Free radial forearm flap *versus* pectoralis major myocutaneous flap reconstruction of oral and oropharyngeal defects: a cost analysis

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Objectives: The free radial forearm flap has replaced the pedicled pectoralis major myocutaneous flap and it has become the 'workhorse flap' used by many head and neck reconstructive surgeons for soft tissue reconstructions. Cost implications of radial forearm flap reconstruction within the context of the overall health care in a particular system need to be investigated particularly before it is labelled as 'costly only'.

Design and Setting: Forty patients who underwent immediate free radial forearm flap reconstruction for oral or oropharyngeal soft tissue defects were matched with patients who underwent pectoralis major myocutaneous flap reconstruction for similar defects. The 2 years of which the overall management costs according to the hospital perspective were calculated were divided into four periods: operative period, the postoperative phase, follow-up during first year and follow-up during second year after discharge.

Results: The total costs within the first 2 years were comparable at ~50 000 euros. The lower costs of hospital admission (24 days *versus* 28 days; $P = 0.005$) in the postoperative phase outweighed the higher costs of the surgical procedure (692 min *versus* 462 min; $P < 0.005$) in radial forearm flap patients when compared with pectoralis major flap patients.

Conclusions: Oral and oropharyngeal reconstruction with radial forearm flap is not more costly than pectoralis major flap reconstruction. Given the better functional outcome and the present cost analysis, reconstruction of oral and oropharyngeal defects is preferably performed using free tissue transfer.

With the application of microvascular surgery, reconstructive options are now diverse, with generally superior functional and cosmetic results when compared with pedicled flaps. The free radial forearm flap has replaced the pedicled pectoralis major myocutaneous flap and it has become the 'workhorse flap' in major reconstructions used by many head and neck reconstructive surgeons for soft tissue reconstructions. The radial forearm flap allows thin, pliable, large paddles of skin to be harvested and subsequently transferred with a long vascular pedicle with relatively large-diameter vessels.[1,2] In head and neck cancer patients, radial forearm flap reconstruction generally results in a better functional outcome for speech and swallowing when compared with pectoralis major flap reconstruction.[3,4]

Head and neck cancer patients who undergo reconstruction with a radial forearm flap have a significantly lower complication rate and shorter hospitalisation than patients who undergo reconstruction with a pectoralis major flap.[5,6] This may result in overall treatment cost savings in this patient population in comparison with methods of reconstruction using pedicled flaps.[7] However, free flap reconstruction used for defects after resection of head and neck cancers requires specialised skills and prolonged operating time. This might, therefore, lead to increased utilisation of resources.[8] However ultimately, the impact of performing radial forearm flap reconstruction on the overall management costs of head and neck cancer patients who require reconstruction seems to be limited.[9]

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Although it has been suggested that the costs of microvascular free tissue transfer might be justified by the high level of patient satisfaction and enhanced quality of life, cost implications of radial forearm flap reconstruction within the context of the overall health care need to be investigated before it is labelled as 'costly only'.[10,11]

For the American situation, a small cost analysis suggested the total 1-year costs of primary head and neck cancer to be similar irrespective of reconstruction technique.[9] However, costs are known to show large differences between different healthcare systems and particularly between the USA and Europe.[12–14] There are no studies comparing the costs of radial forearm flap and pectoralis major flap reconstruction of patients for the European situation, and such information is urgently needed for healthcare decision making. Therefore, we investigated the overall 2-year costs for patients with oral or oropharyngeal cancer receiving a radial forearm flap or a pectoralis major flap as a component of their treatment.

Methods

The records of all patients who underwent immediate free radial forearm flap reconstruction for oral (lateral tongue or floor of mouth) or oropharyngeal (base of tongue or tonsil) soft tissue defects at the VU University Medical Center between 1999 and 2001 were reviewed. All patients had advanced stage (III or IV) oral or oropharyngeal carcinoma. Patients with prior treatment for their carcinoma or who had previous head and neck cancer were excluded.

Ethical considerations

As this is a retrospective study, it was considered that no ethical approval was necessary.

