

RM13 Attributes of Perforator Flaps Used for Prophylactic Soft Tissue Augmentation Prior to Definitive Total Knee Arthroplasty: A Multi-Institutional Experience

University of Pennsylvania, Philadelphia

Presenter: **Said C Azoury, MD**

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Background

Total knee arthroplasty [TKA] for end-stage joint disease can improve the quality of life by restoring unimpeded and pain free ambulation. The dismal rate of failure following a complex periprosthetic knee wound should encourage a desire to seek any means for their prevention before primary TKA.

Methods

A multi-institutional review was undertaken for all patients of the senior authors who specifically had prophylactic soft tissue augmentation with a perforator flap prior to definitive/final TKA. All patients who had flaps for coverage of exposed prostheses or merely wound closure after TKA were excluded. Demographics, initiating conditions, original complications, type of flap used, delay until TKA, number of knee operations, post-operative complications, and final functional status were documented.

Results

Over the past 17 years, 7 flaps were performed for prophylactic soft tissue augmentation in 7 patients with knee soft tissue compromise (Table 1). All patients were males, with a mean age of 51.4 ± 7.9 years. The majority of the original knee insults ($n = 5, 71\%$) were trauma related, while the remainder were due to degenerative joint disease ($n = 2, 29\%$). All had multiple prior knee operations (average, 4-5), and two had prior infected TKA/hardware. All patients subsequently underwent TKA at an average delay of 6.7 ± 5.3 months. For smaller defects in 3 patients, a local island medial sural artery perforator (MSAP) flap was used. For larger defects, an anterolateral thigh (ALT) free flap was selected. All flaps survived completely. Follow-up for the entire group averaged 2.5 ± 2.1 years. The only complication was one patient who developed an infection requiring a revision arthroplasty. TKA was ultimately successful in all patients. Follow-up demonstrated unrestricted ambulation except in the one patient who had had a contralateral below-knee amputation from the original trauma.

Conclusion

In complex patients who have had multiple prior knee operations resulting in suboptimal local tissues or multiple pre-existing scars, prophylactic soft tissue augmentation of the knee region prior to TKA significantly reduces the risk of future complications. The use of the local MSAP or ALT free flap can be ideal choices when properly selected as prophylactic flaps to augment or replace compromised soft tissues about the knee prior to or at the time of definitive total knee arthroplasty. The majority of these cases should lead to TKA salvage and unrestricted ambulation.

RM14 Updated Algorithm for Recipient Vessel Selection in Traumatic Lower Extremity Reconstruction

New York University Langone Health, New York

Presenter: **Z-Hye Lee, MD**

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Background:

Proper selection of recipient vessels in traumatic lower extremity reconstruction remains challenging given that many patients with severe lower extremity trauma is challenging due to concomitant vascular injury and large zones of injury. The aim of this study was to examine outcomes based on recipient vessel selection and to provide a general guideline for selection of proper recipient vessels in traumatic lower extremity reconstruction.

Methods:

A retrospective review of our institutional flap registry from 1979-2016 was performed and a total of 392 soft tissue free flaps used for below knee trauma were identified. Demographics, flap characteristics and outcomes were compared using Chi-square and one-way ANOVA. Outcome measures included major perioperative complications, takebacks, partial and total flap failures.

Results:

