



RESEARCH ARTICLE

Technique selection in transfemoral amputation surgery – an interview study among surgeons

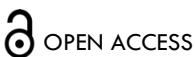
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OPEN ACCESS

PUBLISHED

31 July 2024

CITATION

Schelhaas, R., van Kammen, K., et al., 2024. Technique selection in transfemoral amputation surgery – an interview study among surgeons. *Medical Research Archives*, [online] 12(7). <https://doi.org/10.18103/mra.v12i7.5459>

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DOI

<https://doi.org/10.18103/mra.v12i7.5459>

ISSN

2375-1924

ABSTRACT

Background: In transfemoral amputation surgery, two surgical techniques can be used to secure the transected muscles in the residual limb: myodesis and myoplasty. A scientific basis for determining which surgical technique to use is still lacking. Furthermore, little is known about the circumstances in which surgeons select one technique over the other and the reasons behind their choices. Therefore, this qualitative interview study aims to explore the current practices, influencing factors and decision-making in surgical technique selection in transfemoral amputation surgery.

Methods: Individual, semi-structured interviews were conducted with vascular, orthopedic, and trauma surgeons. Recruitment was purposefully aiming to include surgeons with varying age, gender, surgical specialism, workplace and nationality. Data was analyzed using the Applied Thematic Analysis approach.

Results: Twenty-three surgeons were interviewed. Variation was found in the way surgeons described and applied myodesis and myoplasty. Differences existed for example in which muscles were reattached, how these muscles were reattached, and the position of the hip during muscle fixation. Myodesis was mainly chosen for its potential favorable outcomes, like preventing femur deviation and improving function, while myoplasty was often chosen for practical reasons, like sticking to what was learned, reducing the number of surgical actions involved and minimizing operation time. Moreover, conflicting perspectives existed about the possible advantages and disadvantages of both techniques and whether or not to use a myodesis in the older, more fragile patients. The lack of research and patient follow-ups were mentioned to influence technique selection, along with factors such as the personal experience and training of the surgeon, surgical practices of peers, observed outcomes and patient feedback, and the characteristics of the treated patient population.

Conclusion: This research reveals great variation in technique descriptions and surgical practices in transfemoral amputation surgery. Surgeons have diverse opinions and rationales for the use of myodesis and myoplasty, reflecting varying approaches and preferences in their clinical practice. The findings underscore the lack of evidence to support current choices in surgical technique selection in transfemoral amputation surgery and highlight the need for further research on the advantages and disadvantages of both techniques to provide surgeons with evidence-based recommendations.

Introduction

Yearly around 3.300 individuals in the Netherlands (18 million people) have to undergo a lower limb amputation, of which 20% are at transfemoral level.¹ A transfemoral amputation (TFA) includes any amputation above the knee and below the hip, and is necessitated by conditions such as ischemia and diabetes (~95%) and oncological diseases, infections, and trauma (~5%).^{1,2} A TFA has a large impact on someone's life, greatly affects an individual's mobility,³ and is known for high rates of perioperative morbidity and mortality.⁴ In order to optimize patient and rehabilitation outcomes, selection of the optimal surgical procedure plays an important role, serving in most cases as the starting point for rehabilitation and improving someone's physical well-being.⁵ Moreover, optimizing surgical procedures could reduce risks associated with stump-related issues such as impaired wound healing and hematoma formation, thereby reducing the likelihood of re-amputations.⁴ Although TFA surgery involves various decisions like the applied technique for muscle reattachment, the femur length, and hip positioning during muscle fixation, little is known about current practices and the (reasons for) technique selection in TFA surgery.

Two surgical techniques regarding TFA are distinguished to reattach the transected muscles in the residual limb: 1) the distal end of the muscles can be sutured to the bone through myodesis by the use of drill holes and pass through sutures, or 2) the muscles can be sutured to the antagonistic muscle group through myoplasty, without fixation to the bone.⁶ The choice for either of these techniques may influence surgical outcomes such as residual limb functionality, wound healing and the occurrence of flexion and abduction deviations of the femur.^{2,6-8} In the past decades, only a limited number of studies investigated the differences between myodesis and myoplasty in TFA. A systematic review and narrative synthesis found myodesis as the most prevalently described technique, with the potential to improve muscle function and rehabilitation.⁹ Potential benefits that were reported included maintaining the femoral alignment, preserving muscle function, and improving postoperative ambulation.⁹ However, included resources (e.g. literature, textbooks, videos) describing these benefits lacked patient outcomes or direct comparisons between myodesis and myoplasty. Only one study compared both techniques, reporting less intermuscular fat in the myodesised muscles of two patients.¹⁰ Due to the predominantly descriptive nature of the available studies, the low level of evidence, and the lack of comparisons between myodesis and myoplasty, a scientific basis for determining which surgical technique to use is still lacking.