Matched pairs

The remaining 40 patients in this study group were matched with patients who underwent pectoralis major flap reconstruction in an earlier time frame (1992–1995) based on age (<50, 50–70 and >70 years), gender and tumour site (lateral tongue, floor of mouth and base of tongue or tonsil). If more than one pectoralis major flap patient matched with a radial forearm flap patient, then the most recent patient was chosen. No patients were selected from the period in which radial forearm flap was replacing pectoralis major flap as the reconstructive approach of choice (between 1996 and 1999). No patients treated in recent years were included to allow for sufficient follow-up. Based on these criteria 40 matched pairs could be created. Each patient chart was reviewed for patient (age and gender) and tumour characteristics (stage), hospitalisation and follow-up details. Operating time was defined as time from start to end of surgery. In radial forearm flap patients the operating time of the simultaneous harvesting of the radial forearm flap was added (start to end of surgery plus harvesting of the flap) to include extra personnel in the calculation of costs. The American Society of Anesthesiologists (ASA) physical status classification was used to determine the comorbid condition. Postoperative surgical (wound healing and flap failure) and medical (intensive care admission and other, e.g. pneumonia, cardiovascular and gastrointestinal problems) complications were scored.

Cost analysis

Costs were calculated from admission for surgical treatment up to 2 years after the day of excision of the primary tumour. Cost analysis methods previously developed and used at our institution to investigate the costs of head and neck oncology were applied in this analysis.[15] Costs were calculated according to the hospital perspective, implying that costs made outside the hospital were not taken into consideration.[16] Cost calculations were based on an inventory of all resources consumed within the hospital, on the basis of data stored in the hospital administration system and in patient charts. Only resource use related to the head and neck tumour was recorded; resource use for comorbidity was excluded. For the valuation of the most important items within the resource use, separate unit costs were calculated (Euro, price level 2003) reflecting full hospital costs,[17] including overhead costs, on the basis of the micro-costing method.[18] Costs incurred after the first year of treatment were discounted at a rate of 4%.[17]

The 2 years for which the overall management costs were calculated were divided into four periods: operative period (from admission up to and including the day of surgery), the postoperative phase (from day after surgery to the day of discharge), follow-up during first year and follow-up during second year after discharge. The diagnostic phase was not calculated separately because the diagnostic work-up is generally independent of the type of reconstruction. Costs of positron emission tomography (PET) scanning were not included, because PET is not yet included in the standard diagnostic work-up and was unavailable at the time the pectoralis major flap patients were treated. As the indication for postoperative radiotherapy is independent from the type of reconstruction, costs of radiotherapy were estimated for the whole group independent of time of treatment.

Statistical analysis

The statistical analysis was performed using SPSS for Windows, version 12.00 (SPSS Inc., Chicago, IL, USA), using a two-sided significance level of $\alpha = 0.05$. Categorical variables and patient characteristics were compared by the chi-squared test. Variables expressing resource use or costs were compared by the parametric *t*-test or Wilcoxon's rank sum test, depending on the variable's distribution.

Results

Patients, tumours and follow-up

Forty matched patient pairs were analysed. The mean age at the time of operation was similar for the radial forearm flap group (58 years; range 24–78) and the pectoralis major flap group (58 years; range 38–76; $P = 0.834$). Distribution of gender was 25 males (63%) and 15 females (38%). In each group, the tumour site was lateral tongue in eight (20%) patients, floor of mouth in 10 (25.0%) patients, base of tongue in three (8%) patients and tonsil in 19 (48%) patients. During the 2-year follow-up period, 13 (33%) radial forearm flap patients and 16 (40%) pectoralis major flap patients died ($P = 0.602$). The mean follow-up period was 20.1 months in the radial forearm flap group and 17.9 months in the pectoralis major flap group ($P = 0.327$). In the radial forearm flap group 10 (25%) patients had ASA score 1, 22 (55%) patients ASA 2 and eight (20%) patients ASA 3. These figures were significantly ($P = 0.028$) better for the pectoralis major flap group: 21 (53%), 16 (40%) and three (8%) patients respectively.

