Efficacy of Antero Lateral Thigh Flap in Head and Neck Reconstruction

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DECLARATION

I, Leah Mokgadi Machaka, am submitting this research dissertation for the Degree of Master of Medicine at the University of the Witwatersrand Johannesburg.

I declare that this research report has not been submitted for examination to this or any other university before.

……

Leah Mokgadi Machaka

01 Day of December 2022

DEDICATION AND ACKNOWLEDGEMENTS

- This work is dedicated to my mother, Amanda Machaka, for her prayers, guidance and support that kept me going through difficult times. It is also dedicated to my daughter and my brothers for their unfailing faith in me.
- I would like to thank all my supervisors: Professor E Ndobe for his patience, guidance and support and Dr Nel for her patience, for being a shoulder to cry on and continuous cheering. I'm very grateful.
- I would like to express my gratitude to Zvifadzo Matsena Zingani, a biostatistician, who helped greatly with the statistical analysis of the results.

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ABSTRACT

INTRODUCTION

Head and neck defects commonly from excision of cancer, require complex reconstruction.

Our reconstructive goals are aimed at achieving safety, form and function. Escalation to the highest option on the ladder of reconstruction is obligatory. With the discovery of free anterolateral thigh flaps our reconstructive goals could be attained. Antero lateral thigh flap offered more to the reconstructive options than what it was initially described as. Antero lateral thigh flap not only gained popularity but also became the workhorse flap in head and neck reconstruction. Research has been done all over the world on the application of Antero lateral thigh flap but nothing is reported from South Africa. The aim of the study was to determine the efficacy of antero lateral thigh flap in head and neck reconstruction in plastic surgery department at Charlotte Maxeke Johannesburg Academic Hospital.

Methodology

A retrospective medical record review was conducted at Charlotte Maxeke Johannesburg Academic Hospital which included all adult patients reconstructed with antero lateral thigh flap. Theatre and ward registration were used to identify the patients during the five-year period from 01 January 2014 – 31 December 2018. The number of patients with head and neck cancer during this period totalled 80, of which 33 met the study inclusion criteria: Adults with head and neck cancer reconstructed with antero lateral thigh flap.

Main Outcome Measures – Flap survival, recipient and donor complications and length of hospital stay.

Results

The study comprised 33 patients who had undergone a wide local excision, with/without neck dissection and reconstructed with antero lateral thigh flap. The mean age of the patients was 55.89 +/- 12.77 years. Most participants were male (n=24: 72.73%), female (n=9:27.27%), smokers (n=18: 56.25%) and 25 (78.13%) had SCC diagnosis, there were 15 (44.12%) patients with comorbidities and the average duration of the operation was 10.12+/- 2.65 hours. The most frequent anatomical site was the oral cavity (n=15: 50%). Maximum ICU stay was 2 days (n=31.93: 94%), The median hospital stay was 38 days with an interquartile range of 34-44 days. Post operation complications were experienced by 7 patients – recipient site complication (n=3,9%) and donor site complication (n=4, 12%), with a total flap survival of 94%.

Conclusion

Our experience has given us the confidence to use this flap in a variety of head and neck defects.

The antero lateral thigh flap is highly versatile, has a high survival rate and a low complication rate. Antero lateral thigh flap has found a permanent and highly valued place in head and neck reconstruction.

LIST OF ABBREVIATIONS

ALT	Anterolateral thigh flap
ASIS	Anterior superior iliac spine
CMJAH	Charlotte Maxeke Johannesburg Academic Hospital
LDF	Latissimus dorsi flap
FRFF	Free radial forearm flap
LOS	Length of hospital stay
ICU	Intensive care unit
TFL	Tensor fascia lata

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1.Introduction

Head and neck cancers still pose a formidable challenge to all specialties involved, but especially the plastic surgeon. Reconstruction of head and neck cancer requires intense planning, microsurgical skills and an appropriate flap that can restore both form and function (1).

With a global increase in head and neck cancer, the incidence in Africa, according to the global data statistics analysis, has been attributed to smoking, westernization of lifestyle, diet, HIV/HPV, lack of access to health care facilities and unfavorable health policies, while also taking into consideration the lack of data (under reporting) and poor data capturing (2,3).

Head and neck cancer have ranked 4th in South Africa and 90% of cases were found to be squamous cell carcinoma (SCC) (4). In our setting most, patients present with advanced disease, which has become a major health care burden (2). Cultural believes, lack of education and poverty have been identified as a cause of delayed presentation (2).

Surgical challenges with excision of tumors include removal of the primary lesion and circumferential margin of healthy tissue, leaving a mutilated disfigured organ. The dilemma is while trying to stay oncological radical, to preserve function, minimal aesthetic impact and psychological well-being of the patient (3).

2.1 Literature review

The revolution of the flap has taken a superior turn from the 1970s and 1980s, from the use of pedicle flaps like deltopectoral-, pectoralis major- and latissimus dorsi flap (LDF) to microvascular free tissue transfer (5,6). Since inception of microvascular reconstruction, the role of the pedicle flaps evolved into salvage flaps, mostly indicated for patients that cannot tolerate a lengthy operation or failed free flaps (1,6). Microvascular flaps offering reliable flap survival and more tailored tissue, has resulted in functional and cosmetic outcome far superior to those of pedicle flaps (5,6,7). However, hypothermia, pressure injuries, prolonged procedure length and flap loss are risks associated with free tissue transfer (8,9).

A great deal of consideration is required in flap selection, as they are tailored to each patient. Free flap transfer needs to have certain characteristics: sufficient tissue bulk, low donor site morbidity, superior texture, versatility in shape, availability of diverse tissue types on one pedicle, a two-team approach, long pedicle, possibility of innervation, constant anatomy for safe and easy flap rise (5,10,11). The aggressive resection of these tumors results in a paucity of local options resulting in free flaps becoming the modality of choice for reconstruction (5).

By chronological discovery of flaps the LDF was discovered in 1906 and popularized in 1970, while the free radial forearm flap (FRFF) was discovered in 1978. They were commonly used in head and neck reconstruction. FRFF was popular for its excellent pliability, ease of raising the flap especially for intra oral defect reconstruction (10,12) and LDF for large size defects, ability of raising with multiple skin paddle and voluminous tissue (10). Discovery of the anterolateral thigh flap (ALT) has become a permanent and highly valued option in head and neck surgery because of its resourcefulness (5,13). It offers many advantages required to reconstruct the defect, such as its versatility in design size, thin pliability by thinning immediately or delayed, or bulk if required, a long pedicle with suitable vessel diameter, it is easy to harvest, use a two-team approach, less donor site morbidity, and most importantly, it is the patient's choice over FRFF and LDF (hidden scar) as documented by Brown *et al*., (7,14). Numerous reports from different centers including Wei *et al*., described an ALT success rate of 95% (1,11,15), thus ALT is regarded as superior. The focus now is not on increasing the number of different flaps but to individualize the flap harvested from the donor site, with which the surgical team has experience (10). Indeed, at CMJAH ALT has become the preferred donor site for soft tissue reconstruction in the Head and Neck Unit.