In line with the limited evidence, most guidelines on amputation surgery provide no recommendations on the choice for either of the two techniques in TFA. For example, the Global Vascular Guidelines on the Management of Chronic Limb-Threatening Ischemia state that both procedures can be used.¹⁰ Furthermore, the Dutch guidelines on Amputation and Prosthetics of the Lower Extremity do not specify which surgical technique should be used in TFA surgery,¹¹ and neither do the Guidelines for Rehabilitation of Lower Limb Amputation

of the United States.¹² The British guidelines, however, advise to use a lateral myodesis in TFAs for improved alignment,¹³ and base this on the surgical technique description and retrospective observations of Gottschalk.² Medical textbooks also describe both surgical techniques,^{1,6,14,15} sometimes expressing a preference for myodesis⁶ or myoplasty,¹⁶ and sometimes remaining neutral.^{1,14,15}

Given the diversity in recommendations provided by textbooks and guidelines, it is expected that both techniques are currently used. However, little is known about which technique is selected in which situation, and for what reasons. To the best of our knowledge only one study examined surgeons' perspectives on surgical technique selection in TFA surgery.¹⁷ This study revealed that surgeons primarily based their technique selection on training from their supervisors and personal experiences.¹⁷ Interestingly, all surgeons mentioned the influence of a patient's age when it comes to technique selection, and the chance of a patient to regain the ability to walk after surgery. Myodesis was preferred in younger patients, while myoplasty was more commonly used in older patients with vascular problems.¹⁷ However, the study had a limited scope, encompassing only four surgeons from a single University Medical Center in the Netherlands, which means that knowledge on the current use of practice on a national and international scale is still lacking.

This study aims to explore current practices, influencing factors and decision-making in surgical technique selection in TFA surgery, by conducting semi-structured interviews with a diverse group of experienced surgeons from various nationalities. The findings of this research will provide insight into the individual motives of surgeons and will be a first step in providing evidence based surgical recommendations to optimize patient and rehabilitation outcomes following TFA.

Methods

A qualitative study with semi-structured interviews was conducted. The Medical Ethical committee of the University Medical Center Groningen (UMCG) in the Netherlands concluded that the study was not a clinical research with human subjects as meant in the Medical Research Involving Human Subjects Act (WMO). Approval by a Medical Ethical committee was therefore not required (METc 2023/152). The study was conducted according to the Declaration of Helsinki (October 2013)¹⁸ and was reported in accordance with the Standards for Reporting Qualitative Research (SRQR).¹⁹

PARTICIPANTS

Surgeons were recruited purposefully through the use of the authors' networks consisting of various medical specializations, aiming to include surgeons with varying age, gender, surgical specialism, workplace and nationality. A heterogeneous group of surgeons was selected to obtain a comprehensive view of current practices and to capture a broad range of perspectives and opinions. Potential participants were approached by email between March 2023 and October 2023. Surgeons were found eligible to participate if they had at least 5 years of experience with performing TFA

surgery. With this, we aimed to include surgeons with sufficient experience, thereby providing them the opportunity to reflect from their own perspectives. Written informed consent was obtained before surgeons participated in the study. Sampling continued until data saturation was reached.

STUDY PROCEDURES AND DATA COLLECTION

Individual semi-structured interviews were conducted between April 2023 and October 2023. Interviews were conducted by one of the researchers (RS), who was unacquainted to any of the participants beforehand. The interviewer, holding a Master's degree in Human Movement Sciences without any linkage to specific surgical specialisms, approached the interviews with an open mind and without any presuppositions, ensuring unbiased interactions. Prior to the start of the interviews, the interviewer was trained in performing qualitative research. The semi-structured interview guide (Appendix A) was developed by the first author (RS) and was revised after discussion with all co-authors. Accordingly, the interview guide was pilot tested twice with two experienced surgeons (co-authors PJ & JPdV) and was adjusted before starting data collection.