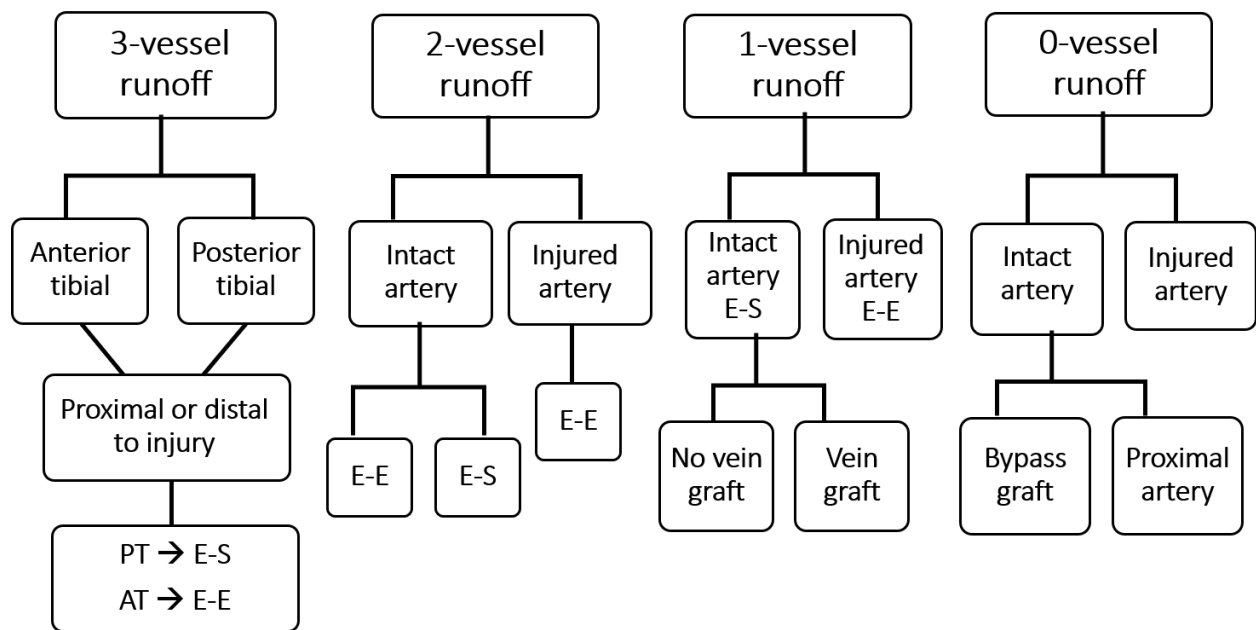
The mean age was 36.2 years (range 4-83) and 76.3% (n=273) of patients were male. Arterial injury was present in 31.8% (n=126) of reconstructions (15.2% with 2-vessel runoff, 8.8% with 1-vessel runoff and 6.6% with 0-vessel runoff). The anterior tibial artery (n=116, 29.3%) and posterior tibial artery (n=209, 52.8%) were the most commonly used as recipients. When comparing them in 3-vesesl runoff legs, there was no significant difference in major complications (p=0.31), flap failures (p=0.32) or operative takebacks (p=0.48). For both vessels, there was no significant difference in complication rates between end-to-end (E-E) vs. end-to-side (E-S) arterial anastomosis although E-S anastomosis was more commonly performed in the posterior tibial artery compared to the anterior tibial artery (67.1% vs. 32.9%, p<0.001). Utilizing a traumatized vessel as a recipient significantly increased major complications (OR 3.59, p=0.02) on logistic regression analysis. Specifically, for a 2-vessel runoff leg, utilizing an injured artery

in E-E fashion compared to a healthy vessel in E-S fashion significantly increased rates of major complication ($p=0.01$) and partial flap failures ($p=0.04$). For 1-vessel runoff leg, an intact artery was utilized in 43% of cases and of these, a vein graft was utilized in 28%. On logistic regression analysis, the use of vein graft significantly predicted complications (OR 6.03, $p=0.003$).

Conclusion s:

Appropriate recipient vessel selection remains a key to optimizing traumatic lower extremity reconstruction and we present an algorithm based on our institutional experience. Specifically, the use of an injured recipient artery and the use of vein grafts significantly increased complications.

Figure 1. Algorithm for Recipient Vessel Selection by Vessel Runoff



RM15 Comparative Analysis of Clinical Outcome and Quality of Life between Amputations and Free Flap Based Reconstructions at the Lower Leg

BG University Hospital Bergmannsheil Bochum, Bochum

Presenter: **Bjorn Behr, MD**

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Background

At the lower leg, soft tissue defects with exposed bones, tendons or hardware require flap coverage. In cases of failed or not feasible reconstruction, amputation is often the consequence. However, little is known about the true impact of reconstruction versus amputation on quality of life in a civil setting. In this retrospective study, we analyzed posttraumatic free flap based reconstructions compared to amputations of the lower leg. We examined functional parameters, quality of life, length of hospital stay and periods of inability to work.

Methods

Patients who underwent free flap reconstruction or amputation after traumatic soft tissue injury to the lower leg were eligible for the study. Besides the analysis of the medical history, the study included thorough clinical examination including the extremity functional scale (LEFS) and SF36-questionnaire for quality of life.