2.2 Discovery of ALT.

Song and coworkers described three flaps from the thigh. The ALT, anterior medial thigh flap and the posterior thigh flap in 1984 (13). Of these three flaps, the ALT became the most popular.

ALT was initially described as a septocutaneous pedicle based on the descending branch of the lateral circumflex femoral artery, but variation occur where the branch runs through the vastus lateralis as a myocutaneous perforator, and this expanded on the possibilities of raising ALT. The myocutaneous vastus lateralis flap was first described in 1987 by Drimmer and Krasna, while the first free myocutaneous vastus lateralis flap was reported in 1992 by Wolff and Holsle for oral cavity cover (14). With more experience gained with ALT, the indication for its use expanded.

Basing a large fasciocutaneous flap on a single perforator was described by Zhou *et al*., while ALT with a size ranging from 25-35cm became a popular complementary choice (7). The two-team approach results in rapid flap raising simultaneously with tumor extirpation which decreases procedure time. This benefit has a tremendous advantageous effect on recipient site complications and reduction in primary reperfusion injury (6,8,9,10).

A study done in Germany on complications at both the recipient and donor sites on 1000 free flaps done including ALT, found that ALT had an acceptable low risk of complications (7,10,13). Townley *et al*., in a retrospective study performed on one hundred patients' post- ALT, found that there was minimal donor site morbidity when assessing function, sensation and the aesthetically acceptable hidden scar. In a comparative

study on the donor site and the contralateral thigh, there was no loss of quadriceps function, although change in sensation was reported but it was statistically insignificant (7).

The ability to raise an ALT flap on multiple perforators gave birth to chimeric ALT, offering an advantage of multiple skin paddle, fascia and muscle component from the vastus lateralis, all on the same pedicle (10). The chimeric flap was an option in defects that required volume re-placement and also in slim patients with not enough bulk (11,15,16). Other uses were documented in cheek defects and total glossectomy (16). Chimeric ALT also solves the problem of deficient recipient vessels due to extensive dissection or post radiation as it only requires one pair of recipient vessels. Furthermore, chimeric flaps are useful in protection of the pedicle preventing orocutaneous fistulas and carotid blowout syndrome (17). A study carried out on 34 patients using ALT in intra oral defects, confirmed recovery of function such as linguistics, chewing and swallowing (5,12,16).

Flap bulk is known as one of the disadvantages of ALT but has found use in patients that require post-operative radiation. Initially the wound appears excessively bulky (11), but it settles to an appropriate size after radiation. In such cases where FRFF was an appropriate flap post-radiation, the recipient site would require volume restoration with fat grafting (1). Thinning of the ALT flap, which creates an alternative for intra oral cover was introduced by Kimura in 1995 (15). Thinning is advantageous in obese patients with excess subcutaneous fat that would make ALT an undesirable choice of flap. Although secondary thinning is possible, it carries extra economic burden on both surgeon and patient (18). The possibility of thinning offered the advantage of a FRFF without donor site morbidity, while being cost effective. However, preservation of the subdermal plexus is a prerequisite for successful thinning, which means that minimal flap thickness must not be less than 4mm (18).

ALT is useful in near or total circumferential cervical esophagus defects. Managing to cover the pharyngo-esophagus and neck defects with two skin paddles. Initially, the jejunum was the flap of choice in such cases. Avoidance of laparotomy and the possibility of creating intra-abdominal complications are benefits of choosing an ALT flap over the jejunum. However, studies have proven that fasciocutaneous flaps provide superior speech rehabilitation compared with an intestinal flap (5,16).

ALT has replaced the use of FRFF which was commonly used in head and neck defects notwithstanding its usefulness in recipient site reconstruction (5,16). FRFF carried a tell-tale sign at the donor site, and sacrificing important vessels rendered it undesirable (7,10). Regardless of LDF creating a favorable donor site, the inability to use a two-team approach was a major disadvantage (10,12). FRFF was popular for tongue reconstruction, but in a comparison study of ALT and FRFF reconstruction, no functional difference in terms of speech and swallowing was found in patients who had a glossectomy (5,12,13,19). The advantage of ALT over FRFF was the donor site morbidity such as cosmetics and sensitivity (7,18). Universally ALT and LDF are the two most versatile options for extensive soft tissue defects to replace the

volume loss in head and neck reconstruction. A comparison study by Koshima and coworkers on ALT and LDF in head and neck reconstruction, confirmed many similarities, with the two variables that showed a marginal difference being the success rate of 91% for LDF and 93% for ALT, and the donor site morbidity of 9% for LDF and 7% for ALT (19). Although LDF and FRFF still remain in the repertoire of microsurgeons, the failure of the two-team approach and the donor site morbidity has outweighed the advantages shared with ALT (11). In 2002, a study was published, by Wei *et al.,* on 672 ALT cases, with only 2% total failure and 3% partial failure reported (13).

Complexity of head and neck defects has led to a quest of discovering a flap that will meet the demands of the defect to restore form and function. McCraw and Dibbell (1967), shared the desire to discover or describe a new flap every year (20). The new approach of individualizing a donor site for flap harvesting has led to identifying the anterolateral thigh as an ideal donor site for head and neck reconstruction (10). ALT offers a large flap with different tissue composition and reduced donor site morbidity, while providing results that are equal or superior to a more traditional approach to head and neck defects. It has also contributed to pre-operative brain storming as to which flap will be ideal for the defect to which tissue composition is required from the donor site to cover the specific head and neck defect.

With head and neck cancer ranking as the 4th most common cancer in South Africa, it is important to investigate the value of using the ALT as a reconstruction flap. Such data although scarce, is available internationally, but not at all in South Africa.

2.3 Anatomy of ALT

The fasciocutaneous tissue between the medial border of the rectus femoris and the posterior lateral border of the vastus lateralis muscle, occupies the anterolateral portion of the thigh from 10cm below ASIS to within 7cm superior to the patella. Blood is supplied by the descending branch of lateral circumflex femoral artery, length range between 8-16cm with a vessel diameter >2mm, with two major perforators, the myocutaneous (88%) and septocutaneous (10%). The pedicle lies in groove between the rectus femoris and vastus lateralis. Innervated by the lateral femoral cutaneous nerve (21).