The interviews lasted approximately 30 minutes and took place at the office of the surgeon or online via Microsoft (MS) Teams (version 1.6.00). Each interview followed a semi-structured interview guide that contained questions about the surgical technique the surgeon uses, the choices the surgeon makes in the selection of one of the two techniques, factors that influence these choices, and any advantages and disadvantages the surgeon experiences (Appendix A). At the start of the interview, questions were asked about participant characteristics such as age, surgical experience, the surgical specialism and the type of hospital (teaching, university or local) where the surgeon was working.

Interviews were recorded with a voice recorder (Philips DVT2510) or with Microsoft (MS) Teams and were transcribed verbatim (by RS). Data that could directly identify the participants was stored at a safe location and only accessible for the researcher (RS). Pseudonymized data were used for further analysis. Participants received their transcripts so that they could check for any adjustments, difference in interpretations or misunderstandings.

DATA ANALYSIS

The qualitative data was analyzed using the Applied Thematic Analysis approach, which is a systematic, inductive method to identify themes from the data in a transparent and credible way.²⁰ This approach aims to

capture participants' perspectives and experiences as accurately and comprehensively as possible.²⁰ The study followed a positivist research paradigm, which assumes that there is a certain reality in the data, requiring statements and claims to be supported by evidence from the data itself. This means that interpretations were derived directly from the data and that data collection and analysis were transparent and systematic. The data analysis followed an iterative process consisting of the steps described by Guest et al (2012)²⁰ using ATLAS.ti software (ATLAS.ti version 22.2.5.0 Scientific Software GmbH, Berlin, Germany). The researcher (RS) read and reread the transcripts; potential themes were proposed bearing the analytic objectives in mind; themes were refined into codes with well-developed definitions and were listed in a codebook. The themes and codebook were adjusted throughout the analysis of the transcripts. Furthermore, to avoid conflation of participants' statements with the researcher's interpretation, the coding was periodically re-checked and four randomly selected interviews were double coded by co-author KvK. Discrepancies in code application were resolved through discussion and the codebook was updated accordingly. Interviews were coded in English, and Dutch quotes were translated into English for publication.

Results

Of the 35 contacted surgeons eventually 23 were interviewed. Reasons for not participating were no response to the invitation (n=7), forwarding the invitation to colleagues (n=2), no interest (n=1), not having performed a TFA for a long time (n=1), and being a junior trainee (n=1). After conducting 20 interviews, no new themes or insights relevant to the research question had emerged, indicating that data saturation had been reached. Consequently, data sampling was concluded after a total of 23 interviews, and no further emails or reminders were sent. A full overview of the 23 participant characteristics are listed in Table 1. Ten orthopedic surgeons, 10 vascular surgeons and three trauma surgeons were interviewed. Age ranged from 38 to 74 years. Surgeons had 6 to 43 years of experience with performing TFAs and performed 2 to 30 TFAs per year. Two surgeons were recently retired (<2 years). Sixteen surgeons were based in the Netherlands, two in Germany, and one each in Norway, the United Kingdom of Great Britain and Northern Ireland, Sweden, Italy, and the USA. Seven surgeons used myodesis, nine surgeons used myoplasty, and seven surgeons used both techniques. Myodesis was mostly performed by orthopedic surgeons, while myoplasty was mostly performed by vascular surgeons. The three interviewed trauma surgeons used both techniques. Mean duration of the interviews was 32.5 ± 8.5 minutes.