Results

32 patients with leg amputations (LA) and 27 patients with free flap reconstruction (LR) of the lower leg could be included in the study. Average time between discharge and exam was 2.7 years in the LA group and 5.9 years in the LR group. Mean age was 57 years in the LA and 59 years in the LR group. LEFS score in the LA group was 43.4%, whereas this value was significantly higher in the LR group (63%). The time interval for patients to return to work was 175 days in the LA group and 500 days in the LR group. Importantly, 78% in the LA group as opposed to 24% in the LR group could not return to their occupation. 70% in the LA group defined their maximal walking distance below 1000m, whereas only 33% in the LR group reported this impairment. Mean hospitalization was 182 days in the LA and 101 in the LR group. Scores of the LA group in the SF-36 analysis deteriorated to -0.84 as compared to the norm population, whereas it was similar to the norm with 0.04 in the LR group.

Conclusion

Patients undergoing complex extremity reconstructions, including free flap transfer to the lower leg, experience prolonged hospitalization. However their functionality and quality of life is significantly higher than in amputated patients. These data emphasize the advantages of free flap based reconstructions of the lower leg and justify reconstructive efforts for limb salvage.

RM16 Long Term Follow up of Pedicled Nerve Free Functioning Rectus Abdominus Muscle Transfer for Flail Arm Reconstruction

Calum Honeyman, Oxford

Presenter: **Calum S Honeyman, MBChB, BSc (Hons), MRCS**

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Background: Free functioning muscle transfers are limited by the availability and regeneration of neural donors. The pedicled nerve free vascularized rectus abdominis transfer (PNFV RAT) overcomes the need for neural regeneration and extends the arc of rotation of possible donors, free of the constraint of the vascular pedicle. The aim of this study is to describe the anatomical feasibility and long term clinical outcomes of a new treatment option to restore elbow flexion in flail arm reconstruction. **Methods:** Anatomical dissection of the nerve and blood supply of six rectus abdominis muscles in three cadavers was performed at the Department of Anatomy, University of Cambridge, United Kingdom. A retrospective case note review was performed for all patients who presented with a total brachial plexus palsy between January 2010 and December 2015, treated with a unilateral pedicled nerve free vascularized rectus abdominis transfer to restore elbow flexion. Medical records were interrogated for the following information: patient demographics; pre-operative diagnostic evaluations; surgical procedure details and clinical outcomes (donor site morbidity, and functional outcomes). **Results:** The anatomical feasibility study demonstrated that it was possible to reliably elevate the rectus abdominis on its intercostal nerve supply and dissect these to the mid-axillary line allowing the muscle to be pedicled on its nerve supply to the arm. Vascular supply could be re-established by anastomosis to recipient vessels in the arm. Four consecutive clinical cases of PNFV RAT's were performed. Average patient age was 36.5 years (range 28 ÷ 47 years) with a male preponderance (M:F, 3:1). Indications for the procedure were a flail upper limb due to traumatic total brachial plexus avulsions (n=3) and poliomyelitis (n=1). One case was performed acutely and the remaining three were delayed procedures. Mean follow-up time after surgery was 2.5 years. Surgical outcomes demonstrated good elbow flexion with M4- power in three patients and M3 power in one patient. Shoulder stability with external rotation was regained in four cases. Two patients developed post-operative incisional hernias, requiring subsequent mesh repair, and one patient developed a hypertrophic recipient site scar. **Conclusion:** We describe the novel concept of a pedicled nerve free vascularized rectus abdominis muscle transfer for biceps reconstruction. This hybrid flap is a safe and effective procedure for functional reconstruction of the elbow and adds to our armamentarium in the management of complete brachial plexus pathology.

RM18 Effects of Alternating Versus Direct Current Electrical Stimulation Devices on Nerve Regeneration Following Repair

Washington University School of Medicine, St. Louis

Presenter: **Hosannah Evie, BS**

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Background: Electrical stimulation (ES) has been shown to be useful in improving nerve regeneration, axonal growth and preferential reinnervation of motor pathways following injury through in vivo and in vitro models. Most of the experiments that have shown this improvement involve the use of alternating current (AC) ES protocols. However, there is some evidence, but limited mechanistic understanding, that direct current (DC) ES could also improve nerve regeneration. In this summer medical student research project funded by the ASRM medical student research grant, we compared two ES devices using either AC or DC ES protocols in a rat tibial cut/repair model to measure their effects to regeneration. We hypothesized that AC ES, but not DC ES, will augment and improve nerve regeneration after surgical repair.