2.4 Harvesting ALT

The patient lies in the supine position on the theatre bed. Markings to identify the intermuscular septum and perforators using the ABC system – an AP line is drawn between the ASIS and superolateral border of the patella. This vertical line marks the intermuscular septum between the rectus femoris and vastus lateralis. The mid-point of this vertical line a 3cm radius circle is drawn, the most consistently present cutaneous perforator B is located within that circle especially the inferior lateral quadrant of the circle using the handheld

doppler probe. Other perforators can be found 5cm proximal and distal to perforator B, respectively perforator A and C. The flap is centred over the location of the cutaneous perforator.

Dissection begins at the medial border of the flap over the rectus femoris muscle, as a subfascial dissection which is done slowly and carefully while identifying suitable perforators emerging from the muscle and entering the fascia and skin. Once the perforators are found you may proceed to identify the descending branch of the lateral circumflex artery found in the groove between the rectus femoris and vastus lateralis muscle. The course of the perforator must be traced in a retrograde dissection in 3 steps – by firstly: free the overlying muscle using the unroofing technique, secondly: free the lateral muscle attachment and thirdly: free the vessels from the muscle on the base back to the descending branch of the lateral circumflex artery, the artery is divided once a suitable length is achieved. The size of the skin paddle is determined by the defect size. If the skin paddle is between 7 and 8cm, the defect can be closed primarily. Defects that are greater than 8cm will require a skin graft, to avoid closure under tension which may result in muscle ischaemia, muscle swelling compartment syndrome and subsequent nerve injury. Vascular anastomosis is performed using microsurgery techniques on the branches of the external carotid artery as the recipient artery and the internal jugular vein as the recipient vein.

Post - operative monitoring is vital for early identification of complications such as vascular compromise. ICU monitoring has become a valuable step of flap monitoring in the post-operative period and has been adopted as a mandatory standard of care.

When a thin pliable flap is required, a suprafascial dissection is done leaving 4mm tissue on the flap and a small cuff of fascia is left around the perforator. Defects that occur in the following anatomical sites (hemiglossal, buccal mucosa, palate and pharyngeal wall) require a thin flap.
When bulk is required, the fasciocutaneous flap may be raised with the vastus lateralis muscle.

3.Motivation

3.1 Problem statement

With head and neck cancer ranking 4th in South Africa, it is important to evaluate our reconstructive option and assess if our goals of reconstruction are achieved with using an ALT flap in head and neck reconstruction. Such data is although scarce, available internationally, but not at all in South Africa.

3.2 Aim

The aim of the study is to evaluate the proficiency of ALT in the Head and Neck Reconstruction Plastic Surgery Unit at the Charlotte Maxeke Johannesburg Academic Hospital.

3.3 Study objectives

a. To determine indication for ALT.
b. To determine size of flap raised.
c. To determine percentage of flap survival.
d. To determine donor site morbidity.
e. To determine length of hospital stay

4. Research methodology

4.1 Study setting

This study was done at CMJAH, one of the teaching hospitals of Wits University.

4.2 Study design population and sampling procedure.

4.2.1 Study design: A retrospective review design

A retrospective medical records review was conducted at the CMJAH on all adults presenting with a head and/or neck defect reconstructed with ALT.

4.2.2 Study population

The patient register in the theatre and ward was used to identify the admitted patients during a period on 1/01/2014 – 31/12/2018.

4.2.3 The sample and sampling procedure

From the 80 patients admitted to the Head and Neck Unit at CMJAH, a sample of 33 patients (42.5%) was selected for the study, as these patients met the following criteria.

a. Inclusion criteria

- All head and neck cases reconstructed with ALT at CMJAH.
- Adults > 18years.
- Patients medically fit to withstand a lengthy operation.
- Patients with controlled medical conditions.

b. Exclusion criteria

- Small defects of head and neck that are closed primarily.

- Reconstruction with ALT in extremities.
- Patients with psychiatric conditions.

4.3 Data collection

4.3.1 Participants identification

Each participant's record selected for the study was assigned a study number. No patient identifiers were recorded.

4.3.2 Data capturing

All the data collected were entered into the data sheet and into an Excel spread sheet.

4.4 Data analysis

The data was captured, cleaned and managed in Excel before importing into STATA 17.0 for analysis. Categorical variables were summarised using frequencies and percentages. Pie charts and bar charts were used to provide a pictorial view of some of the categorical variables. The normality assumption of continuous variables was assessed using a histogram with a superimposed normal curve and the Shapiro Wilk test. Continuous variables which were not normally distributed were summarised using mean and standard deviation (SD), while non-normally distributed data was summarised using the median and interquartile (IQR) range. The results were presented in tables.

4.5 Possible bias

4.5.1 Source of bias

The findings in a sample of patients seen in a single unit were used, which may bias the outcomes of the study to the broader local experience.

4.6 Ethics

No direct research was carried out on patients (only their hospital records were accessed). The privacy of the participants was still respected, and the data and findings were treated ethically and with confidentiality. Patient anonymity was ensured by giving each patient record a study number only without recording any patient identifiers. Collected data are kept in a safe place only accessible to the researcher.

Permission to conduct the study was sought from the Human Research Ethics Committee (HREC) of the University of the Witwatersrand and the Research Board of the CMJAH.

5. Results

The number of patients admitted with head and neck pathology over an approximate five-year period was 80 patients, 41%(33/80) met the inclusion criteria and were reconstructed with ALT. Patient characteristics are given in Table 1.

5.1 Patient characteristics

The following details pertain to the 33 patients who met the inclusion criteria for the study:
In terms of gender, the majority of patients, 73%, were male (24/33), and 27%, were female (9/33). Median age of our patients was 55.89 (Range 28 - 78years). The majority of patients in the study group were smokers (18/33, 54%), and 45% (15/33) had comorbidities such as hypertension, diabetes, peripheral vascular disease. There was a gradual increase in the number of operations performed during the study period. In 2014-2015 a total of four patients were operated on. In 2016-2017 the number of cases doubled to nine and in the period of 2018 alone a total of 14 cases were operated on, which is almost triple the number of cases of 2014-2015 (Figure 1). In this study, the most common presenting pathology was SCC, totalling 75% (25/33) of patients in the study population. All of the aforementioned data is represented in Table 1 below, which is the summary of the characteristics of the sample size.