Table 1: Participant characteristics (n = 23)

Participant	Gender (F/M)	Surgical specialism	Experience with TFAs (years)	Primary treated indications for TFA	Used technique	Country
O1	M	orthopedic	25	Oncology	myodesis	NLD
O2	M	orthopedic	10	Oncology, infections	myodesis	NLD
O3	M	orthopedic	18	Oncology (children)	myodesis	NLD
O4	M	orthopedic	42	Vascular, trauma, congenital	myodesis	USA
O5	M	orthopedic	20	Oncology, infections	myoplasty	ITA

Participant	Gender (F/M)	Surgical specialism	Experience with TFAs (years)	Primary treated indications for TFA	Used technique	Country
O6	M	orthopedic	20	Oncology	both	NLD
O7	F	orthopedic	20	Oncology, diabetic, vascular	both	DEU
O8	M	orthopedic	40	Vascular, trauma	both	SWE
O9	M	orthopedic	6	Oncology	both	DEU
O10	F	orthopedic	7	Oncology	both	NLD
V1	M	vascular	17	Vascular	myodesis	NOR
V2	M	vascular	15	Vascular or diabetic	myodesis	NLD
V3	M	vascular	43	Vascular	myoplasty	NLD
V4	M	vascular	12	Vascular	myoplasty	NLD
V5	M	vascular	8	Vascular	myoplasty	NLD
V6	M	vascular	27	Vascular	myoplasty	NLD
V7	M	vascular	10	Vascular or diabetic	myoplasty	NLD
V8	F	vascular	20	Vascular or diabetic	myoplasty	NLD
V9	M	vascular	18	Vascular	myoplasty	NLD
V10	M	vascular	27	Vascular	both	GBR
T1	M	trauma	22	Trauma	myodesis	NLD
T2	M	trauma	19	Trauma	myoplasty	NLD
T3	M	trauma	15	Trauma	both	NLD

O1-O10: orthopedic surgeons, V1-V10: vascular surgeons, T1-T3: trauma surgeons, F: Female, M: Male, NLD: the Netherlands, NOR: Norway, GBR: United Kingdom of Great Britain and Northern Ireland, DEU: Germany, SWE: Sweden, USA: United States of America, ITA: Italy

Five themes were generated from the data: 1) Variation in technique descriptions and surgical practices, 2) Practical and outcome related reasons to use a myodesis or myoplasty, 3) Factors influencing technique selection, 4) Decision-making factors to decide whether to use a myodesis or myoplasty as indicated by surgeons who use both techniques, and 5) Surgeons' willingness to change and the requirements to initiate this.

VARIATION IN TECHNIQUE DESCRIPTIONS AND SURGICAL PRACTICES

Surgeons described various surgical techniques to reattach the muscles in the residual limb. Although a rough distinction was made between myodesis and myoplasty, variation existed in the way surgeons defined these techniques. The group of surgeons who used a myodesis

described techniques varying from only attaching specific muscle groups to the bone, to attaching all muscle groups to the bone (Table 2). The adductor myodesis was mentioned most often (n=6), which was described as the technique in which the adductor muscles were brought over the end of the femur to be sutured to the lateral side of the bone. Furthermore, among the surgeons who used a myoplasty, some surgeons explained closing the muscles around the end of the femur in layers, also paying attention to the deeper layer of muscles, while others mentioned to only stitch the fascia together (Table 3). Please note that adding up the number of surgeons in Table 2 and 3 does not yield the total number of interviewed surgeons, as some surgeons described multiple techniques or used both myodesis and myoplasty.

Table 2: Technique descriptions myodesis

Described technique	Muscle groups that are attached to the bone	Drill hole location	No. of drill holes	No. of surgeons using this technique
Adductor myodesis	Hip adductors	Lateral	2	6
Fixation of all muscle groups	Hip adductors, quadriceps, hamstrings	Anterior, posterior, lateral, medial	4-5	4
Flexor myodesis	Quadriceps	Anterior, posterior	2-3	2
Fixation of patella on femur*	Quadriceps	NA	0	2*
Not specified				2

* This applies solely to cases of very distal TFAs, just above the femoral condyles. For more proximal TFAs, the technique descriptions provided by these two surgeons are included in the other categories.

Table 3: Technique descriptions myoplasty

Described technique	Muscle groups involved	No. of surgeons using this technique
Stitching muscles and fascia in layers	Anterior and posterior muscle groups*	10
Fixation of fascia	Fascia of the anterior and posterior muscles	4
Not specified		2

* Adductor muscles were also taken together with the anterior and posterior muscle groups, but were not explicitly identified

Among the surgical technique descriptions that were given, the biggest difference between myodesis and myoplasty was seen in whether or not surgeons reattached the adductor muscles. Ten out of the fourteen surgeons who used a myodesis mentioned the process of locating and isolating the adductor muscles, and fixating them either to the bone or to the other muscles already attached to the bone. However, the majority of surgeons using myoplasty (9 out of 16) mentioned to not specifically identify the adductor muscles, and to take them together with the other muscle groups or leaving them unattached.