Treatment

The mean total operating time (in which simultaneous flap harvesting is added) in radial forearm flap patients was significantly longer when compared with pectoralis major flap patients: 692 and 462 min ($P < 0.005$) respectively. The mean postoperative length of hospital stay was significantly shorter in the radial forearm flap group (24 days) than in the pectoralis major flap group (28 days; $P = 0.005$).

Adjuvant radiotherapy was applied in all radial forearm flap patients and in 37 (93%) pectoralis major flap patients. Postoperative radiotherapy consisted of 28 fractions of 2 Gy. Depending on the results of histopathological examination of the surgical specimen about 60% of the patients will receive five additional fractions. Therefore, the mean number of fractions is 31. Given the costs per fractions of €203.70,[15] the mean costs of postoperative radiotherapy were estimated to be €6314.70.

Wound healing problems, e.g. fistula and wound dehiscence, were more frequently observed in the pectoralis major flap group ($n = 10$) when compared with the radial forearm flap group ($n = 3$). There was one flap failure in the radial forearm flap group. Medical complications, e.g. pneumonia, cardiovascular problems and gastrointestinal problems, were more frequently found in the radial forearm flap ($n = 8$) group than in the pectoralis major flap group ($n = 2$). Admission to the intensive care unit was more frequently needed in the radial forearm flap group ($n = 6$) than in the pectoralis major flap group ($n = 1$).

Costs

Costs in the diagnostic phase per patient treated for advanced stage oral or oropharyngeal carcinoma are shown in Table 1. Mean costs per patient during the different stages per type of reconstruction during the first 2 years are shown in Table 2. Only costs of patients alive were used for this intention-to-treat analysis in each stage and costs of radiotherapy were not included. The mean costs of the surgical procedure were significantly ($P < 0.0005$) higher for radial forearm flap patients (€6243) than pectoralis major flap patients (€4748). In the postoperative period, the mean costs of the hospital days was significantly ($P = 0.02$) higher for the pectoralis

Table 1. Costs in diagnostic phase per patient treated for advanced stage oral or oropharyngeal carcinoma

	Number	Costs per unit	Costs
First visit head and neck surgeon	1.00	360	360
Second outpatient visit head and neck surgeon	1.00	93	93
Visit anaestesiologist	1.00	160	160
Visit psychiatric practitioner	0.25	39	10
Visit consulting physician	1.00	39	39
Outpatient visit dietetics	0.30	18	5
Chest X-ray	1.00	48	48
Panoramic X-ray of mandible	1.00	17	17
MRI (oral cavity)	0.50	259	129
MRI (orophaynx)	1.00	259	259
Laboratory diagnostics	20.0	3	60
Panendoscopy (including histopathology)	30 min	10	294
Hospital admission days	3	643	1930
Total oral cavity			3160
Total oropharynx			3289

Table 2. Mean (and median) costs per patient during the different stages per type of reconstruction in the first 2 years (in euros). Only costs of patients alive are used for analysis in each stage. Costs of radiotherapy are not taken into account