Table 1: Descriptive statistics (n = 33)

Variable	Frequency	Percentage
Gender		
Female	9	27.27
Male	24	72.73
Smoker		
No	14	42.42
Yes	19	57.57
Comorbidity		
No	18	54.54
Yes	15	45.45
Diagnosis		
Dermatofibrosarcoma	5	15.15
Others	2	6.06
SCC	26	78.78
Date of operation		
2014-2015	6	18.18
2016-2017	11	33.33
2018	16	48.48
Duration of operation in hours (mean ± SD)	10.12±2.65	
Age in years (mean ± SD)	55.89±12.77	

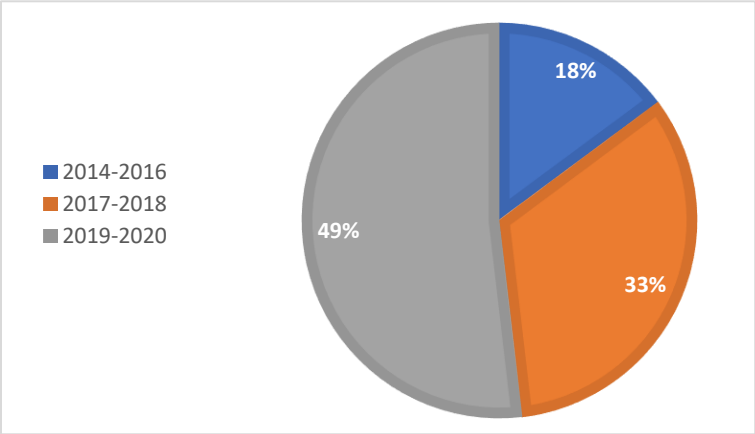

Figure 1: Procedures per year of the study period

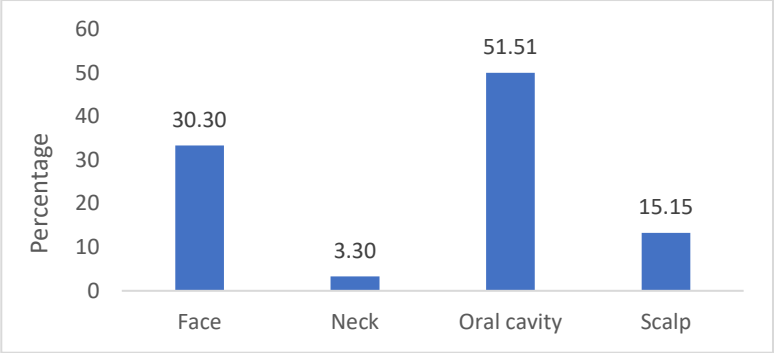

Figure 2: Anatomical site distribution

As per Figure 2 above and Table 2 below, the most frequent anatomical site of reconstruction was the oral cavity (n=17; 51%) followed by the face (n=10; 30.30%), the scalp (n=5; 15.15%) and lastly the neck (n=1; 3.30%). The right thigh was the dominant donor site (n=24; 72%).

Table 2: Anatomical reconstruction site and ALT donor side distribution

Variable	Frequency	Percentage
Anatomic site		
Face	10	30.30
Neck	1	3.30
Oral cavity	17	51.51
Scalp	5	15.15
ALT side		
Left thigh	9	27.27
Right thigh	24	72.73

Most participants had skin grafts (n=17, 51.52%) while 16 (48.48%) had a primary closure.

Four skin grafted donor sites had a partial graft loss, which was managed conservatively with dressings until it re-epithelialized (Table 3).

Table 3: Donor site morbidity and complications

Variable	Frequency	Percentage
Donor site		
Primary closure	16	48.48
Skin graft	17	51.52
Donor site complications		
Graft loss	4	12.12
None	29	87.88

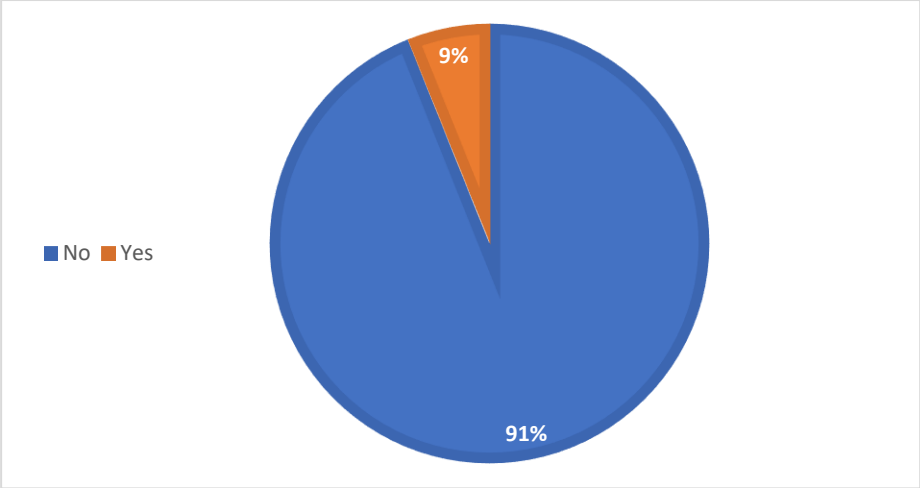

Figure 3: Post- operative complication outcome

Nine percent of patients experienced post - operation complications (two were vascular compromised, and one had flap dehiscence) (Figure 3). The flap failure rate was 6%.

Table 4 shows results for the ICU stay and hospital length of stay. Most of the patients stayed in ICU for 2 days (n=31, 93.94%) while only 2 (6.06%) stayed for a day in the ICU. The median hospital length of stay was 38 days with interquartile range of 34-44 days.

Table 4: ICU stay and total hospital length of stay

Variable	Frequency	Percentage
ICU stays		
1 day	2	6.06
2 days	31	93.94
Total length of stay		
Median (IQR)	38 (34-44) days	

The head and neck defects were due to ablation surgery which leave a complex defect requiring a large flap. As indicated in our results, most donor sites required a skin graft to close it. Usually, a flap size of >8cm require a skin graft to close it. The oral cavity was the highest presenting pathological anatomical area which is known for the complexity of the defects followed by the face, scalp then the neck. We had three patients (9%) with recipient site complications and 6% resulted in a total flap loss resulting in a flap survival rate of 94%. Primary closure of donor site healing was uneventful. Major donor site complications were observed in four cases (12%), with the most common being partial skin graft loss. The donor site complications were treated conservatively as per standard wound care management.

6. Discussion

The role of a reconstruction elevator in the head and neck reconstruction by using free tissue transfer has been firmly established. This led to the discovery of a variety of free flaps for head and neck reconstruction. However, the ALT flap possessed the workhorse attributes (no repositioning, versatile design, adequate soft tissue, composite tissue flap on one pedicle, constant anatomy, easy and safe to harvest, long pedicle, minimal donor site morbidity) as proven by multiple publications (21,22,23). The ALT flap is extremely versatile for a heterogeneous group of extensive soft tissue head and neck defects.