V9: *“And then there’s always the question, what do you do with the adductors? And I don’t do anything with them. I know that theoretically, you could get a kind of abduction contracture, but I’ve never seen that in practice, so I’m not really worried about that.”*

Another variation in surgical practices was the hip positioning during fixation of the muscles. Nine surgeons, of whom seven performed a myoplasty, mentioned to hold the hip flexed while attaching the muscles in the residual limb. This flexed position varied from slightly lifting the residual limb off the operating table, to placing a bolster below the thigh with hip flexion angles ranging from 30 to 45 degrees. Fourteen surgeons mentioned to have the residual limb in neutral position. Six of these surgeons performed myodesis, three performed myoplasty and five used both techniques. Two surgeons explicitly mentioned to place a bolster below the buttock to make sure the hip is elevated, resulting in a bit of hip extension and the possibility to close with the hip in neutral position. While some surgeons were convinced that securing the muscles with a flexed hip would be harmless, others argued that it could lead to the onset of hip flexion contractures.

O3: *“Yes, you have to make sure that you don’t fixate it with the hip in flexion, because then, of course, you’ve already made your first contracture.”*

Other variations in surgical practices were seen in drain use, management of the nerves, and the use of diathermy. Whereas five surgeons advocated for the use of a drain

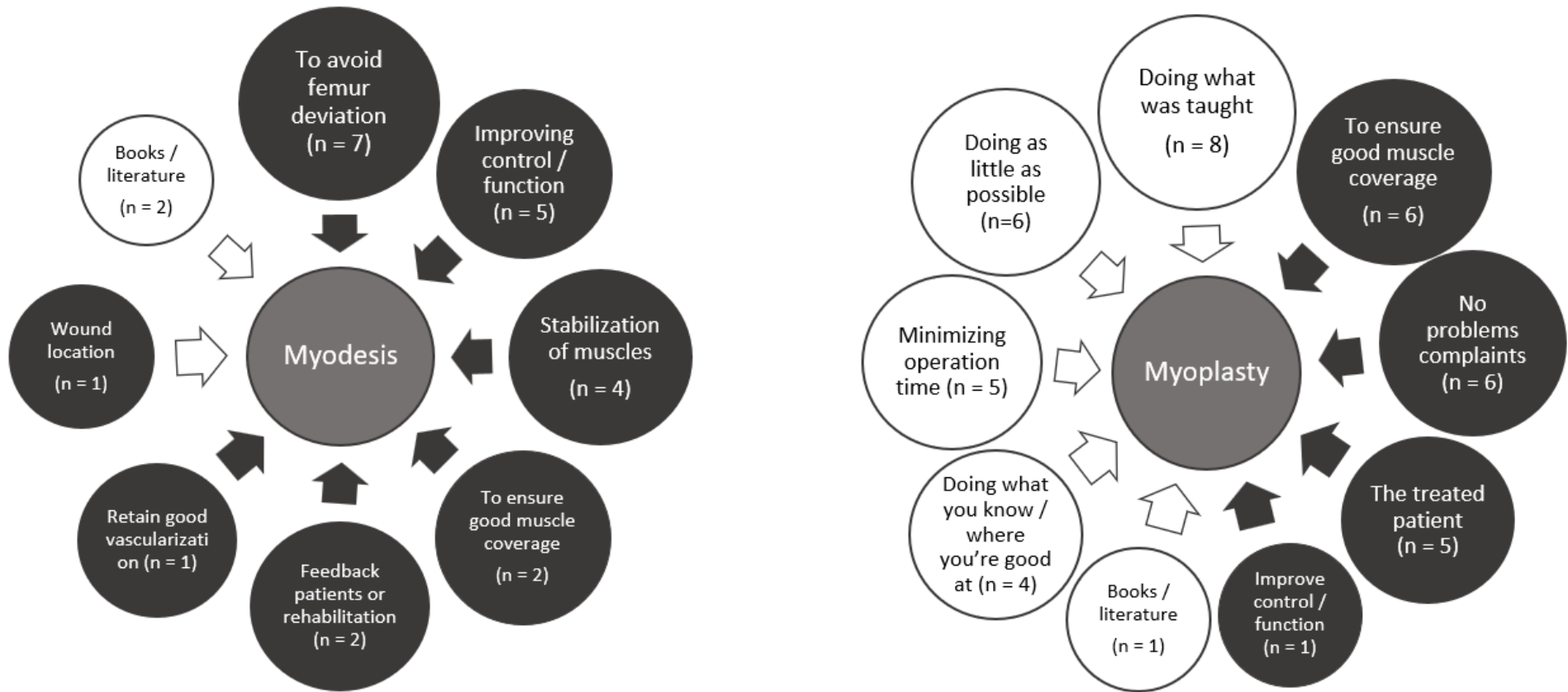
to prevent hematoma formation, four surgeons mentioned to never use a drain, and one surgeon mentioned occasional use. Regarding the management of the nerves, variations existed in whether or not surgeons ligated the nerve, placed a nerve sheet catheter, or infiltrated the nerve with a local anesthetic. However, surgeons’ practices were similar when it came to dissecting the nerve as high as possible, under traction. Regarding the use of diathermy, five surgeons mentioned to use diathermy for muscle and/or nerve dissection, while three surgeons explicitly mentioned to avoid the use of diathermy to minimize tissue damage.

