

# Acellular Dermal Matrix Performance Compared with Latissimus Dorsi Myocutaneous Flap in Expander-Based Breast Reconstruction

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**Background:** Latissimus dorsi myocutaneous flap (LDMF) with tissue expander provides excellent results in breast reconstruction. Acellular dermal matrix (ADM) has been used in expander-based reconstruction (EBR) with good results. This study assesses how ADM compares to LDMF in EBR.

**Methods:** The cohorts comprised 124 patients (218 breasts) who had EBR using ADM between 2006 and 2012, and 242 patients (266 breasts) who had EBR using LDMF between 1994 and 2012. Postoperative complications, reoperations, Breast-Q scores, and objectively assessed aesthetic outcomes were compared.

**Results:** Median age was 55 years for both ADM (range 23–84) and LDMF (range 26–88) groups. No statistically significant differences were noted between the groups in the rates of major postoperative complications ( $P > 0.3$ ). Forty-nine of the 218 (22.5%) in the ADM group and 67 of 266 (25.2%) in the LDMF group had a total of 63 and 84 reoperations, respectively ( $P = 0.52$ ), with no significant differences in the reoperations rate ( $P > 0.3$ ). No significant differences were observed in the Breast-Q scores. Some categorical differences were noted in the aesthetic outcomes; however, the difference between the overall outcomes was not significant ( $P = 0.54$ ).

**Conclusion:** Our study revealed no statistically significant differences in the complications or reoperation rates, patient satisfaction, or overall aesthetic outcomes when comparing the use of ADM to LDMF in EBR. In conclusion, this study supports the hypothesis that ADM performs as well as LDMF in EBR. (*Plast Reconstr Surg Glob Open* 2019;7:e2414; doi: [10.1097/GOX.0000000000002414](https://doi.org/10.1097/GOX.0000000000002414); Published online 30 September 2019.)

## INTRODUCTION

Secondary only to lung cancer, breast cancer is the most common cause of cancer-related mortality in females and accounts for 500,000 deaths worldwide

annually.<sup>1,2</sup> It affects ~1 in 8 women, and with 1,600,000 new cases, each year has an increasing prevalence. Mastectomy remains one of the primary treatments, and plastic surgeons play a crucial role in reconstruction.<sup>3</sup> With approximately 100,000 breast reconstruction procedures performed annually in the United States, identifying the safest, most efficient, and cosmetically superior technique is crucial.<sup>4</sup>

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The popularity of breast reconstruction using autologous tissue emerged in the late 1980s after the public acceptance of silicone breast implants deteriorated due to inflated claims of their risks.<sup>5,6</sup> During this time, reconstruction using the latissimus dorsi myocutaneous flap (LDMF) increased as a viable option.<sup>7–9</sup> This procedure yielded a relatively low complication rate and favorable aesthetic outcomes, especially when combined with a tissue expander.<sup>10–12</sup> LDMF was originally indicated for patients with a history of significant radiotherapy or complex mastectomies.<sup>13,14</sup> Currently, LDMF has been shown to be particularly useful in unilateral reconstruction and

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in those patients who had radiation with acceptably low capsular contracture rates (6%–12%).<sup>15,16</sup>

More recently, reconstruction using allogenic tissue with acellular dermal matrix (ADM) has become increasingly popular. ADM was introduced in 2001 for revisional aesthetic surgery and was first used for expander-based reconstruction (EBR) in 2007.<sup>17,18</sup> EBR using ADM has had variable, but increasingly reliable reported surgical and aesthetic outcomes.<sup>19,20</sup>

To date, no large study has directly compared LDMF with ADM in patients undergoing EBR. This study evaluates and compares the incidence of complications, aesthetic quality, and patient satisfaction between EBR using LDMF and ADM.