Methods: Forty five (45) male Lewis rats were randomized into three groups: No ES, DC ES at 0.5 mA constant current for 1hour, and AC ES at 0.5 mA constant current for 1 hour. All groups underwent a tibial nerve cut and repair surgery followed by ES (or no ES). Walking track analysis was conducted on a cohort of n=9 rats per group. Before, and then twice weekly up until the 8 week endpoint, rat walking tracks were measured and scored using the tibial function index (TFI). In a separate cohort of rats (n=6 per group), at a 3 week endpoint, tibial nerve distal to the repair site was harvested for histological analysis and retrograde traced using fluorogold (4% solution) to measure the extent of early axon regeneration was sensory and motor neurons.

Results: All experiments have been started and are ongoing. The cohort of rats assessed using walking track analysis demonstrated no impaired function prior to surgery, and severely impaired function (based on TFI) immediately after the nerve injury with repair. Early results at 32 days do not demonstrate any differences between treatment groups yet. Walking track analysis will be continued until the 8 week endpoint. Additionally, the cohort of rats labeled with a retrograde tracer will be assessed by the end of summer to be reported at this meeting.

Conclusions: This comparison of AC versus DC ES has translational implications given that ES devices capable of either ES paradigm are available for clinical use. Our results will help further develop and guide ES therapies as they translate to the clinic to treat nerve injuries.

RM19 Investigation of Scar Formation within Nerve Grafts used in Facial Nerve Surgery

Univeristy of Rochester Medical Center, Rochester

Presenter: **Scott Echternacht, Medical Student**

Scott Echternacht, Medical Student

University of Rochester Medical Center, Rochester, NY

RM20 From Bench-to-Bedside: Implications for Facial Reanimation Surgery Gained from Axonal Load Quantification and Nerve Morphometry of a Cadaver Study in 106 Facial Halves

Dept. of Plastic Surgery, University Hospital of Regensburg, Regensburg

Presenter: **Andreas Kehrer, MD, PhD**

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Background

Peripheral facial palsy causes severe functional, aesthetic and psychological impairments. Restoration of symmetry and facial expressions is possible through cross-face-nerve-grafts (CFNG), nerve transfers and functional muscle transplantation. Various criteria must be taken into account to choose the right donor nerve for coaptation. Previous studies showed that an axon capacity exceeding 900 axons is correlated with strong functional results. Our group conducted an anatomical and histological study of the facial and masseteric nerve systems in 106 facial halves. The aim of our current study was to translate our results of axonal load quantification and nerve morphometry into a clinical setting to facilitate donor nerve selection and improve clinical outcomes.

Methods

Microsurgical dissection was performed on 106 hemifaces of fresh unpreserved cadavers. Facial nerve biopsies were taken in clinically important donor nerve regions (1084 biopsies). Nerve twigs were classified as level I or level II. Level I branches were direct branches of the primary divisions. Level II branches were direct branches of the level I branches. Additionally, 154 masseteric nerve biopsies were harvested. Biopsies were PPD-fixed, sectioned and stained for digital semi-automated axon quantification with ImageJ-software. Cross sections were measured by two orthogonal vectors using a Zeiss AxioVision software. Measurements included nerve sheath structures and perineurium comparable to a clinical situation. A total of 50 clinical biopsies taken from patients undergoing neurotization procedures and free muscle transplants were processed similarly. An overall correlation of diameter with axonal load was performed. Cut-Off-Values were evaluated using ROC-Curve-Analysis.