Apart from the variations in surgical practices, all surgeons indicated they want to keep the femur of the residual limb as long as possible. Most surgeons who specified this, described transection of the femur a hand’s width or 10-12 cm above the femoral condyles, where the femur narrows from metaphysis to diaphysis. Furthermore, without explicitly asking, the majority (n = 15) of surgeons mentioned the importance of a good muscle coverage of the bone end, and closing without too much tension, to prevent protrusion of the femur.

PRACTICAL AND OUTCOME RELATED REASONS TO USE A MYODESIS OR MYOPLASTY

Surgeons had different reasons for using a myodesis or myoplasty (Figure 1). The most mentioned reasons to use a myodesis were to avoid deviation or movement of the femur within the residual limb (n=7), to improve control and functioning of the residual limb (n=5), and to ensure a stable fixation of the muscles around the femur (n=4).

O8 *“Well, the advantages of the Frank Gottschalk [myodesis] method is that you get good control of the femur. So that when you have a prosthesis, you can rely on that, you can maneuver the femur within the stump [residual limb]. And if you don’t make a myodesis, the femur will move all around, so to say. And since the strong muscles are up on the trochanter major, they will tend to make an abduction and you will have a problem with the femur going on the lateral wall of your stump [residual limb], uncontrolled so to say. So that’s the reason to use a myodesis.”*



- Outcome related reasons
- Practical reasons

Figure 1: Reasons to use a myodesis or myoplasty

The most common reason to use a myoplasty was because surgeons were taught so (n=8). Other reasons that were mentioned were: to do as little as possible (n=6), to ensure good muscle coverage (n=6), and to minimize operation time (n=5). Furthermore, surgeons mentioned that they did not experience problems or received any complaints that would make them change their technique (n=6).

O5 *"It [Myoplasty] is a bit faster and simpler I think. I think that's the main reason. I also feel that I'd be better off covering my residual limb with muscle tissue, so that I am a bit more guaranteed to have a well-wrapped bone end, so to speak."*

V7 *"At some point you have mastered a technique and you see that everyone around you is also doing that technique and if you don't really see problems with that, you don't have the tendency to change it."*

Lastly, the inactive and often frail patient population treated was mentioned as a reason for using myoplasty (n=5). According to some surgeons there are less functional demands for the residual limb of these patients and the operating time should be minimized.

V6 *"Well, a very large proportion of patients who must have an amputation in vascular surgery, and especially those who have a transfemoral amputation, they are, not always, but often very severe patients of which a very large part, I think one-third, a year later is no longer alive. So yes, those [patients] are very often nursing home patients. Not all of them though, but we might also have the idea that there aren't a lot of requirements for that stump [residual limb]. So that could also be another factor why we do this [myoplasty] technique more often."*

This reason was however not supported by everyone. Four surgeons who also treated vascular patients explicitly opted for myodesis, even in the older, more fragile patients, because they believed that a myodesis yield better outcomes than a myoplasty following a TFA. V2 *"I believe that when you fix it [the muscles] with a myodesis, the likelihood that you [the patient] will spend the rest of your life in bed with your leg elevated is reduced. So I think someone deserves to get a myodesis, it only takes me an extra two minutes."*

One surgeon even highlighted a specific advantage of myodesis in vascular patients. He noted that, when combined with an adductor flap, myodesis better preserves the obturator vessels compared to the traditional anterior/posterior flaps, where the adductor is detached.