## METHODS

After obtaining study approval by the Institutional Review Board at Mayo Clinic, we conducted a retrospective review of patients who received EBR using ADM between June 2006 and December 2012, and patients who had EBR using LDMF between April 1994 and December 2012. Patients were excluded if they had failed a previous breast reconstruction or if they were not breast cancer victims. Postoperative complications were tracked and included breast seroma, capsular contracture (grade 3 or 4), prosthesis exposure, prosthesis rupture, and aesthetic considerations (malposition, symmastia, size). The number of reoperations and scar revisions were also recorded. Patient satisfaction was assessed using the Breast-Q preoperatively and postoperatively. To measure patient satisfaction, photos of LDMF and ADM patients who completed their second stage of reconstruction were randomly selected and assessed by 3 independent physicians on a 1–10 scale based on the inframammary fold, position, resemblance of a natural breast, visible scarring, and symmetry. A subgroup analysis for each cohort with and without a history of radiotherapy was also conducted to assess differences in complication rates and patient satisfaction. Fisher exact and Wilcoxon rank sum tests were used for statistical analysis.

## RESULTS

Our retrospective analysis included 124 patients (218 breasts) with EBR using ADM and 242 patients (266 breasts) with EBR using LDMF. The median age was 55 years (23–84 years for ADM, and 26–88 years for LDMF) (Table 1). There were no statistically significant differences in postoperative complication rates (Table 2). Mastectomy flap necrosis was the most common recorded complication and similar between the groups (ADM: 6.9%, LDMF: 6.4%). The reoperation rate for ADM compared with LDMF was also similar (22.5% versus 25.2%,  $P = 0.52$ ). There was no statistically significant difference in Breast-Q scores (Table 3). LDMF displayed significantly better scores in aesthetic subcategories for volume ( $P < 0.01$ ), placement ( $P < 0.01$ ), and inframammary fold ( $P = 0.02$ ), but no significant difference in overall aesthetic appearance ( $P = 0.54$ ) (Table 4). The most common indication for

**Table 1. Demographic Data**

Variable	Overall	LDMF	ADM
No. patients	366	242	124
No. breasts	484	266	218
Radiotherapy (breasts)	140	112 (42.1%)	28 (12.8%)
Median age at first stage, y	55 (23, 88)	55 (26, 88)	55 (23, 84)
Follow-up period, mo	23 (1, 191)	28 (1, 191)	18 (1, 76)

reoperation in both groups was aesthetics (malposition, symmastia, size) (Table 5).

Prior history of radiotherapy was significantly higher in the LDMF cohort compared with patients with ADM (42.1% versus 12.8%,  $P < 0.001$ ). Of the patients who received LDMF, those with a history of radiotherapy had a significantly higher rate of breast cellulitis (8.0% versus 1.9%,  $P = 0.032$ ) and a lower rate of seroma (0.0% versus 4.5%,  $P = 0.044$ ) (Table 6). Patients with ADM and prior radiotherapy had a significantly increased risk of capsular contracture compared with ADM patients without radiotherapy (21.4% versus 2.1%,  $P < 0.001$ ) (Table 7). There was no significant difference in Breast-Q scores for either LDMF or ADM patients with or without a history of radiotherapy (Table 8–9).

## DISCUSSION

In 2016, ~100,000 women had reconstruction after mastectomy in the United States.<sup>23</sup> EBR using ADM and LDMF are both common reconstructive methods. The use of ADM was introduced in the early 2000s but has had conflicting reports of postoperative complication rates.<sup>24,25,26</sup> Perhaps a more complicated procedure, LDMF is generally regarded as reliable with favorable aesthetic outcomes, low complications rates, and performs well in the face of radiation.<sup>12,27</sup>

There is little-published data directly comparing outcomes of EBR using ADM or LDMF. The purpose of this study was to analyze the clinical and aesthetic outcomes of these 2 procedures. In 2016, Youssef et al<sup>29</sup> performed a study that prospectively tracked 20 patients, with 12 receiving immediate ADM and 9 delayed LDMF. They found no differences between clinical and patient satisfaction, which is similar to our results. Thus far, we present the most substantial study comparing EBR using LDMF and ADM.

