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Autologous reconstructions are associated with greater overall medium-term care costs than implant-based reconstructions in the Finnish healthcare system: A retrospective interim case-control cohort study

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Summary *Purpose:* Previous studies have mainly reported the short-term costs of different reconstruction techniques. Revision operations may increase costs in longer follow-up. Authors report medium-term data on different reconstruction methods. We hypothesised that the reconstruction method would affect not only the duration of reconstruction process but also total costs.
Methods: The reconstruction database was reviewed from 2008 to 2019. Women with autologous (deep inferior epigastric perforator, transverse musculocutaneous gracilis and latissimus dorsi [LD] without implant) and implant-based (implant and LD with implant) reconstructions were included. Variables evaluated included age, body mass index, smoking, comorbidities, radiotherapy, complications and readmissions. Risk factors for multiple revision surgeries were analysed. Time to definitive reconstruction and related costs were also calculated.
Results: In total, 591 patients with autologous reconstructions and 202 with implant-based reconstructions were included. The median follow-up time was 73 months. Definitive reconstruction was obtained in 443 days in implant-based reconstructions and in 403 days in autologous reconstructions ($P = 0.050$). Independent risk factors for multiple surgeries were younger age

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($P < 0.001$) and comorbidity ($P = 0.008$). No statistically significant difference was observed in the rate of overall surgical procedures ($P = 0.098$), but implant-based reconstructions were more commonly associated with two or more planned operations ($P = 0.008$). Autologous reconstructions were associated with greater total cost ($22 052 vs. $18 329, $P < 0.001$).
Conclusions: This review of reconstructions over a 12-year study period revealed that autologous reconstructions are associated with greater overall costs, but there is no statistically significant difference in reconstruction time or rate of surgical procedures. However, a full cost assessment between reconstructive techniques requires a much longer follow-up period.

Introduction

Breast reconstruction is often a multistage process that includes a primary operation followed by a correction of the contralateral side, re-shaping of the reconstructed breast, nipple reconstruction and an areola complex tattoo to complete the reconstruction.[1] The reconstructive modality influences the number of operations needed and the duration of the reconstructive process. For example, a two-staged implant reconstruction requires more planned outpatient appointments for serial expansion, and thereafter at least one more operation is required to change the permanent implant. During the breast reconstruction process, every operation and hospital visit involves the use of scarce healthcare resources. Although economic arguments might seem distasteful, they are important considerations when choosing a breast reconstruction modality. Thus, an analysis of the costs involved can help surgeons and healthcare providers make informed decisions on the allocation of limited resources.[2]

In the existing literature, mixed results have been reported regarding the costs of different reconstruction techniques. For example, Atherton et al. reported that implant reconstruction was associated with lower costs than latissimus dorsi (LD) or abdominally-based reconstructions ($11 156 vs. $14 718 vs. $15 149). In their study, 107 abdominally based flaps, 98 LDs and 73 implant reconstructions were included with an average follow-up time of 3 years. The mean number of secondary procedures was 1.5 for implant reconstructions, 1.6 for LDs and 0.8 for deep inferior epigastric perforator (DIEP) flaps.[2] However, it was suggested that any financial advantage implants had over autologous tissue would disappear if followed up for long enough.[2] Furthermore, a study by Fischer et al. with 142 free flaps and 60 two-staged implant reconstructions with 4 year's follow-up also showed that free flap reconstructions required fewer procedures than two-staged implant reconstructions (1.8 vs. 3.4). No significant differences were observed in the total costs of the primary operations of free flaps and implant reconstructions ($21 567 vs. $22 064), but implant reconstruction was associated with a greater total cost for secondary procedures.[3] Another study by Fischer et al. with 310 propensity-matched patients with a free flap or two-staged implant reconstruction also agreed with these findings. The cost of secondary procedures in implant reconstruction was $10 157 and $3 200 in free flap reconstruction, and the follow-up time in that study was 2 years.[4] In a longer-term study by Lagares-Borrego et al. with a follow-up time of 45.3 months for DIEPs ($n = 67$) and 80.4 months for two-stage implant reconstructions ($n = 67$), no statistically significant differences were observed in total costs between reconstruction methods ($22 463 for DIEP and $24 423 for implant reconstruction). In that study, however, implant reconstructions required a greater number of surgery sessions to complete the reconstruction (3.07 vs. 2.32).[5]