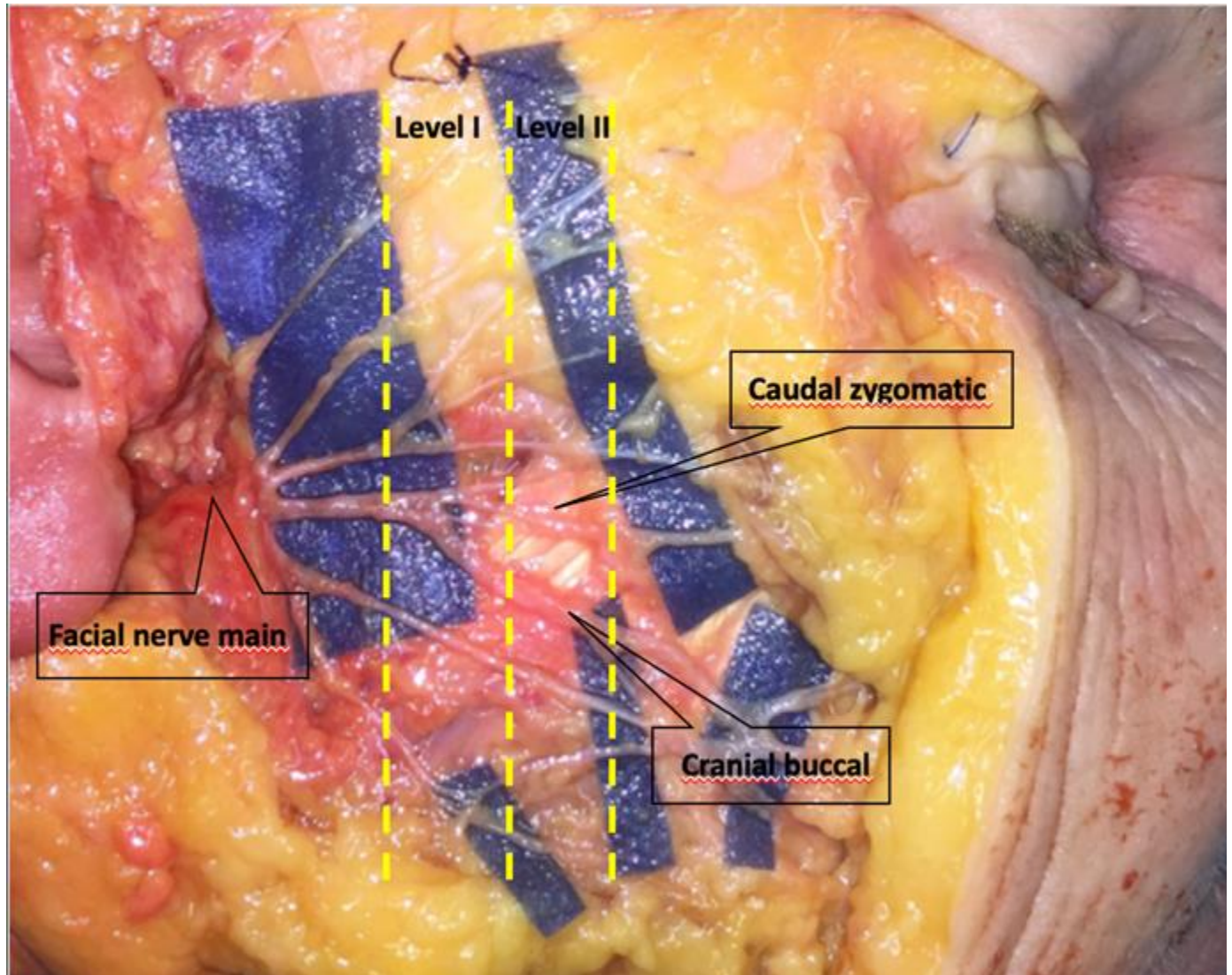
Results

Level II zygomatic branches showed 1067 ± 531 axons per millimeter (n= 161; r= 0.61; p= 0.0001). Level II buccal branches showed 1208 ± 530 axons / mm (n= 208; r= 0.58; p= 0.0001).