	Operating period			Postoperative stage			Follow-up stagefirst year			Follow-up stagesecond year		
Cost category	PMFF ($n = 40$)	FRFF ($n = 40$)	*P*-value	PMMF ($n = 39$)	FRFF ($n = 40$)	*P*-value	PMMF ($n = 38$)	FRFF ($n = 40$)	*P*-value	PMMF ($n = 30$)	FRFF ($n = 35$)	*P*-value
Inpatient hospital days HN unit	3330 (1287)	1609 (1287)	0.119	18 181 (17 372)	14 735 (12 868)	0.002	4758 (0)	2220 (0)	0.081	5812 (1609)	3511 (0)	0.159
Inpatient hospital days ICU	283 (0)	212 (0)	0.559	218 (0)	1629 (0)	0.399	0 (0)	35 (0)	0.330	47 (0)	0 (0)	0.280
Ablative and reconstructive HN surgery	4748 (4652)	6243 (6225)	0.000							93 (0)	0 (0)	0.280
Other HN surgery	37 (0)	4 (0)	0.539	425 (0)	383 (0)	0.957	266 (0)	85 (0)	0.159	473 (0)	281 (0)	0.288
Surgery other than HN	10 (0)	21 (0)	1.000				36 (0)	0 (0)	0.144	48 (0)	8 (0)	0.895
Outpatient visit HNS							678 (651)	633 (558)	0.325	416 (419)	322 (372)	0.128
Consultation HNS by telephone							3 (0)	1 (0)	0.079	6 (0)	3 (0)	0.288
First visit consulting physician							72 (0)	60 (0)	0.251	16 (0)	32 (0)	0.239
Outpatient visit consulting physician							442 (319)	575 (496)	0.454	257 (71)	259 (142)	0.550
Consultation other physician	13 (0)	9 (0)	0.508	16 (0)	26 (0)	0.176	39 (39)	24 (0)	0.056	26 (0)	29 (0)	0.907
Paramedical services	82 (60)	93 (80)	0.934	1084 (832)	1404 (1122)	0.041	225 (136)	524 (55)	0.450	244 (23)	71 (0)	0.103
Laboratory diagnostics	376 (313)	530 (440)	0.000	573 (442)	1135 (597)	0.051	260 (72)	247 (57)	0.768	410 (141)	292 (41)	0.110
Imaging diagnostics	291 (0)	272 (71)	0.006	101 (48)	251 (48)	0.677	272 (91)	398 (364)	0.007	278 (98)	448 (230)	0.218
Pathology diagnostics	66 (28)	54 (28)	0.651	12 (0)	17 (0)	0.078	22 (0)	30 (0)	0.502	21 (0)	40 (0)	0.482
Other acts	39 (0)	7 (0)	0.785	99 (0)	103 (0)	0.857	230 (60)	145 (11)	0.151	294 (71)	419 (56)	0.405
Total	9265 (7011)	9031 (8646)	0.008	20 719 (18 279)	19 703 (14 620)	0.052	7302 (2174)	4975 (2378)	0.689	8440 (3153)	5714 (1291)	0.252

PM, pectoralis major myocutaneous flap; FRFF, free radial forearm flap; *n*, number of patients alive and analysed; HN, head and neck; HNS, head and neck surgeon.

major flap patients (€18 181) than the radial forearm flap patients (€14 735). In Table 3, the mean costs per patient for each type of reconstruction in the first 2 years is shown if all initially treated patients are analysed regardless of survival outcome (intention-to-treat analysis). The total mean costs were for the pectoralis major flap patients €51 963 and for radial forearm flap €48 097.

Discussion

In this case–control study, costs in previously untreated patients with advanced stage oral or oropharyngeal carcinoma who underwent free radial forearm flap or pedicled pectoralis major myocutaneous flap reconstruction were compared. While the mean operating time in the operative period was longer for radial forearm flap patients, the postoperative length of hospital stay was longer in the pectoralis major flap patients. The lower costs of hospital admission in the postoperative phase outweighed the higher costs of the surgical procedure in radial forearm flap patients when compared with pectoralis major flap patients. The mean total costs within the first 2 years were only €3866 lower for the radial forearm flap patients (€48 097) when compared with the pectoralis major flap patients (€51 963). In this intention-to-treat analysis, more patients died in the pectoralis major flap group when compared with the radial forearm flap group, lowering the mean costs per patients more for the pectoralis major flap group. Therefore, although not statistically significant in this analysis mean costs for radial forearm flap patients may be lower than for pectoralis major flap patients.

Strengths of the study

In several other cost analyses in head and neck reconstruction more heterogeneous groups were compared due to inclusion of trauma patients, previously treated patients, different tumour sites and different pedicled and free flaps.[4,9,19–21] In comparing the present homogeneous groups using matched pair analysis the influence of these potentially confounding variables is avoided as much as possible. In our institute radial forearm flap replaced pectoralis major flap as the reconstructive approach of choice for oral and lateral oropharyngeal defects from 1996 onwards. To minimise patient selection bias, pectoralis major flap patients were selected from the period before 1996 and radial forearm flap patients from the period after 1999. In the study of Funk *et al.*,[9] the surgeon managing the cases had the choice to chose the

Table 3. Mean (and median) costs per patient for each type of reconstruction in the first 2 years (in euros). All treated patients are used for analysis regardless of death (intention-to-treat analysis)