This study explores the hypothesis that an association exists between reconstruction type, duration of the reconstruction process and long-term total costs. In our 12-year study, implant-based and autologous breast reconstructions were reviewed to assess the distribution of unplanned and planned readmissions, to identify those risk factors associated with multiple secondary revision surgeries, to analyse time to definitive reconstruction and to calculate total costs.

Patients and methods

This retrospective study was conducted using data from the breast reconstruction database prospectively maintained by Tampere University Hospital (Finland). We identified patients who had undergone breast reconstruction between 1 January 2008 and 31 December 2019. Follow-up was performed until 31 May 2020. All women with DIEP, TMG, LD and implant reconstructions were included in the study. Patients without complete data of the reconstruction process or other reconstruction methods were excluded from the study.

We hypothesised that the implant-based reconstruction type would have a longer time to definitive reconstruction and greater total costs than the autologous reconstruction type in long-term follow-up. The endpoints of the study were an achieved definitive reconstruction and time to definitive reconstruction until 31 May 2020. The one-sided *post hoc* power for total costs in our study was 1 with an alpha of 0.05. A demand for statistical power was 0.80 between time and costs in the implant-based and autologous reconstruction groups. According to means and standard deviation, the *post hoc* power of time to definitive reconstruction was 0.86 with an alpha of 0.05.

Permission to access the clinical records of the patients for the study was obtained from the Scientific center of Tampere University Hospital, which is a public university hospital. In our plastic surgery unit, we have eight se-

Table 1 Registered parameters and definitions.

	Definition
Patient characteristics	Age BMI (Kg/m^2) Smoking status (smoker/non-smoker) Comorbidities • Diabetes • Cardiovascular disease (CVD) • Asthma or chronic obstructive pulmonary disease (COPD) • Hypothyreosis • Other
Radiation therapy	Radiation therapy before or after reconstruction
Reconstruction indications	Delayed Immediate (including prophylactic procedures)
Reconstruction techniques	Autologous • DIEP (deep inferior epigastric perforator) flap • LD (latissimus dorsi) without implant • TMG (transverse musculocutaneous gracilis) flap Implant-based • immediate permanent implant • two-stage • LD with implant
Complications (Graded according to the Clavien-Dindo classification)	Grade I: Seroma, other minor deviation from normal postoperative course without the need for pharmacological treatment or surgical interventions Grade II: Infection without surgical intervention, but requiring oral pharmacological treatment (antibiotics) Grade III: Deep infection, haematoma, skin or fat necrosis requiring surgical intervention in the operating theatre Grade IV: Life-threatening complication (e.g. pulmonary embolism)
Unplanned	
Visits	Emergency room visits for a wound complication or seroma
Operations	Operation required within 30 days after the primary operation because of the complication
Hospital stay days	Hospitalisation days after the unplanned operations
Planned	
Visits	Scheduled visit to the outpatient clinic
Operations	Secondary revision surgeries • A correction of the contralateral side, fat grafting and nipple reconstruction • Donor-site correction
Hospital stay days	Hospitalisation days after planned operations
The time to definitive reconstruction	Time from initiation of reconstruction until completed areola complex tattoo or the last clinic visit

Grade I and II were defined as minor complications, grade III as complication requiring re-surgery and grade IV as medical complication.

nior surgeons and three resident surgeons. The study was reported according to the STROBE guidelines. By reviewing the clinical records, we ensured that there were no duplicates.