As evident from our study, ALT flaps were used over a range of head and neck defects at different sites and sub-sites, after oncological resection was done, followed by confirmation of clear margins by intra operative pathology. Regarding different anatomical sites: A. face defects: require an ALT with multiple compositions for the complex reconstruction. The diversity of ALT to be raised as a chimeric flap met the complex requirements. In multiple skin paddle or bi-paddling of the flap with a de-epithelialized segment, ALT provided lining and cover. In one case a commissure was replaced by harvesting an ALT with the tensor fascia lata (TFL) tunnelled and anchored over the zygoma. B. Neck contour defects: the ALT fat tissue replaced complex contour defects of the neck, with very thin ALT muscle included. It also provided cover for exposed vessels. C. Oral cavity defects: ALT provided bulk for the tongue and floor of mouth and was used

to provide the sulcus. D. Scalp defects: the long pedicle of the ALT was able to reach the recipient vessels. The large amount of soft tissue with the potential of thinning later, made it easy to cover the large calvarial defects.

We used the donor site closure as an indirect measure of the flap size harvested. The donor site with a width of >8cm, required a split thickness skin graft to close the site. In our study, 51% of the patients, required skin grafts to close the donor sites. Anticipated defect size can be estimated pre-operatively, but the final size is determined following the ablative surgery of the head and neck (21).

From our study, there are several points identified about raising ALT that are worth mentioning: Firstly, constant discussion with the tumour surgeons as they give an indication of the complexity of the defect, its composition and size. As these surgeons identified recipient vessels and thus assist in anticipating the length of pedicle required and the diameter of the vessels, especially the veins. In most cases we used couplers to anastomose the veins since we experienced discrepancy in the diameter of the veins. Secondly, capture as many perforators present within the flap, more than one perforator increases vascular reliability of the flap. Thirdly, always anastomose two veins. Fourthly, mark the one side of the pedicle so that the orientation of the vessels is correct. This prevents/minimizes the possibility of twisting, especially in a chimeric flap.

Admission to ICU after free flap reconstruction is considered routine by most head and neck surgeons. The ICU offers critical and close monitoring of the flap and of the patient's general
physiological state. The first 48-72hours are critical and needs to be closely monitored to identify any vascular compromise, which may lead to flap failure. The maximum period spend in ICU in our study was two days. We had two cases with vascular compromise resulting in an emergency theatre booking for a relook and with a 100% flap loss, and one case with flap dehiscence, debrided and secondary sutures done (24,25).

The fact that each patient has two ALT harvest sites, the choice between the left or right lies with the surgeon preference, the other site is a potential lifeboat. There are two outcomes with the donor site, primary closure, or skin graft. In our study 51% of donor sites required skin grafts. We experienced partial skin graft loss in four patients. They were all treated conservatively, and the sites had re-epithelised on discharge. Yoshiro Abe identified the following factors to contribute to a delay in wound healing: Raised BMI, smoking and skin graft. He suggested to avoid skin grafts in patients with the afore mentioned factors (23,26).

The median length of stay (LOS) in our study was 38days (Range: 34-44 days). Head and neck reconstructed defects are reported to have a variable LOS ranging from days to months (22). The following factors have been identified widely in studies investigating factors that contribute to LOS: pre-operative work-up (ASA score, pre and post- operative haemoglobin levels, pre- operative radiation, optimising

comorbidities and need for blood transfusion) and post-operative (speech and swallowing assessment, removal of tracheostomy, feeding assessments, monitor donor site, pre-radiation workup, formal histology report) (26). Although our flap failure rate was only 6%, the identified factors were the major contributors to LOS. Besides the financial impact LOS has on the health care system, it can also be an indirect measure of flap complications.

7. Conclusions

Our experience has given us the confidence to use the ALT flap in a variety of head and neck defects. The ALT flap is highly versatile, has high survival and low complication rates. Therefore, ALT has found a permanent and highly valued place in head and neck reconstruction.

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Appendix A: Ethics clearance certificate

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

11 February 2021
Person No: 684377
PAG

Dr LM Machaka
13 Great Britain Street
Turffontein
2190
South Africa

Dear Dr Leah Machaka

Master of Medicine in Plastic and Reconstructive Surgery: Approval of Title

We have pleasure in advising that your proposal entitled *Efficacy of Antero lateral thigh flap in head and neck reconstruction* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

Appendix B: Permission to do research from CMJAH CEO and Clinical Director

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

CHARLOTTE MAXEKE JOHANNESBURG ACADEMIC HOSPITAL (CMJAH)
Office of the Clinical Director

Enquiries: Ms. TT Mahlangu
Tel: (011) 488-3365
Email: Thandi.Mahlangu4@gauteng.gov.za
Physical Address: Room 262A,17 Jubilee, Parktown 2193 Postal Address: Private Bag x39, Johannesburg 2000

27 January 2021

To: Dr. L.M Machaka

RE: PROVISIONAL APPROVAL OF RESEACH STUDY

TITLE: EFFICACY OF ANTERO LATERAL THIGH FLAP IN HEAD AND NECK RECONSTRUCTION

Permission to conduct the above-mentioned study is provisionally granted subject to:

1. Submitting an Ethics Clearance Certificate from the University of Witwatersrand Human Research and Ethics Committee (HREC).
2. Submitting proof of registration on the National Health Research Database (NHRD).

Please submit the above documents at your earliest convenience for final approval to be granted. Please note that your study cannot commence until a final approval letter is issued.

Supported / ~~Not Supported~~

Dr J. Punwasi
Clinical Director
Date: 27/01/2021

Approved / Not Approved

Ms. G Bogoshi
Chief Executive Officer
Date: 29.01.2021

Appendix C: Plagarisim score report

a0039871:Machaka_for_Turnitin.docx

ORIGINALITY REPORT

10%	4%	9%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Chana, J.S.. "A review of the advantages of the anterolateral thigh flap in head and neck reconstruction", British Journal of Plastic Surgery, 200410 Publication	2%
2	Klaus-Dietrich Wolff, Frank Hölzle. "Raising of Microvascular Flaps", Springer Science and Business Media LLC, 2018 Publication	1%
3	www.thieme-connect.com Internet Source	1%
4	Karan D'Souza, Mathew Norman, Adam Greene, Colby J.F Finney et al. "PREDICTION OF MASSIVE TRANSFUSION WITH THE REVISED ASSESSMENT OF BLEEDING AND TRANSFUSION (RABT) SCORE AT CANADIAN LEVEL I TRAUMA CENTERS", Injury, 2022 Publication	1%
5	Breast Reconstruction, 2016. Publication	<1%
	Submitted to University of Witwatersrand	