Cost category	PMMF ($n = 40$)	FRFF ($n = 40$)	*P*-value
Inpatient hospital days HN unit	29 935 (26 702)	21 635 (16 729)	0.009
Inpatient hospital days ICU	531 (0)	1876 (0)	0.777
Ablative and reconstructive HN surgery	531 (0)	1876 (0)	0.000
Other HN surgery	1058 (90)	717 (0)	0.526
Surgery other than HN	80 (0)	28 (0)	0.388
Outpatient visit HNS	956 (1023)	914 (884)	0.660
Consultation HNS by telephone	8 (0)	3 (0)	0.119
First visit consulting physician	80 (0)	88 (0)	0.616
Outpatient visit consulting physician	613 (354)	802 (638)	0.334
Consultation other physician	84 (77)	84 (39)	0.679
Paramedical services	1537 (1302)	2083 (1580)	0.114
Laboratory diagnostics	1489 (1168)	2167 (1312)	0.244
Imaging diagnostics	857 (469)	1313 (1142)	0.023
Pathology diagnostics	115 (66)	135 (77)	0.473
Other acts	574 (322)	622 (134)	0.384
Total costs			
Diagnostic phase and radiotherapy not included; 95% confidence interval	42 733 (36 436); 36 473–48 993	38 709 (30 627); 32 617–44 801	0.160
Diagnostic phase and radiotherapy included; 95% confidence interval	51 963 (45 910); 45 538–58 388	48 097 (40 166); 41 949–54 245	0.157

PM, pectoralis major myocutaneous flap; FRFF, free radial forearm flap; *n*, number of patients analysed; HN, head and neck; HNS, head and neck surgeon.

reconstructive procedures, which might have led to bias. In the study of Petruzzelli *et al.*,[19] many of their pectoralis major flap patients had multiple medical comorbidities, making them unsuitable for microvascular free tissue transfer. Moreover in the study of Kroll *et al.*,[20] the pectoralis major flap may have been selected for more patients with advanced disease and systemic medical problems, contributing to longer hospitalisation and added cost. In the study of Tsu *et al.*,[4] some selection bias was introduced as the specific type of reconstruction was left to the discretion of the reconstructive surgeon. McCrory and Magnuson[21] reviewed the records of patients requiring head and neck reconstruction with different flap types. It is likely that the surgeon's choice of flap based on patient and defect characteristics may have introduced substantial bias. Defects repaired with free flaps were probably not truly comparable with those repaired with pedicled flaps. Therefore, the prolonged hospital stay in patients with free flaps may be caused by the more complex defect rather than by the flap type used. Smeele *et al.*[22] reported on cost differences between pectoralis major flap and radial forearm flap reconstruction performed in a certain period in a matched pair control study. Because in this study the selection for flap type was not mentioned, some bias may be present.

Overall management costs were similar for both types of reconstruction, as was also found by Funk *et al.*[9] and Smeele *et al.*[22] In only one study the costs of radial forearm flap were lower than for pectoralis major flap, at least partially due to patient selection bias.[20] In some studies a modest difference costs in reconstruction in favour of pectoralis major flap was found that is outweighed by the intangible costs of pectoralis major flap reconstruction.[4,19,21] Because of aforementioned forms of bias in previous studies and the different methods used, studies should be compared with caution. Moreover, medical healthcare systems may differ substantially, potentially limiting its general applicability of cost analysis.[14] Therefore, it was found warranted to perform a cost analysis for the Dutch healthcare system.

Most studies only calculated the patient charges (billing data) as surrogate for actual healthcare costs, potentially limiting its generalisation and societal importance.[9,19,21,22] Integral direct medical costs, as used in the present study, represents the actual hospital costs more accurately.[15] Costs made outside the hospital were not considered. Since in the Netherlands, management of head and neck cancer is limited to a small number of centres, it is unlikely that patients had used resources in other hospitals. Moreover, because the vast majority of paramedical services, e.g. physical, swallowing and speech therapy, are applied in these centres, the costs of these therapies are also included in the cost analysis.