We collected data on patient characteristics, reconstruction indications, techniques, complications, number of planned and unplanned hospital visits, secondary operations and hospital stays, and time to definitive reconstruction. Detailed information on the registered parameters and definitions is presented in Table 1. Patient characteristics included age, body mass index (BMI), smoking status, comorbidities and adjuvant therapies. BMI was calculated in kg/m2. Comorbidities were divided into diabetes, cardiovascular disease (CVD), asthma or chronic obstructive pulmonary disease (COPD), hypothyreosis, and others. History of radiotherapy was recorded. Reconstruction indications were delayed or immediate (including prophylactic procedures). Autologous reconstruction techniques included DIEP

Table 2 The demographic characteristics, main clinical record data, and secondary operations associated with different reconstruction techniques ($N = 793$).

	Implant-based ($n = 202$)	Autologous ($n = 591$)	*p*-value
Age, years, Md (Range)	56 (27-76)	53 (19-72)	<0.001
BMI, Md (IQR)	24.7 (22.4-28.6)	26.3 (23.6-29.0)	0.001
Active smoking, n (%)	25 (12)	50 (8)	0.101
Comorbidity, n (%)	77 (38)	180 (30)	0.045
History of radiotherapy, n (%)	96 (47)	323 (55)	0.080
Complications, n (%)			<0.001
None	84 (42)	329 (56)	
Minor	83 (42)	148 (25)	
Major	33 (16)	109 19()	
Secondary operations			
Md (IQR, range)	1 (1-2, 0-7)	1 (1-1, 0-6)	0.098
0, n (%)	15 (7)	26 (4)	0.013
1, n (%)	129 (64)	443 (75)	
2, n (%)	39 (19)	86 (15)	
≥3, n (%)	19 (9)	33 (6)	
Duration of follow-up, months, Md (IQR)	79 (49-116)	68 (32-109)	0.001
Time to definitive reconstruction, days, Md (IQR)	443 (332-744)	403 (321-661)	0.050

Implant-based reconstructions include pure implant and latissimus dorsi (LD) with implant reconstructions. Autologous reconstructions include microvascular reconstructions (DIEP and TMG) and LD without implant reconstructions. Comorbidity includes cardiovascular disease, diabetes, asthma/chronic obstructive pulmonary disease and hypothyreosis. Minor complications= Seroma or other minor deviation from normal postoperative course without the need for surgical interventions and infection without surgical interventions but requiring oral pharmacological treatment (antibiotics). Major complications= Deep infection, haematoma, skin or fat necrosis requiring surgical intervention in the operating theatre. Secondary operations include all unplanned and planned operations after primary operation. Md=Median, IQR=Interquartile range. Differences between reconstruction techniques were tested using Pearson Chi-square test or Independent-samples Mann-Whitney test.

flap, LD without the implant and transverse musculocutaneous gracilis (TMG) flap. Implant-based reconstructions included LD with the implant, two-stage expander and direct implant. All postoperative complications were scored using the Clavien-Dindo classification.

Readmissions included both unplanned visits and operations and planned visits and operations. An unplanned visit was defined as an emergency room visit for a wound complication or seroma. The unplanned operation was an operation required within 30 days after the primary operation due to complications. Unplanned hospital stay days were hospitalisation days after the unplanned operation. The planned visit was a scheduled visit to the outpatient clinic. The planned operation included secondary revision surgeries (a correction of the contralateral side, fat grafting and nipple reconstruction) and donor-site correction. Planned hospital stay days were hospitalisation days after planned operations.

The time to definite reconstruction was defined as the time from initiation of the reconstruction until completed areola complex tattoo or the last clinic visit.