Prior history of radiotherapy was significantly higher in patients with LDMF. Otherwise, there were no differences in demographics or preference for either procedure based on age group. Further, there were no significant differences between the 2 procedures in any of the tracked postoperative complications or reoperation rates. These findings differ from previous literature. In 2010, Chun et al<sup>24</sup> found an increased 4.2- and 5.3-times risk of seroma formation and infection, respectively, when using ADM for breast reconstruction compared with not using ADM. Ho et al<sup>31</sup> also concluded that patients were more likely to develop infections after using ADM for breast reconstruction. Interestingly, the prevalence of infection with ADM in our study was 5.7%, which is comparable to Ho's meta-analysis. Although the infection rate was not significantly

**Table 2. Complications Based on Type of Surgery**

Variable	Overall (n = 484)	LDMF (n = 266)	Rate (%)	ADM (n = 218)	Rate (%)	P (Two-tailed)
Age at first stage, y	55 (23, 88)	55 (26, 88)	—	55 (23, 84)	—	0.49
Radiotherapy	140	112	42.1	28	12.8	<0.001
Unplanned reoperation	116	67 (84 reop)	25.2	49 (63 reop)	22.5	0.522
Malposition	27	13	4.9	14	6.4	0.552
Capsular contracture (grade III/IV)	19	9	3.4	10	4.6	0.639
Time of onset of capsular contracture, mo	13 (5, 39)	12.5 (5, 39)	—	13 (6, 30)	—	0.87
Ruptured/leaking prosthetic	8	6	2.3	2	0.9	0.304
Prosthetic removal (other than infection)	18	11	4.1	7	3.2	0.638
Infection (requiring prosthetic removal)	23	11	4.1	12	5.5	0.524
Seroma (breast)	15	7	2.6	8	3.7	0.602
Hematoma (breast)	7	3	1.1	4	1.8	0.706
Scar revision	26	12	4.5	14	6.4	0.419
Breast cellulitis	21	12	4.5	9	4.1	1.000
Skin necrosis	32	17	6.4	15	6.9	0.856
Fat necrosis	7	3	1.1	4	1.8	0.706
Follow-up period, mo	23 (1, 191)	28 (1, 191)	—	18 (1, 76)	—	<0.001

**Table 3. Summary and Association of Breast-Q Satisfaction Scores According to Surgery Type**

Score Variables	Overall Sample (N = 78)	LDMF (N = 58)	ADM (N = 20)	P
Satisfaction with breasts	71 (59, 85)	71 (59, 91)	66 (59, 82)	0.49
Satisfaction with outcome	75 (61, 100)	75 (61, 100)	75 (64, 93)	0.93
Psycho-social well-being	86 (67, 100)	86 (70, 100)	84 (63, 100)	1.00
Sexual well-being	63 (47, 77)	63 (49, 77)	63 (38, 77)	0.79
Physical well-being: chest	85 (74, 91)	83 (74, 100)	85 (71, 91)	0.40
Satisfaction with nipples	61 (36, 89)	55 (31, 89)	61 (50, 100)	0.29
Satisfaction with information	80 (65, 100)	80 (64, 100)	88 (70, 100)	0.35
Surgeon	100 (100, 100)	100 (100, 100)	100 (100, 100)	0.88
Medical staff	100 (100, 100)	100 (100, 100)	100 (100, 100)	0.99
Office staff	100 (100, 100)	100 (100, 100)	100 (100, 100)	0.75

The sample median (IQR) is given for continuous variables. The following variables have unavailable information: satisfaction with outcome (n = 11), physical well-being: chest (n = 9), satisfaction with nipples (n = 36), surgeon (n = 7), and office staff (n = 3). IQR, inter-quartile range.

**Table 4. Objective Aesthetic Outcomes**

Category	Score*	ADM (n = 53†)	LDMF (n = 121†)	P
Volume	0-3	0 (0%)	0 (0%)	<0.01
	4-6	4 (7.5%)	42 (34.7%)	
	7-10	49 (92.5%)	79 (65.3%)	
Contour	0-3	1 (1.9%)	1 (0.8%)	0.83
	4-6	23 (43.4%)	53 (43.8%)	
	7-10	29 (54.7%)	67 (55.4%)	
Placement	0-3	0 (0%)	2 (1.7%)	<0.01
	4-6	13 (24.5%)	58 (47.9%)	
	7-10	40 (75.5%)	61 (50.4%)	
Inframammary fold	0-3	3 (5.7%)	5 (4.1%)	0.02
	4-6	29 (54.7%)	40 (33.1%)	
	7-10	21 (39.6%)	76 (62.8%)	
Scar	0-3	0 (0%)	2 (1.7%)	0.42
	4-6	49 (92.5%)	94 (77.7%)	
	7-10	4 (7.5%)	25 (20.7%)	
Overall	0-3	0 (0%)	1 (0.8%)	0.54
	4-6	32 (60.4%)	75 (62%)	
	7-10	21 (39.6%)	45 (37.2%)	

Postoperative photographs following the completion of the second stage were blindly assessed by independent staff members. The P values were obtained using Wilcoxon rank sum exact test.