FACTORS INFLUENCING TECHNIQUE SELECTION

Identified factors that influence technique selection included 1) the personal experience of the surgeon, 2) surgical training and practices of supervisors, 3) surgical practices of peers, 4) observed outcomes and patient feedback, 5) research and evidence, and 6) the characteristics of the treated patient population. The influence of the personal experience aligns with the reason mentioned in Figure 1: "Doing what you know / where you are good at". Surgeons tend to favor the technique they are most familiar with or feel most confident about. This was also indicated by some

surgeons who mentioned that they don't know how to perform a myodesis.

V6: *"Yes, a lot needs to happen to make me change my technique, but I'm open to that. I do have to look up how to do it [a myodesis] then."*

Five surgeons who were initially trained in using myoplasty later adjusted their practices to incorporate myodesis, based on their subsequent learning and observed patient outcomes. Three surgeons mentioned that after learning from Gottschalks technique⁸ and observing results, they were convinced to use a myodesis, also in vascular patients. The two other surgeons who adjusted their techniques mentioned to have shifted from myoplasty to myodesis based on their observed outcomes. This underscores the influences of surgical practices of peers and supervisors, and the feedback from patients.

O4: *"After learning of his [Gottschalks] technique and observing the patients, I was thoroughly convinced that he was right ... My bias is I follow those patients, so I know what the outcomes are of my patients and that's one of the reasons why I changed from my training, learning to do the classic [myoplasty] technique, and switching to the adductor technique because the outcomes, certainly my observed outcomes, are much better."*

On the other hand, some surgeons continued performing myoplasty because they did not observe any problems or differences within their patients.

O9: *"My patients are also very well cared for when I do a myoplasty and they also have no problems with prosthesis care afterwards, so then you think: Why should I? Why would I do it differently? That's kind of it."*

Aforementioned quotes show that some surgeons (n=10) followed their patients post-TFA and observed their outcomes. However, six surgeons explicitly mentioned to not routinely follow-up on their patients after a TFA, since it is not part of standard care, with patients typically being referred to rehabilitation centers or nursing homes. This lack of feedback from patients was also seen as an influencing factor guiding technique selection, since surgeons do not see the results of their actions.

V8: *"And the contracture, yes I think it is something you do see, but what is not really a problem I think. But again, we don't see the patients afterwards and we certainly don't follow them up in the long term, so I can't – or shouldn't – really judge that."*

The lack of patient follow-ups or reflecting on a surgeons' own actions is as a big problem according to some surgeons.

O4: *"I'm biased in favor of the adductor myodesis, and my answer is, to the person who does the classic anterior posterior flaps, my response is they likely don't follow the patients. They send the patients to the rehabilitation doctor and don't follow them. My bias is I follow those patients, so I know what the outcomes are."*

V1: *"Because many of us are not good at reflecting at all, they don't think about improving. They don't reflect about what they do. I remember as a young surgeon when I asked a superior surgeon why do you do it like that? ... And the worst answer I could get was "Because I always have done it this way". That is a very bad answer because you haven't*

reflected why you do it, you just do it because somebody showed you to do that and that's what a monkey does. A monkey does repetitive movements and we don't want to be monkeys."

Another factor influencing technique selection is the lack of research and evidence. Surgeons indicated that they wouldn't change their technique unless convincing results would demonstrate the superiority of one technique over the other.

O5: "And if things are clearly better or faster, then of course you do that [change your technique], but if little is clear about it or if no good research has been done, then of course you just stay in your own familiar environment, right? Then you're going to do the same thing you've always done. So yes, I'm curious. I'd love to hear what the results of the research are."