Costs were calculated separately for planned and unplanned visits and operations as were the total costs for the reconstruction process and the secondary revision surgeries. All data were individually calculated for each patient. Using the figures available from the hospital's finance department, we derived costs for each reconstruction type. These costs included: (1) an operation planning visit to the outpatient clinic and preoperative imaging (mammography, ultrasound and computed tomographic angiography (in DIEP flaps)). (2) Primary reconstructive operation (including operating room costs, materials, devices, implants). (3) Postoperative hospital stays (cost per night (length of stay within the hospital was recorded individually from patient records)). (4) Scheduled control visits to the outpatient clinic after the operation. The practice in our department is to have two planned follow-up visits (at 3 months and 6 months) after the operation for all reconstruction methods. With expander implants, serial expansion visits were calculated. The number of scheduled visits was recorded individually from patient records. (5) Planned secondary revision surgery (including operating room costs, materials, devices, implants). The number of surgical sessions was calculated individually from patient records, and the costs were calculated for each session. (6) Unplanned visits for a wound complication or seroma were calculated individually from patient records (costs included possible imaging costs). (7) Unplanned operations required within 30 days of the reconstruction operation due to complications (costs included operating room costs and materials). (8) Postoperative hospital stays after unplanned operations (cost per night (length of stay within the hospital was recorded individually from patient records). In this study, we included only secondary healthcare (hospital) costs. From Monday to Friday, our department operates a consulting room for patients with wound problems or seroma. We ask patients to contact us if there are any problems. At weekends, patients can contact the emergency department of our hospital. We are therefore able to contact and record most of our patients with wound problems. These cost calculations did not include professional service fees or charges, patient travel costs, psychology service costs, lost productivity or workdays missed secondary to a prolonged recovery.

The datasets analysed during this study are available from the corresponding author on reasonable request.

Statistics

Any differences in categorical factors between the reconstruction techniques were tested using Pearson chi-square test or Fisher's exact test. Due to the skew distributions, a non-parametric Mann–Whitney test was performed. Multivariable logistic regression analyses were applied to estimate odds ratios (ORs) and 95% confidence intervals (CIs) to analyse the association between possible risk factors for two or more secondary operations. A value of $P < 0.05$ was considered statistically significant. IBM SPSS Statistics version 26.0 for Windows software (SPSS, Chicago, Illinois) was used for the statistical analyses.

Results

Reconstructions were most commonly delayed. The Median follow-up time was 73 months

A total of 850 breast reconstructions were performed in 793 women during the study period. Of these patients, 672 (85%) had delayed reconstruction and 121 (15%) immediate reconstruction. Bilateral reconstruction was performed in 57 (7%) patients. Autologous reconstructions ($n = 591$) included 447 DIEPs (76%), 12 TMGs (2%) and 132 LDs without implant (22%). Implant-based reconstructions ($n = 202$) included 42 two-stage expander (21%), 9 direct implant (4%) and 151 LD with implant (75%) reconstructions.

Median follow-up for the whole study group was 73 months (Interquartile Range (IQR) 36–111 months). The median follow-up for autologous reconstructions was 68 months (IQR 32–109 months) and 79 months (IQR 49–116 months) for implant-based reconstructions (Table 2). The detailed characteristics of the complications associated with different reconstruction techniques and their risk factors are reported in our earlier study.[6]

No statistically significant difference in the overall rate of surgical procedures between groups. The time to definitive reconstruction tended to be longer in the implant-based reconstruction group

Table 2 summarises the demographic characteristics, main clinical record data and the overall secondary surgical procedures associated with different reconstruction techniques for the whole study group ($n = 793$). There were some differences in baseline characteristics between reconstruction groups. Patients with implant-based reconstruction were older (median 56 years, range 27–76 vs. median 53 years, range 19–72, $P < 0.001$) and had some comorbidity more often ($P = 0.045$) than patients in the autologous group. Patients with autologous reconstruction had a higher median BMI (26.3, IQR 23.6–29.0) compared to patients in the implant-based group (24.7, IQR 22.4–28.6) ($P = 0.001$). No statistically significant difference was observed between groups in the receiving of radiation therapy ($P = 0.080$).

The median time to definitive breast reconstruction in implant-based reconstructions was 443 days (IQR 332–744) compared to 403 days (IQR 321–661) in autologous reconstructions ($P = 0.050$).