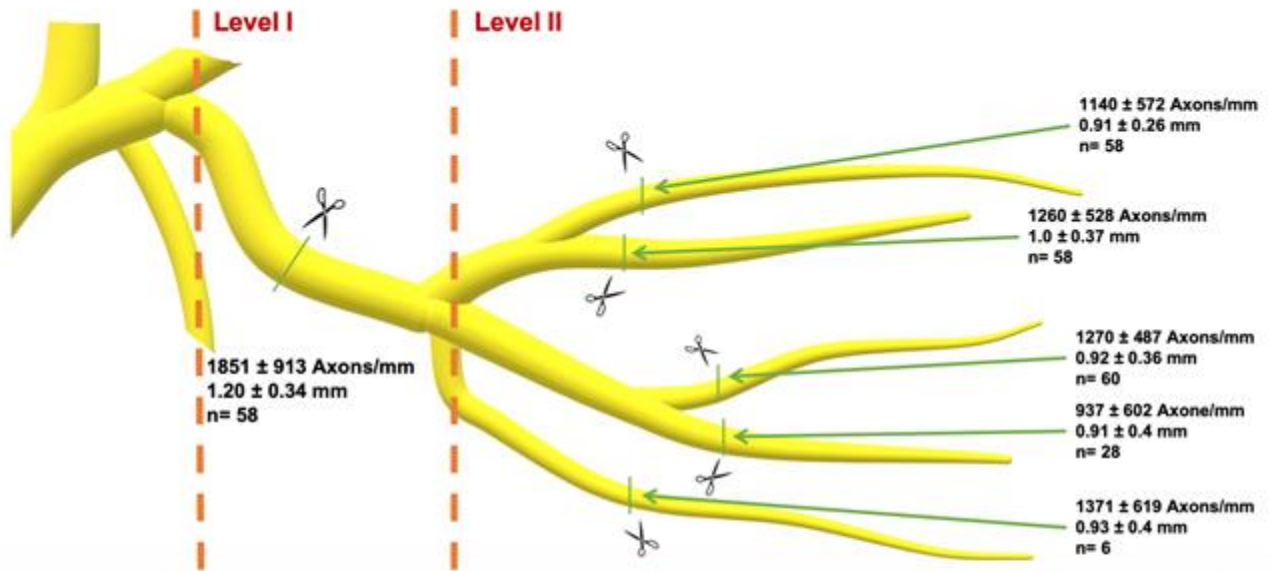
Axonal density in the buccal system was consistently higher than in the zygomatic system ($p=0.006$). A cut-off value of greater than 900 axons at level II in the zygomatic system was calculated at 0.94 mm. In level II buccal donor branches at 0.84 mm. The descending masseteric branch showed 1477 ± 428 ($n=18$; $r=0.64$; $p=0.004$) axons / mm. Values were compared to respective results in our clinical series. Diameter selection of donor nerve branches in patients in relation to cadaver study results are described and improved axonal load.

Conclusion

Axonal load quantification and nerve morphometry from the cadaver study significantly improved donor nerve selection in maximizing axonal load without causing sequelae.



Buccal branches



Branches	Diameter (mm)								Axon-Increase per 0.1 mm	R ²
	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0		
Buccal-1	1422	1686	1951	2216	2480	2746	3010	3275	132	0.136
Zygomatic-1	966	1387	1808	2229	2650	3071	2492	3913	210	0.429
Buccal-2	766	984	1201	1419	1637	1854	2072	2289	108	0.334
Zygomatic-2	630	868	1105	1342	1580	1817	2055	2292	118	0.370

RM21 Reinnervation of Nipple-Areolar Complex after Mastectomy Enhances Sensory Recovery

Stanford University, Palo Alto

Presenter: **Danielle H Rochlin, MD**

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Background

Nipple-sparing mastectomy (NSM) often renders the breast skin and nipple-areolar complex (NAC) insensate. This loss of sensation has profound negative psychological, sexual, and safety consequences. No studies have demonstrated successful restoration of NAC sensation following mastectomy. We propose a new technique of preserving the breast sensory nerves and using them to reinnervate the NAC after mastectomy.

Methods

A retrospective study was performed of female-to-male transgender patients who underwent mastectomy from 2016 to 2019. The medial and/or lateral intercostal nerves were dissected out to length and preserved during mastectomy. Neurotomy was performed to nerve stumps at the base of the NAC. Sensation was assessed postoperatively for right (R) and left (L) sides using Semmes-Weinstein monofilaments (6.65, 4.56, 4.31, 3.61, and 2.83 grams) at the nipple, areola, and breast skin 2 centimeters from the areola in each quadrant. Outcomes were compared to a cohort of patients who underwent mastectomy without neurotization using unpaired t-tests.