6	Student Paper	<1 %
7	archotol.jamanetwork.com Internet Source	<1 %
8	K.M. Lee, S.-C. Eun. "Experimental Canine Facial Transplantation", Transplantation Proceedings, 2014 Publication	<1 %
9	Horn, Dominik, Rene Jonas, Michael Engel, Kolja Freier, Jürgen Hoffmann, and Christian Freudlsperger. "A comparison of free anterolateral thigh and latissimus dorsi flaps in soft tissue reconstruction of extensive defects in the head and neck region", Journal of Cranio-Maxillofacial Surgery, 2014. Publication	<1 %
10	Kao-Ping Chang, Ching-Hung Lai, Wen-Lung Liang, Chung-Sheng Lai, Sin-Daw Lin. "Alternative reconstruction of donor defect of free radial forearm flap in head and neck cancer", Journal of Plastic Surgery and Hand Surgery, 2010 Publication	<1 %
11	Michael Russell, Georgia Mackay, Ali Hooshyari, Juliette Arianna Meyer, Lomani O'Hagan, Isaac Cranshaw. "Racial and ethnic differences in abdominal soft tissue sarcoma	<1 %

	incidence in New Zealand: a retrospective audit", ANZ Journal of Surgery, 2021 Publication	
12	Craig S Brown, Nicholas H Osborne, Hsou M Hu, Dawn Coleman et al. "Endovascular surgery is not protective against new persistent opioid use development compared to open vascular surgery", Vascular, 2021 Publication	<1 %
13	Submitted to University of Hong Kong Student Paper	<1 %
14	www.mmj.eg.net Internet Source	<1 %
15	asrjetsjournal.org Internet Source	<1 %
16	"Raising of Microvascular Flaps", Springer Science and Business Media LLC, 2005 Publication	<1 %
17	Alaa Rahhal, Fadi Khir, Amer Hussien Aljundi, Yaser AlAhmad et al. "Clinical outcomes of high - intensity doses of atorvastatin in patients with acute coronary syndrome: A retrospective cohort study using real - world data", British Journal of Clinical Pharmacology, 2020 Publication	<1 %

18	Arik Zaretski, Fu-Chan Wei, Chih-Hung Lin, Ming-Huei Cheng, Chung-Kan Tsao, Christopher Glenn Wallace. "Anterolateral Thigh Perforator Flaps in Head and Neck Reconstruction", Seminars in Plastic Surgery, 2006 Publication	<1 %
19	Weitz, J., K. Kreutzer, F.J.M. Bauer, K.-D. Wolff, C.-P. Nobis, and M.R. Kesting. "Sandwich flaps as a feasible solution for the management of huge mandibular composite tissue defects", Journal of Cranio-Maxillofacial Surgery, 2015. Publication	<1 %
20	bmcpublichealth.biomedcentral.com Internet Source	<1 %
21	mdpi-res.com Internet Source	<1 %
22	Sung-Weon Choi. "An Anatomic Assessment on Perforators of the Lateral Circumflex Femoral Artery for Anterolateral Thigh Flap", Journal of Craniofacial Surgery, 07/2007 Publication	<1 %
23	Wolff, K.D.. "Indications for the vastus lateralis flap in oral and maxillofacial surgery", British Journal of Oral & Maxillofacial Surgery, 199810 Publication	<1 %

24	Marc W. Herr, Derrick T. Lin. "Microvascular Free Flaps in Skull Base Reconstruction", S. Karger AG, 2012 Publication	<1 %
25	Remco de Bree, Chris Hartley, Ludwig E. Smeele, Dirk J. Kuik, Jasper J. Quak, C Ren?? Leemans. "Evaluation of Donor Site Function and Morbidity of the Fasciocutaneous Radial Forearm Flap", The Laryngoscope, 2004 Publication	<1 %

Exclude quotes	On	Exclude matches	< 5 words
Exclude bibliography	On		

APPENDIX D: APPROVED PROTOCOL

CANDIDATE'S SURNAME: Machaka	FIRST NAME/S: Leah Mokgadi	STUDENT NUMBER: 684377

CURRENT QUALIFICATIONS: MBCHB			
TEL: (011) 434-2906	CELL: 0837048515	E-MAIL: drmachaka@gmail.com	FAX:

DEGREE FOR WHICH PROTOCOL IS BEING SUBMITTED:MMED		
PART-TIME OR FULL-TIME: Full time		
FIRST REGISTERED FOR THIS DEGREE: yes	TERM : 2nd semester	YEAR:3rd
DEPARTMENT: Plastic surgery		
TITLE OF PROPOSED RESEARCH: Efficacy of Anterolateral thigh flap in Head and Neck Reconstruction		
CANDIDATE'S SIGNATURE:		DATE: 30/08/2020
SUPERVISOR 1 (NAME & SURNAME): Prof Elias Ndobe		50% Supervision
SUPERVISOR'S QUALIFICATIONS: MBCHB , FCS(SA)Plast		
SUPERVISOR'S DEPARTMENT: Plastic surgery		
SUPERVISOR'S ADDRESS / TEL / E-MAIL: University of Witwatersrand Johannesburg. 7 York Rd, Parktown, Johannesburg, 2193. (011) 488-4911 (082) 415-6140 Elias.Ndobe@wits.ac.za		
SUPERVISOR 2 (NAME & SURNAME): Dr Marietha Nel		50% Supervision
SUPERVISOR'S QUALIFICATIONS : BSc, BSc Hon (Parmacol), MSc, PhD		
SUPERVISOR'S ADDRESS / TEL / E-MAIL: Cell: 079 858 5690 Email: marietha.nel@wits.ac.za		
SUPERVISOR 3 (NAME & SURNAME):		% Supervision

SUPERVISOR'S QUALIFICATIONS	
SUPERVISOR'S ADDRESS / TEL / E-MAIL:	

SYNOPSIS OF RESEARCH:*(Brief summary of proposed research project; between 200-300 words only; with sub-headings: an introduction and justification for study, aim/s, proposed methodology and expected outcome/s)*

[Use reverse side of this page if more space is required]

Background:

Head and neck defects commonly from excision of cancer, require complex reconstruction. Our reconstructive goals are aimed at achieving safety, form and function. Escalation to the highest option on the ladder of reconstruction is obligatory. With the discovery of free anterolateral thigh flaps (ALT), our reconstructive goals could be attained. ALT offered more to the reconstructive options than what it was initially described as. ALT not only gained popularity but also became the workhorse flap in head and neck reconstruction. Research has been done all over the world on the application of ALT, but nothing is reported from South Africa.

Aim:

We would like to share our experience on the efficacy of ALT in the Head and Neck Reconstruction Plastic Surgery Unit at the Charlotte Maxeke Johannesburg Academic Hospital.

Methods:

Retrospective study over a period of 5 years at CMJAH Head and neck unit. Analysis of head and neck reconstructed with an ALT.

Possible Outcomes:

We want to demonstrate the Effectiveness of ALT in head and neck reconstruction.