The rate of overall secondary operations (unplanned and planned) did not differ significantly between groups ($P = 0.098$). Of the autologous reconstructions, 75% ($n = 443$) achieved a definitive reconstruction after one secondary operation compared to 64% ($n = 129$) in the implant-based group. In the implant-based group, 19% ($n = 39$) required two and 9% ($n = 19$) three or more revision surgeries compared to the autologous group 15% ($n = 86$)/6% ($n = 33$) ($P = 0.013$).

Independent risk factors for multiple secondary revision surgeries include younger age and comorbidity

The demographics of patients who required two or more secondary revision surgeries are presented in Table 3. A median BMI of 26.2 (15.2–34.4) in the autologous reconstruction group was higher than that in the implant-based reconstruction group (23.7, range 18.4–36.9). However, no statistically significant differences were found in age, comorbidities, history of radiation therapy or complications between groups. To characterise risk factors for more than two secondary revision surgeries, multivariable-adjusted logistic regression analysis was performed (Table 4). Younger age ($n = 177$, 22%, OR 0.97; 95% CI 0.95–0.99) and comorbidities ($n = 67$, 26%, OR 1.67; 95% CI 1.14–2.44) were independent risk factors for more than two secondary revision surgeries.

The unplanned readmission rate and the number of planned secondary revision surgeries were higher in implant-based reconstructions

We performed a separate analysis of planned and unplanned readmissions (Tables 5 and 6; Figure 1). The unplanned readmission rate was higher in implant-based reconstructions ($n = 118$, 58%) compared to autologous reconstructions ($n = 258$, 44%) ($P < 0.001$). The most common cause of unplanned readmissions was an emergency room visit for a minor wound complication or seroma. Implant-based reconstructions were more commonly associated with two or more planned secondary revision surgeries ($n = 58$, 29%) compared to autologous reconstructions ($n = 123$, 20%) ($P = 0.008$).

Autologous reconstructions were associated with greater medium-term cost

We calculated the total costs of the reconstruction process in different reconstruction methods as well as sep-

Table 3 Demographics of patients who required two or more secondary revision surgeries ($N = 177$).

	Implant-based ($n = 58$)	Autologous ($n = 119$)	p-value
Age years, Md (Range)	54 (27–69)	51 (29–71)	0.512
BMI,			
Md (Range)	23.7 (18.4–36.0)	26.2 (15.2–34.4)	<0.001
BMI≥30, n (%)	6 (10)	18 (15)	0.383
Radiation, n (%)	29 (50)	67 (56)	0.430
Comorbidities, n (%)	22 (38)	45 (38)	0.963
CVD	13 (22)	25 (21)	
Asthma/COPD	9 (16)	20 (17)	
Complication,			
Md (Range)	1 (0–3)	1 (0–3)	0.855
Minor, n (%)	22 (38)	33 (28)	0.313
Major, n (%)	9 (15)	27 (23)	

Implant-based reconstructions include pure implant and LD with implant reconstructions. Autologous reconstructions include microvascular (DIEP and TMG) and LD without implant reconstructions. Complication$n$ = complication demanding re-surgery after primary operation. Md=Median, IQR=Interquartile range. Differences between reconstruction technique types were tested using Mann–Whitney U test or Pearson Chi-square.

Table 4 Demographic factors of the 177 (22% of 793 patients) patients associated with two or more secondary revision surgeries.