Results

Eight transgender patients had bilateral nipple sparing mastectomy with nipple reinnervation. Mean age was 17.5 years (range 16 to 19 years). Final follow up was a mean of 9.4 ± 4.3 months for the treated group and 34.7 ± 12.9 months for the control group, which consisted of 10 patients. Compared to control patients, treated patients had significant improvement in sensation at the nipple (Control- R 5.58 ± 1.13 , L 4.95 ± 0.90 ; Treated- R 3.41 ± 0.53 , L 3.21 ± 0.57 ; $p \leq 0.0002$), areola (Control- R 5.09 ± 0.60 , L 5.13 ± 0.57 ; Treated- R 3.34 ± 0.39 , L 3.41 ± 0.44 ; $p = 0.0001$), and peripheral breast skin (Control- R 4.70 ± 0.91 , L 4.47 ± 0.78 ; Treated- R 3.00 ± 0.35 , L 2.98 ± 0.35 ; $p = 0.0001$) (Figure 1). For treated patients, there was no statistically significant difference in sensation between preoperative baseline and postoperative sensation for all tested areas at a final follow up time of up to 14.1 months. Three treated patients additionally reported recovery of tickling sensation with light touch.

Conclusion

Immediate reinnervation of the NAC after mastectomy enhances recovery of NAC sensation in patients undergoing female-to-male mastectomy. This proof of concept study has substantial implications regarding restoration of NAC sensation following mastectomy for oncologic indications, which will be investigated in future studies.

RM22 Advanced-Stage Chest Wall Sarcoma Resection and Microvascular Reconstruction: Indications, Outcomes, and Survival Based on a 12-Year Experience

Christopher Nguyen, Winnipeg

Presenter: **Christopher M Nguyen, MD**

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Background: High-grade, locally-advanced, with or without systemic metastases, primary chest wall sarcomas (AJCC III-IV) are rare neoplasms frequently associated with poor 5-year survival. Radical resection aiming to obtain local control often requires soft tissue microvascular reconstruction and chest wall stabilization. The functional impairment and the oncologic benefit of such radical surgical approach in this complex patient population remains to be defined. The objective of this study is to evaluate our clinical experience with massive full-thickness chest wall resections of late stage sarcomas requiring microvascular reconstructions.

Methods: A retrospective analysis of a prospectively-maintained database from 2007-2019 identified 44 massive chest wall resections. 19 patients had histologically confirmed high grade, advanced-stage (III/IV) chest wall sarcomas treated with radical resection and complex chest wall reconstruction. Patient demographics (age, gender, comorbidities), tumor pathology (type, size, location), extent of resections, reconstruction techniques, length of stay (LOS), and perioperative complications. Overall survival was calculated using Kaplan–Meier curve.

Results: Patient population included 9 females, 10 males with a mean age of 61.6 ± 21.5 years. 8 patients were Stage III, and 11 were Stage IV. 8 patients had systemic metastasis. Indications for resection included palliative for hygiene or pain (n=10), and curative intent (n=9). The mean tumor diameter was 14 ± 9 cm. All cases required microvascular flap reconstruction (n=19), with the majority utilizing Composix Gortex/Prolene mesh (n=12) for chest wall stabilization. Flap type included: single DIEP (n=10), bilateral DIEP (n=4), single ALT+ TFL (n=1), bilateral ALT (n=1), bilateral ALT + TFL (n=1), supercharged latissimus/serratus (n=2). There were no perioperative mortalities or flap losses. Complications occurred in 9 cases (Clavien-Dindo classification grade II, n=3, grade IIIa, n= 3, grade IV n=3). Median LOS was 15 days. Mean follow-up time was 30.1 months. Mean overall survival time of 32.1 ± 36.2 months (stage III- 53.2 ± 47.2 months; stage IV – 16.7 ± 13.8 months, $p < 0.001$).

Conclusion: Microvascular reconstruction of radical composite chest wall resection for advanced-stage sarcomas can be associated with high flap success rate and acceptable complication rate. Limited LOS and significant length of survival support this aggressive approach. We report a mean survival time of 34.5 months with mortality significantly influenced by underlying stage of the disease. The option for complex reconstructions remains a viable option for high-grade, advanced stage primary sarcoma of the chest wall.