\*0 = worst result, 10 = best result. Score of 0-3 = Poor; 4-6 = Fair; and 7-10=Good.

†Number of patients.

different from LDMF patients in our study, there are a few hypotheses for the higher rate associated with ADM. Prior publications have tried to explain this phenomenon by linking it to the quality of the remaining skin flap.<sup>24,29,31</sup> The compliance of ADM allows it to adjust to a higher initial volume. The high intraoperative filling volumes

of tissue expanders result in an augmented stretching of the native breast flap. This can compromise blood supply and lead to necrosis with the development of a secondary infection.<sup>27,31</sup> To prevent this complication, some authors have recommended avoiding aggressive initial overexpansion and using indocyanine green angiography

**Table 5. Reoperation Incidences Based on Type of Surgery (Breasts)**

Variable	Overall (n = 484)	LDMF (n = 266)	Rate (%)	ADM (n = 218)	Rate (%)	P (two-tailed)
Aesthetic (malposition, symmastia, size)	30	18	6.8	12	5.5	0.578
Capsular contracture (grade III/IV)	7	5	1.9	2	0.9	0.466
Exposure of prosthetics	15	6	2.3	9	4.1	0.295
Seroma (breast)	13	4	1.5	2	0.9	0.695
Hematoma (breast)	9	3	1.1	3	1.4	1.000
Infection (requiring removal of prosthetic)	23	11	4.1	12	5.5	0.524
Necrosis (skin, flap, fat)	18	10	3.8	8	3.7	1.000
Ruptured/leaking prosthetic	8	6	2.3	2	0.9	0.304
Scar/skin revision/resection	22	10	3.8	12	5.5	0.387
Flap loss	1	1	0.4	0	0.0	—
Exploration	1	0	0.0	1	0.5	—

**Table 6. LDMF (Breasts) Complications Based on Radiation Therapy**

Variable	Without Radiotherapy (n = 154)	Rate (%)	With Radiotherapy (n = 112)	Rate (%)	P (Two-tailed)
Age at first stage, y	57 (33, 88)	—	51 (26, 78)	—	0.003
Unplanned reoperation	35	22.7	32	28.6	0.317
Malposition	7	4.5	6	5.4	0.780
Capsular contracture grade III/IV	5	3.2	4	3.6	1.000
Time of onset of capsular contracture, mo	13 (6, 39)	—	12 (5, 35)	—	0.81
Ruptured/leaking prosthetic	3	1.9	3	2.7	1.000
Prosthetics removal (other than infection)	6	3.9	5	4.5	1.000
Infection (requiring prosthetics removal)	5	3.2	6	5.4	0.535
Seroma (breast)	7	4.5	0	0.0	0.044
Hematoma (breast)	0	0.0	3	2.7	0.073
Scar revision	6	3.9	6	5.4	0.766
Breast cellulitis	3	1.9	9	8.0	0.032
Skin necrosis	12	7.8	5	4.5	0.319
Fat necrosis	1	0.6	3	2.7	0.313
Follow-up period, mo	33 (1, 191)	—	25 (1, 182)	—	0.100

**Table 7. ADM (Breasts) Complications Based on Radiation Therapy**

Variable	Without Radiotherapy (n = 190)	Rate (%)	With Radiotherapy (n = 28)	Rate (%)	P (Two-tailed)
Age at first stage, y	55 (23, 84)	—	55 (37, 71)	—	0.75
Unplanned Reoperation	41	21.6	8	28.6	0.467
Malposition	12	6.3	2	7.1	1.000
Capsular contracture (grade III/IV)	4	2.1	6	21.4	<0.001
Time of onset of capsular contracture, mo	11 (6, 30)	—	14 (10, 19)	—	0.5
Ruptured/leaking prosthetic	1	0.5	1	3.6	0.241
Prosthetic removal (other than infection)	5	2.6	2	7.1	0.222
Infection (requiring prosthetic removal)	11	5.8	1	3.6	1.000
Seroma (breast)	6	3.2	2	7.1	0.600
Hematoma (breast)	2	1.1	2	7.1	0.081
Scar revision	12	6.3	2	7.1	1.000
Breast cellulitis	7	3.7	2	7.1	0.608
Skin necrosis	11	5.8	4	14.3	0.109
Fat necrosis	3	1.6	1	3.6	1.000
Follow-up period, mo	17 (1, 76)	—	19 (7, 54)	—	0.16