WITS ETHICS NOT REQUIRED:	Yes No	IF Y SUPPLY ETHICS CLEARANCE CERTIFICATE AS ATTACHMENT AND INCLUDE ETHICS NUMBER HERE:
WITS ETHICS PENDING:	Yes No	
WITS ETHICS APPROVED:	Yes No	
(circle appropriate symbol)*		

***Please note the final human ethics clearance certificate or animal ethics certificate must be available prior to starting research**		
As supervisor/s, I/we confirm that I have read the protocol which has been submitted for assessment.		
SIGNATURE OF SUPERVISOR/S:		
SIGNATURE PG OFFICE STAFF ……..	REGISTERED YES….. NO…..	STAMP

Efficacy of Antero Lateral Thigh Flap in Head and Neck Reconstruction

Introduction

Head and neck cancers still pose a formidable challenge to all specialties involved, but especially the plastic surgeon. Reconstruction of head and neck cancer requires intense planning, microsurgical skills and an appropriate flap that can restore both form and function (1).

With a global increase in head and neck cancer, the incidence in Africa according to the global data statistics analysis, has been attributed to smoking, westernization of lifestyle, diet, HIV/HPV, lack of access to health care facilities and unfavorable health policies while also taking into consideration the lack of data (under reporting) and poor data capturing (2,3).

Head and neck cancer has ranked 4th in South Africa and 90% of cases was found to be squamous cell carcinoma (4). In our setting most patients present with advanced disease which has become a major health care burden (2). Cultural believes, lack of education and poverty have been identified as a cause of delayed presentation (2). Surgical challenges with excision of tumors includes removal of the primary lesion and circumferential margin of healthy tissue leaving a mutilated disfigured organ. The dilemma is while trying to stay oncological radical, to preserve function, minimal aesthetic impact and psychological well-being of the patient (3).

The revolution of the flap has taken a superior turn from the 1970s and 1980s, from the use of pedicle flaps like deltopectoral-, pectoralis major- and latissimus dorsi flap (LDF) to microvascular free tissue transfer (5,6). Since inception of microvascular reconstruction the role of the pedicle flaps evolved into salvage flaps, mostly indicated for patients that cannot tolerate a lengthy operation or failed free flaps (1). Microvascular flaps offering reliable flap survival and more tailored tissue, has resulted in functional and cosmetic outcome far superior to those of pedicle flaps (5,6,7). However hypothermia, pressure injuries, prolonged procedure length and flap loss are risks associated with free tissue transfer (8,9).

A lot of consideration is required in flap selection, as they are tailored to each patient. Free flap transfer needs to have certain characteristics: sufficient tissue bulk, low

donor site morbidity, superior texture, versatility in shape, availability of diverse tissue types on one pedicle, a two team approach, long pedicle, possibility of innervation, constant anatomy for safe and easy flap rise (5,10,11). The aggressive resection of these tumors result in a paucity of local options resulting in free flaps becoming the modality of choice for reconstruction (5).

By chronological discovery of flaps the LDF was discovered in 1906 and popularized in 1970, while the free radial forearm flap (FRFF) was discovered in 1978. They were commonly used in head and neck reconstruction. FRFF was popular for its excellent pliability, ease of raising the flap especially for intra oral defects reconstruction (15) and LDF for large size defects, ability of raising with multiple skin paddle and voluminous tissue (10). Discovery of the anterolateral thigh flap (ALT) has become a permanent and highly valued option in head and neck surgery because of its resourcefulness (5,13). It offers many advantages required to reconstruct the defect, such as its versatility in design size, thin pliability by thinning immediately or delayed, or bulk if required, a long pedicle with suitable vessel diameter, is easy to harvest, use a two team approach, less donor site morbidity, and most importantly, is the patient's choice over FRFF and LDF (hidden scar) as documented by Brown *et al*., (13). Numerous reports from different centers including Wei *et al*., describing an ALT success rate of 95% (1,14), ALT is regarded as superior. The focus now is not on increasing the number of different flaps but to individualize the flap harvested from the donor site, with which the surgical team has experience (10). Indeed at CMJAH ALT has become the preferred donor site for soft tissue reconstruction in the Head and Neck Unit.

About ALT

Song and coworkers described three flaps from the thigh. The ALT, anterior medial thigh flap and the posterior thigh flap in 1984 (12). Of these three flaps, the ALT became the most popular.

ALT was initially described as a septocutaneous pedicle based on the descending branch of the lateral circumflex femoral artery, but variations occur where the branch will run through the vastus lateralis as a myocutaneous perforator and this expanded on the possibilities of raising ALT. The myocutaneous vastus lateralis flap was first described in 1987 by Drimmer and Krasna, while the first free myocutaneous vastus

lateralis flap was reported in 1992 by Wolff for oral cavity cover (13). With more experience with ALT, the indication for its use expanded.

Basing a large fasciocutaneous flap on a single perforator was described by Zhou *et al*., while ALT with a size ranging from 25-35cm became a popular complementary choice (13). The two team approach results in rapid flap raising simultaneously with tumor extirpation which decreases procedure time. This benefit has a tremendous advantageous effect on recipient site complications and reduction in primary reperfusion injury (6,8,9,10).

A study done in Germany on complications at both the recipient and donor sites on 1000 free flaps done including ALT, found that ALT had an acceptable low risk of complications (8,9). Townley *et al*., in a retrospective study done on 100 patients post- ALT, found that there was minimal donor site morbidity when assessing function, sensation and the aesthetically acceptable hidden scar. In a comparative study on the donor site and the contralateral thigh, there was no loss of quadriceps function, although change in sensation was reported but it was statistically insignificant (3,7).

The ability to raise an ALT flap on multiple perforators gave birth to chimeric ALT, offering an advantage of multiple skin paddle, fascia and muscle component from the vastus lateralis, all on the same pedicle (14). Chimeric flap was an option in defects that required volume re-placement and also in slim patients with not enough bulk (3). Other uses have been documented in cheek defects and total glossectomy (19). Chimeric ALT also solve the problem of deficient recipient vessels due to extensive dissection or post radiation as it only requires one pair of recipient vessels. Furthermore, chimeric flaps are useful in protection of the pedicle (3) preventing orocutaneous fistulas and carotid blowout syndrome (14). A study carried out in 34 patients using ALT in intra oral defects confirmed recovery of function such as linguistic, chewing and swallowing (5,15).

Flap bulk is known as one of the disadvantages of ALT but has found use in patients that require post-operative radiation. Initially the wound appears excessively bulky (11), but it settles to an appropriate size after radiation. In such cases where FRFF was an appropriate flap post-radiation, the recipient site would require volume

restoration with fat grafting (1). Thinning of the ALT flap, which creates an alternative for intra oral cover was introduced by Kimura in 1995 (13). Thinning is advantageous in obese patients with excess subcutaneous fat that would make ALT an undesirable choice of flap. Although secondary thinning is possible it carries extra economic burden on both surgeon and patient (14). The possibility of thinning offered the advantage of a FRFF without donor site morbidity, while being cost effective. However, preservation of the subdermal plexus is a prerequisite for a successful thinning, which means that minimal flap thickness must not be less than 4mm (18).