		Secondary corrections required				
	Total number of patients with reconstruction	Number of patients operated ≥2 times	(% of ≥2 times operated patients)	OR	(95% CI)	p
Reconstruction						
Implant-based	202	58	(29)	1.00		
Autologous	591	119	(20)	0.62	(0.42–0.90)	0.012
Younger age	793	177	(22)	0.97	(0.95–0.99)	0.001
BMI						
BMI<30	653	153	(23)	1.00		
BMI≥30	140	24	(17)	0.61	(0.37–1.01)	0.052
Radiation						
No	374	81	(22)	1.00		
Yes	419	96	(23)	1.10	(0.78–1.55)	0.587
Comorbidities						
No	536	110	(21)	1.00		
Yes	257	67	(26)	1.67	(1.14–2.45)	0.008
Complication						
No	413	85	(21)	1.00		
Yes	380	92	(24)	1.18	(0.83–1.66)	0.358

Multivariable-adjusted logistic regression analysis was performed, showing results using odds ratios (OR) with 95% confidence intervals (CI). Implant-based reconstructions include pure implant and LD with implant reconstructions. Autologous reconstructions include DIEP, TMG and LD without implant reconstructions. Complication$n$ = complication demanding re-surgery after primary operation.

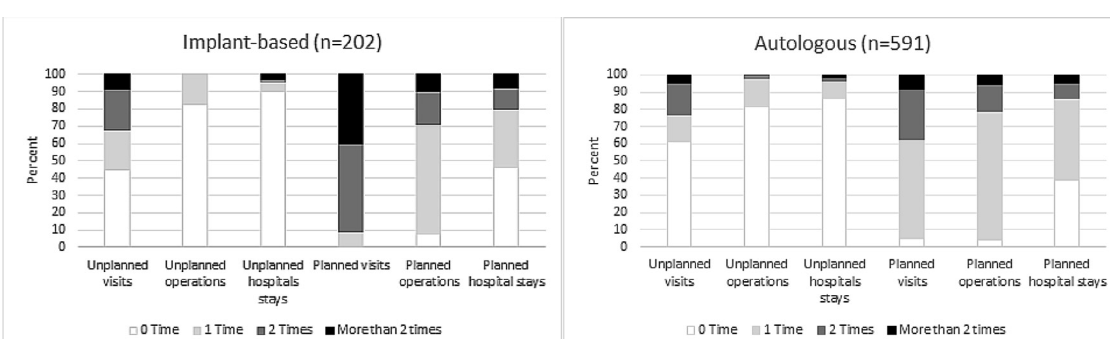

Figure 1 Comparison of planned and unplanned visits, operations and hospital stays associated with different reconstruction techniques. Implant-based reconstructions = direct implant, two-staged implant and LD with implant. Autologous reconstructions = DIEP, TMG and LD without implant.

Table 5 Comparison of unplanned hospital visits, operations and hospital stay after different reconstruction techniques ($N = 793$).

	Implant-based ($n = 202$)	Autologous ($n = 591$)	p-value
Unplanned return visit to hospital			
Md (IQR, Range)	1 (0-6)	0 (0-5)	<0.001
Number of visits, n (%)			0.001
0	91 (45)	363 (61)	
1	46 (23)	93 (16)	
2	48 (24)	106 (18)	
>2	17 (8)	29 (5)	
Unplanned operation due to complication			
Md (IQR, Range)	0 (0-1)	0 (0-3)	0.648
Number of operations, n (%)			0.254
0	167 (83)	482 (82)	
1	35 (17)	98 (17)	
2	0 (0)	10 (2)	
>2	0 (0)	1 (<1)	
Unplanned stays in hospital, days,			
Md (IQR, Range)	0 (0-5)	0 (0-4)	0.244
Number of the hospital stay days, n (%)			0.060
0	182 (90)	512 (87)	
1	11 (5)	61 (10)	
2	3 (2)	11 (2)	
>2	6 (3)	7 (1)	
Readmission rate of unplanned admissions, n (%)	118 (58)	258 (44)	<0.001

Implant-based reconstructions include pure implant and LD with implant reconstructions. Autologous reconstructions include DIEP, TMG and LD without implant reconstructions. Md=Median, IQR=interquartile range. Differences between reconstruction technique types were tested using Fisher's exact test or Independent-samples Mann-Whitney test.

Table 6 Comparison of planned hospital visits, secondary operations and length of hospital stay after secondary operations with different reconstruction techniques ($N = 793$).