intraoperatively to assess the flap viability.<sup>27,31</sup> Thin, ischemic flaps are also prone to implant extrusion and seroma formation.<sup>32</sup> Another hypothesis postulated that ADM could act as a nidus of infection.<sup>31</sup>

LDMF is a versatile reconstructive technique, utilized in immediate, delayed, or salvage reconstruction.<sup>30,33,34</sup> Reconstruction with the LDMF previously fell out of popularity due to concerns about high capsular contracture rates when used with an implant, and the parallel development of abdominal-based free flaps.<sup>11,35</sup> However, the popularity

of the LDMF has since increased due to concomitant use of tissue expanders.<sup>11,35</sup> One of its advantages over ADM is the inclusion of healthy adjacent tissue for rotational coverage. This provides an improved appearance with a more natural feel to the reconstruction.<sup>36</sup> Regarding cosmetic outcomes, LDMF was superior to ADM when considering volume, placement, and inframammary fold. However, the overall aesthetic outcome was not significantly different between the groups. There is conflicting literature on the aesthetic outcomes of LDMF. Some authors have

**Table 8. Summary and Association of Breast-Q Satisfaction Scores for LDMF with Radiation Versus LDMF without Radiation Patients**

Score Variables	Overall Sample (N = 58)	Without Radiotherapy (N = 31)	With Radiotherapy (N = 27)	P
Satisfaction with breasts	71 (59, 91)	71 (59, 91)	71 (55, 85)	0.93
Satisfaction with outcome	75 (61, 100)	75 (61, 100)	75 (67, 75)	0.53
Psycho-social well-being	86 (70, 100)	82 (63, 100)	92 (76, 100)	0.53
Sexual well-being	63 (49, 77)	60 (47, 77)	63 (49, 85)	0.68
Physical well-being: chest	83 (74, 100)	88 (77, 100)	81 (74, 100)	0.38
Satisfaction with nipples	55 (31, 89)	61 (36, 100)	41 (31, 81)	0.24
Satisfaction with information	80 (64, 100)	77 (62, 100)	85 (64, 100)	0.41
Surgeon	100 (100, 100)	100 (85, 100)	100 (100, 100)	0.22
Medical staff	100 (100, 100)	100 (100, 100)	100 (100, 100)	0.54
Office staff	100 (100, 100)	100 (100, 100)	100 (100, 100)	0.39

The sample median (IQR) is given for continuous variables. The following variables have unavailable information: Satisfaction with outcome (n = 7), physical well-being: chest (n = 6), satisfaction with nipples (n = 23), surgeon (n = 4), and office staff (n = 2). IQR, inter-quartile range.

**Table 9. Summary and Association of Breast-Q Satisfaction Scores for ADM with Radiation Versus ADM without Radiation Patients**

Score Variables	Overall Sample (N = 20)	Without Radiotherapy (N = 14)	With Radiotherapy (N = 6)	P
Satisfaction with breasts	66 (59, 82)	71 (61, 91)	61 (58, 64)	0.11
Satisfaction with outcome	75 (64, 93)	75 (67, 86)	75 (47, 100)	1.00
Psycho-social well-being	84 (63, 100)	92 (82, 100)	68 (55, 79)	0.065
Sexual well-being	63 (38, 77)	68 (47, 77)	42 (37, 63)	0.21
Physical well-being: chest	85 (71, 91)	85 (73, 91)	73 (55, 93)	0.60
Satisfaction with nipples	61 (50, 100)	61 (61, 81)	68 (36, 100)	1.00
Satisfaction with information	88 (70, 100)	96 (77, 100)	70 (54, 91)	0.075
Surgeon	100 (100, 100)	100 (100, 100)	100 (81, 100)	0.76
Medical staff	100 (100, 100)	100 (100, 100)	100 (91, 100)	0.079
Office staff	100 (100, 100)	100 (100, 100)	100 (100, 100)	0.32