ALT is useful in near or total circumferential cervical esophagus defects. Managing to cover the pharyngo-esophagus and neck defects with two skin paddles. Initially, the jejunum was the flap of choice in such cases. Avoidance of laparotomy and the possibility of creating intra-abdominal complications are benefits of choosing an ALT flap over the jejunum. However, studies have proven that fasciocutaneous flaps provide superior speech rehabilitation compared with an intestinal flap (5).

ALT has replaced the use of FRFF which was commonly used in head and neck defects notwithstanding its usefulness in recipient site reconstruction (5). FRFF carried a tell-tale sign at the donor site, and sacrificing important vessels rendered it undesirable (10). Regardless of LDF creating a favorable donor site, the inability to use a two team approach was a major disadvantage (10,14). FRFF was popular for tongue reconstruction, but in a comparison study of ALT and FRFF, no functional difference in terms of speech and swallowing was found in patients who had a glossectomy (5,14,15). The advantage of ALT over FRFF was the donor site morbidity such as cosmetics and sensitivity (7). Universally ALT and LDF are the two most versatile options for extensive soft tissue defects to replace the volume loss in head and neck reconstruction. A comparison study by Koshima and coworkers on ALT and LDF in head and neck reconstruction, confirmed many similarities, with the two variables that showed a marginal difference being the success rate of 91% for LDF and 93% for ALT, and the donor site morbidity of 9% for LDF and 7% for ALT (16). Although LDF and FRFF still remains in the repertoire of microsurgeons, the failure of the two team approach and the donor site morbidity has outweighed the advantages shared with ALT. In 2002, two studies were published one by Wei *et al.,* on 672 ALT cases, with only 2% total failure and 3% partial failure reported, and the

other by Gedbou and Wei on the efficiency of ALT in head and neck soft tissue cover on 1 280 cases.

Complexity of head and neck defects has led to a quest of discovering a flap that will meet the demands of the defect to restore form and function. McCraw and Dibbell (1967), shared the desire to discover or describe a new flap every year (20). The new approach of individualizing a donor site for flap harvesting has led to identifying the anterolateral thigh as an ideal donor site for head and neck reconstruction. ALT offers a large flap with different tissue composition and reduced donor site morbidity, while providing results that are equal or superior to a more traditional approach to head and neck defects. It has also contributed to pre-operative brain storming from which flap will be ideal for the defect to which tissue composition is required from the donor site to cover the specific head and neck defect.

With head and neck cancer ranking 4th in South Africa, it is important to investigate the value of using the ALT in the reconstruction procedure. Such data is although scarce, available internationally, but not at all for South Africa.

Aim

To evaluate the efficacy of ALT in head and neck reconstruction at CMJAH in South Africa.

Study Objectives

- To review all ALT head and neck reconstructions.
- To determine indication for ALT.
- To determine size of flap raised.
- To determine percentage of flap survival.
- To determine donor site morbidity.
- To determine length of hospital stay.

Method

Design - This is a retrospective study on head and neck reconstruction with ALT.

Site of study – Department of Plastic Surgery Head and Neck Unit at CMJAH.

Study Population – Records of patients who had head and neck reconstruction with ALT.

Sample size – Our study sample will include all head and neck defects over a period of 5 years (1/01/2014 - 31/12/2019) at CMJAH, focusing on only the head and neck defects reconstructed with ALT that meets the inclusion criteria. Data available is estimated to be ± 100 patients in total of which ALT reconstructions are estimated to be ± 30 cases and the other ± 70 cases reconstructed with another type of flap or defects primarily closed.

Inclusion criteria –

- All head and neck cases reconstructed with ALT at CMJAH.
- Adults > 18yrs
- Medically fit to withstand a lengthy operation
- Patients with controlled medical conditions

Exclusion Criteria –

- Small defects of head and neck that are closed primarily.
- Reconstruction with ALT in extremities.
- Patients with psychiatric conditions.

Measuring tools or instruments:

- Flap survival based on clinical assessment, number of relooks and duration of hospital stay.
- Data collection – Hospital records on head and neck reconstruction with ALT.
- Data collected will be entered into an Excel spread sheet in Windows 10. Categorical data will be expressed in percentages. Mean and standard deviation will be used as a measure of central tendency, if the data is normally distributed. The Fisher's exact test will be used to compare categorical data. For continuous data the student t-test will be used. The level of significance will be set at a p-value of 0.05.

Ethics

- Permission to conduct the study will be sought from the Human Research Ethics Committee (HREC) (medical) of the University of the Witwatersrand and the Research Board of the CMJAH.
- Patient anonymity will be ensured by giving each patient record only a study number without recording any patient identifiers.
- Collected data will be kept in a safe place only accessible to the researcher.

Funding/Budget

- There will be no cost implications to the hospital, any stationary costs will be covered by the researcher.

Problems anticipated

- There might be some difficulty in finding patient's records, incomplete records and difficulty in deciphering hand writing.

Data collection sheet.

1. Patient study number:
2. Diagnosis:
3. Age in years:
4. Gender: M/F
5. Comorbidities:
6. Smoker: Y/N
7. Date of operation:
8. Anatomical units involved:
9. Type of operation :
10. Defect size:
11. Site of ALT: L/R
12. ALT size:
13. Donor site : Primarily closed or skin graft
14. Duration of operation:
15. Post Operation ICU care: Y/N
16. Length of stay in ICU:
17. Post operation complications:
18. Donor site complications:

19. Length of hospital stay:

Timeline of activities

Process 2020-2021	Jul	Aug	Sep	Oct	Nov	Jan	Feb	Aug	Sep	Oct
Project idea	**X**									
Literature review	**X**	**X**								
Preparing protocol		**X**	**X**							
Protocol deadline				14/10/20						
Protocol Assessment					11/11/20					
Ethics application				31/10/20						
Collection data					**X**	**X**				
Data analysis							**X**	**X**		
Writing up – report								**X**	**X**	
Report submission										**X**
Finalise/submit -publication										**X**

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5. Vaughan ED. Functional outcomes of free tissue transfer in head and neck cancer.Oral oncology 2009; 45:421-430.

6. Potter JK, Osborn TM. Preparation of the neck for microvascular reconstruction of the head and neck. Oral maxillofacial surgery clinics of North America 2008; 20:521-526.

7. Townley WA, Royston EC, Karmiris N, Crick A, Dunn RLR. Critical assessment of the anterolateral thigh flap donor site. J Plast Reconstr Aesthetic Surg [Internet]. 2011;64(12):1621–6. Available from: http://dx.doi.org/10.1016/j.bjps.2011.07.015

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