	Implant-based ($n = 202$)	Autologous ($n = 591$)	*p*-value
Planned visits, Md (IQR, Range)	2 (2-4, 0-10)	2 (2-3, 1-10)	0.066
Number of visits, n (%)			0.018
0	1 (<1)	0 (0)	
1	18 (9)	28 (5)	
2	101 (50)	343 (58)	
>2	82 (41)	220 (37)	
Planned secondary operations, Md (IQR, Range)	1 (1-2, 0-6)	1 (1-1, 0-5)	0.148
Number of operations, n (%)			0.008
0	16 (8)	26 (4)	
1	128 (63)	442 (75)	
2	38 (19)	91 (15)	
>2	20 (10)	32 (5)	
Hospital stays after secondary operations, days, Md (IQR, Range)	1 (0-1, 0-6)	1 (0-1, 0-7)	0.606
Number of the hospital stay days, n (%)			0.005
0	93 (46)	229 (39)	
1	69 (34)	282 (48)	
2	24 (12)	52 (9)	
>2	16 (8)	28 (5)	

Implant-based reconstructions include pure implant and LD with implant reconstructions. Autologous reconstructions include DIEP, TMG and LD without implant reconstructions. Md=Median, IQR=interquartile range. Differences between reconstruction technique types were tested using Mann-Whitney *U* test or Fisher's exact test.

Table 7 Costs of breast reconstructions in USDs ($), according to the method used ($N = 793$).

	Implant-based	Autologous	*p*-value
Planned and unplanned	$n = 202$	$n = 591$	
Total cost ($), Median (Range)	18,329 (11,102-30,897)	22,052 (15,224-41,644)	<0.001
Planned	$n = 202$	$n = 591$	
Cost of planned visits ($), Median (Range)	597 (398-1989)	838 (597-2188)	<0.001
Cost of planned secondary operations ($), Median (Range)	2947 (0-17,683)	2947 (0-16,456)	0.962
Unplanned visits	$n = 111$	$n = 228$	
Costs of unplanned visits ($), Median (Range)	406 (203-1220)	406 (203-1016)	0.862
Unplanned secondary operations	$n = 35$	$n = 109$	
Cost of unplanned secondary operations ($), Median (Range)	2116 (2116-2116)	2116 (2116-6347)	0.051

Implant-based reconstructions include pure implant and LD with implant reconstructions. Autologous reconstructions include DIEP, TMG and LD without implant reconstructions. Differences between reconstruction technique types were tested using Independent-samples Mann-Whitney test.

arate costs for planned and unplanned visits and operations (Table 7). Autologous reconstruction had a greater total cost (median $22 052, range $15 224-$41 644) compared to implant-based reconstructions ($18 329, range $11 102-$35 662, $P < 0.001$). The cost of planned visits was greater in autologous reconstructions ($838, range $597-$2 188) compared to implant-based reconstructions ($597, range $398-$1 989, $P < 0.001$). No difference was found between groups in the costs of planned secondary operations ($P = 0.962$), unplanned visits ($P = 0.862$) or unplanned operations ($P = 0.051$).

Discussion

Our 12-year analysis revealed that autologous techniques are associated with greater overall care costs. In previous shorter-term studies, implant reconstructions have been reported to have lower costs than LD or abdominally-based reconstructions.[2] However, even though the primary operation costs for implant and LD or abdominally based reconstructions are reported to be the same, the costs for secondary procedures are greater than for free flap reconstructions[3,4]. In a study of DIEPs and two-stage implant reconstructions with longer follow-up, no statistically significant differences in total costs were found between methods[5]. Although our study can be considered to be a medium-term study, it is evident that a full cost assessment of the reconstructive methods would require longer than 10 to 12 years. After that timepoint, revision operations with implants might just start to require capsulectomies and even secondary flap reconstructions. Therefore, a 20-year follow-up period might provide a more accurate assessment of the total costs.