The sample median (IQR) is given for continuous variables. The P values were obtained using Wilcoxon rank sum exact test. The following variables have unavailable information: satisfaction with outcome (n = 4), physical well-being: chest (n = 3), satisfaction with nipples (n = 13), surgeon (n = 3), and office staff (n = 1). IQR, inter-quartile range.

described a suboptimal aesthetic profile for LDMF, and others claim the inframammary fold has a better cosmetic outcome with ADM.<sup>22,37</sup> However, LDMF does offer increased volume secondary to the thickness of the muscle, subcutaneous tissue, plus the skin paddle if fashioned for the flap.<sup>32</sup> Although muscle atrophy can decrease final volume, this can be adjusted with fat grafting.<sup>32,39-41</sup>

In breast reconstruction, quality of life outcomes are crucial factors. This study used BREAST-Q, a widely validated tool, to assess the impact on quality of life.<sup>38</sup> There were no significant differences in BREAST-Q scores between either cohort.

Breast cancer treatment is a multidisciplinary approach and radiotherapy is a pivotal component to consider when planning reconstruction. We found a higher incidence of patients receiving LDMF in those who had a history of radiotherapy. LDMF is typically preferred in patients with radiotherapy because it inserts vascularized tissue coverage in ischemic postradiation chests.<sup>34</sup> The flap can also be performed as a delayed or salvage procedure to reduce radiation-associated complications.<sup>30,32,37,42</sup> This is a potential advantage over ADM, which relies on incorporation and neovascularization. We also noticed that patients with ADM who received radiotherapy had higher rates of capsular contracture compared with LDMF patients with

radiotherapy (21% versus 3.6%). This contrasts previous literature that ADM decreases capsular contracture rates, even in the presence of radiotherapy.<sup>44-46</sup> This desirable feature of the LDMF over ADM could be a deciding factor for which reconstruction modality to choose, especially in more advanced cancer patients who need radiotherapy.

There is still debate about which technique is superior, and some important factors must be considered when determining the optimal approach. For example, LDMF has been associated with postoperative shoulder weakness, donor site morbidity and is relatively contraindicated in patients with a history of posterolateral thoracotomy.<sup>34,42,43</sup> ADM has been associated with a higher risk of implant rupture/removal or revisional surgery.<sup>28</sup> Although ADM is expensive, usually costing \$2,000–\$5,000 per patient, it takes 79–165 minutes less operating room time compared with LDMF.<sup>21,22,29,47</sup> Further, ADM has been determined superior to LDMF regarding hospital resource utilization with fewer readmissions and shorter lengths of stay.<sup>47</sup> This advantage is especially noted when ADM is performed as a single stage procedure, with direct to implant placement.<sup>22,47</sup> However, these studies lacked aesthetic, and patient satisfaction outcomes and most surgeons argue that performing a second stage procedure is helpful because it creates an opportunity to revise the pocket for an improved cosmetic outcome.<sup>22,47,48</sup>

Regarding future directions, a cost analysis is needed to determine the exact difference in resource utilization between the 2 procedures. The current literature is also lacking in data directly comparing ADM with other breast reconstructive techniques.

Our study is not foreign to limitations. Due to the retrospective nature of our work, there is a potential for recall bias and confounding. Besides, as a retrospective chart review, the impact of our findings is inferior to a prospective study. Furthermore, 3 different surgeons performed the reconstructive procedures analyzed in this study. Additionally, the Breast-Q™ had a low response rate (21.3%) and is not fully representative of our patient population. Also, skin paddles were used in some LDMF patients, which can create a different aesthetic appearance compared with not using skin islands. Finally, the LDMF cohort had a significantly higher rate of prior radiotherapy. This demographic difference could impact outcome comparisons between these 2 groups.

### CONCLUSIONS

When comparing ADM to LDMF in EBR, there were no significant differences in postoperative complications or aesthetic outcomes. This study supports that ADM performs as well as LDMF in EBR and both modalities are comparable alternatives for breast reconstruction after mastectomy. Notably, however in patients with a history of radiotherapy, there was a higher capsular contracture rate when using ADM.

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