Limitations of the study

A relative limitation of the present study is its historical bias. Patients who underwent pectoralis major flap reconstruction were treated before 1996, while radial forearm flap patients underwent reconstruction after 1999. However, in general the management of these patients has probably not changed substantially during this period except for the type of reconstruction. Only random assignment to treatment groups could have overcome these types of bias. However, as the functional outcome after radial forearm flap is generally regarded as being better than after pectoralis major flap, such a study is unethical and thus not feasible. Because diagnostic work-up and adjuvant radiotherapy are generally independent on type of reconstruction the costs were estimated for both groups together. Although preoperative preparations for pectoralis major flap and radial forearm flap reconstruction are comparable, the costs of inpatient hospital days in the operative period was higher for pectoralis major flap reconstruction. This probably reflects a difference in preoperative work-up in both (pectoralis major flap and radial forearm flap) time periods. However, after correction for costs of inpatient hospital days, the lower hospital admission costs still outweighed the higher operative costs for radial forearm flap. The higher costs of postoperative laboratory diagnostics, postoperative paramedical services and follow-up imaging diagnostics for radial forearm flap reconstruction may also reflect a more recent time period. However, these costs were low when compared with costs of surgery and hospital admission and did not make radial forearm flap overall more expensive than pectoralis major flap reconstruction.

As cost analysis partially depends on the difference in healthcare systems, the applicability to other countries may be a problem. Particularly between the USA and Europe, differences may be present. The healthcare systems in the different European countries may also differ, but in general the main findings may be valid for all countries: free flap reconstruction is not more expensive than pedicled flaps, because the costs of the longer hospital stay (due to complications and rehabilitation) in pedicled flap reconstruction outweighed the costs of the longer operating time in free flap reconstruction.

ASA was used as a surrogate marker for representing comorbidity. Unfortunately, more specific comorbidity scales could not be determined in this retrospective study.

Comparison with other studies

In the present study, as was expected and shown in other studies,[4,19,21,22] it was found that the mean operating time for patients with radial forearm flap reconstruction was significantly longer when compared with pectoralis major flap patients. The mean postoperative length of hospital stay was significantly shorter in the radial forearm flap group than in the pectoralis major flap group, as was also found in a study of Kroll *et al.*[21] In the present study a higher surgical complication rate was found in the pectoralis major flap group when compared with the radial forearm flap group. Moreover, in several other studies a higher complication rate was reported for pectoralis major flap reconstructions when compared with free flap reconstruction.[5,6] This may have been caused by a higher incidence of partial flap necrosis and dehiscence that further resulted in wound abscesses and fistula. To overcome these complications, healing by secondary intention or re-operation may be required which can prolong hospitalisation. As functional outcome of radial forearm flap reconstruction is better than that of pectoralis major flap reconstruction, the period of rehabilitation for the latter group may be longer, requiring increased duration of hospitalisation. These findings resulted in higher operation cost but lower cost in the postoperative phase for radial forearm flap patients when compared with pectoralis major flap patients.[9]

Funk *et al*. found that within the context of overall management costs in the first year, the primary determinants of healthcare expense for head and neck cancer patients are comorbidity and extent of disease, not reconstructive technique.[9] Moreover, comorbid condition is a prognostic factor for complications in major surgery of the oral cavity and oropharynx with microvascular soft tissue reconstruction.[23] In the present study, ASA scores of radial forearm flap patients were significantly worse than those of pectoralis major flap patients. If ASA score is used as measure for comorbid condition, the risk for complications was higher in the radial forearm flap group when compared with the pectoralis major flap group. Indeed, in the radial forearm flap group a higher rate of medical complications and intensive care admission was found when compared with the pectoralis major flap group. Despite this higher risk, the postoperative length of hospital stay for radial forearm flap patients was significantly shorter than that for pectoralis major flap patients. If ASA scores would have been similar, this difference in hospital stay may even be greater. In the present study matched pair analysis based on tumour site and age was used and all patients had advanced stage disease.

Conclusion

Oral and oropharyngeal reconstruction with free radial forearm flap is not more costly than pedicled pectoralis major myocutaneous flap reconstruction. Given the better functional outcome and the present cost analysis, reconstruction of major oral and oropharyngeal defects is currently preferably performed using free tissue transfer.

Conflict of Interest

None to declare.

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