We did not find a statistically significant difference in the rate of overall surgical procedures between groups, but implant-based reconstructions were more commonly associated with two or more planned revision surgeries. However, when evaluating the results of the studies considering secondary operations following different reconstruction methods, it is important to remember the features of the reconstruction techniques. The higher rate of secondary revision surgeries in the implant-based reconstruction group might be, at least partly, explained by the staged nature of the two-staged expander reconstruction, and therefore a direct outcome comparison between modalities may not be fair. Previous studies have reported that the rate of secondary operations required after implant reconstructions varied from 1.5 to 3.4 operations compared to 0.8 to 2.3 operations after DIEPs[2,3,5,7] and 1.6 to 2.0 operations after LDs.[2,7] In our study, the median was one secondary operation in both groups. Of the implant-based reconstructions, 63% achieved a definitive reconstruction after one planned secondary operation compared to 75% of autologous reconstructions.

It has been reported in earlier studies that patients with implants obtain a definitive reconstruction slower than patients with a free flap. In a study by Fischer et al., the difference was 542 days versus 306 days[3] and 26.9 months versus 20.1 months in a study by Lagares-Borrego.[5] In our study, the difference in reconstruction time of 40 days between study groups only tended to be longer without reaching full statistical significance due to the skewed shape of distributions and consequently the use of non-parametric tests instead of parametric tests. According to means and standard deviation, the *post hoc* power of time to definitive reconstruction was 0.86. The reconstruction methods studied in our study differed from those in earlier studies. This may therefore be the reason for the difference in reconstruction times between the methods reported in previous studies and those reported in our study. For example, in our study, autologous reconstructions included LD flaps without implant in addition to microvascular flaps and implant-based reconstructions included LD flaps with implants, whereas previous studies compared free flaps and two-staged implant reconstructions.

Independent risk factors for multiple operations were younger age and comorbidity. According to the findings of previous studies, younger women are more concerned about the appearance of scars and have higher expectations for an improved appearance after reconstruction[8], whereas older patients tend to have lower expectations[9], which may serve to explain the findings in our study. On the contrary, the rate of reconstruction following mastectomy is lower amongst older women,[10] which was also reported in our study. A small number of older patients in a study population can also influence the results.

Comorbidities, especially asthma/COPD, were found to be risk factors for complications in our previous study in this study population[6]. Patients with comorbidity are more likely to have complications in the primary operation, which leads to the need for more revision surgeries. A study by Fisher et al. showed that complications after breast reconstructions can also result in a need for further surgery, increased length of hospital stay and greater use of resources[11].

The purpose of this study was to perform a longer follow-up evaluation of our most common reconstruction modalities to enhance the preoperative decision-making process. In further studies, a larger prospective study including Breast-Q might provide more information. When women desiring reconstruction comes to the outpatient appointment, they usually ask for a treatment recommendation. By using the data obtained in this study, surgeons can better screen the risk factors and counsel the patient. A reconstruction technique that is chosen to meet the individual needs of the patient can also help reduce the consumption of scarce healthcare resources.

This study has several limitations. The retrospective nature of the study may be prone to an overall observer bias, recording bias and selection bias. Retrospective study designs may also lead to an inaccurate representation of the study population and the inability to capture emotional responses. We did not have any patient-reported outcome measures (PROMs), which would have provided more information in comparing reconstructive modalities. At our institution, we strongly favour the use of autologous reconstructions, and therefore the volume of implant-based reconstructions was lower. Neither patients nor the reconstruction methods were randomised. The choice of reconstruction modality depends on patient preference, indication, availability of reconstructive options and the preference of the surgeon. However, even in a prospective study, the randomisation of patients might not be ethically acceptable. Our data are based on the practices and figures of one healthcare system. As the costs and timings of breast reconstructions will vary widely between different healthcare systems, our results might not be applicable in some settings.

Conflicts of interest

None.

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Ethics approval statement

This is an observational study. The Ethics Committee of Tampere University Hospital has confirmed that no ethical approval is required.

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