstruction should be the technique of choice, as it is not associated with higher resource usage, has shorter operative times and length of stay, eliminates donor site morbidity and tends towards lower complication rates than traditional techniques.

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Authors AJRK, AML and JF initiated this study. Premier Research Ltd performed statistical analysis with a fellowship from LifeCell. LifeCell had no part in determining the study design, in the data collection, interpretation and analysis of data, in the writing of the manuscript and in the decision to submit the manuscript for publication.

Conflict of interest statement

Statistical analysis was generated by Premier Research, which employs KJ, through a fellowship from LifeCell. All other authors declare no support and financial relationships with any other organisations that might have had interest in the submitted work.

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