Table 4: Decision making factors in technique selection (n = 7)

Decision making factor	Myodesis	Myoplasty
Age (n=3)	Younger patients	Older patients
Ability to walk (n=1)	Patient is expected to walk again after TFA	Patient is not expected to walk again after TFA
Wish of patient (n=1)	If a patient wishes to get a myodesis	
Muscle coverage (n=5)	Enough muscles/fascia to wrap around the transected femur (n=2)	Not enough muscles/fascia to wrap around the transected femur (n=2)
	Not enough muscles to cover the femur (n=3)	Enough muscles to cover the femur (n=3)
Bulky muscles (n=1)	When muscles are too bulky	

SURGEONS' WILLINGNESS TO CHANGE AND THE REQUIREMENTS TO INITIATE THIS.

Several mindsets were distinguished in surgeons' willingness to change their surgical technique. Eight surgeons were convinced about one technique being better than the other, while four surgeons had no idea, and five surgeons did not believe in differences between the two techniques.

T2: "Well, I just don't believe in it, in the [myodesis], well let's say, it's my personal preference to do it this way."

V7: "I don't know if there is a real benefit to do myodesis, I just don't know"

O6: "Of course, you can have whole theories about that, that if you fixate muscles they will get certain functions. I don't really believe that, except maybe with the exception of certain muscles that you can still fix somewhere in a tendon, that could be [possible]. But if you're going to fixate muscles that have just been taken through the muscle belly, I don't believe that it [the fixation] makes any difference. And that's why I don't believe that a myodesis or attaching the muscles to each other really makes a functional difference."

When surgeons were asked what was needed in order to change their technique, they emphasized the importance of convincing results that demonstrate one technique being better than the other, without an increase in the risk of complications. Surgeons expressed the need for a certain benefit for their patient group, encompassing improved functional outcomes (n=8), enhanced wound healing (n=3) and a better rehabilitation (n=3). Furthermore, most surgeons had limited knowledge about

DECISION-MAKING FACTORS TO DECIDE WHETHER TO USE A MYODESIS OR MYOPLASTY AS INDICATED BY SURGEONS WHO USE BOTH TECHNIQUES

The seven surgeons who use both techniques were asked to identify the factors on which they decided to use a myodesis or myoplasty. Decisions were made based on characteristics of the patients and the muscle condition (Table 4). Variation existed in surgeons' reasoning about the muscle coverage. Two surgeons chose to use a myodesis whenever there was enough muscle/fascia to wrap around the femoral end, while three surgeons reasoned the other way around and indicated that they used a myodesis when there was not enough muscle available to cover the bone with a myoplasty. Three surgeons preferred to use a myodesis and two surgeons preferred using a myoplasty whenever possible.

the disadvantages of both techniques and mainly speculated about this. Most mentioned disadvantages of myodesis were the need to perform extra actions (n=7), insufficient coverage of the bone end (n=5), increased operation time (n=3), and the requirement for more extensive dissection of muscles and periosteum to expose the femur, potentially leading to tissue and bone damage (n=3). The most frequently mentioned disadvantages of myoplasty included the development of contractures and abnormal muscle pulls (n=6), instability and movement of muscles around the bone end (n=4), movement of the femur within the residual limb (n=3), protrusion of the femur through the skin (n=3) and the retraction of muscles (n=3).

Discussion

This study aimed to explore current practices, influencing factors, and decision-making in surgical technique selection in TFA surgery. Our results show that while a general distinction between myodesis and myoplasty can be made, there is variability in how these techniques are described and applied. Given reasons to use a myodesis were mainly outcome related while reasons to use a myoplasty were mainly practical. The lack of research and patient follow-ups notably influences the current technique selection, and explains why surgeons see no reason to change their technique. Additionally, factors such as the personal experience of the surgeon, their training, surgical practices of peers and supervisors, observed outcomes and patient feedback, and the characteristics of the treated patient population influences technique selection. These results and the sometimes conflicting perspectives of surgeons, highlight the need for further research on the advantages and

disadvantages of both techniques to provide evidence-based recommendations and assist surgeons in selecting the most suitable surgical approach.

This study reveals a great amount of variation in how surgeons perform TFA surgery, which is in line with a systematic review that showed that the included resources (literature, textbooks, videos) varied in their descriptions of involved muscles, muscle insertions, and patient positioning when describing myodesis and myoplasty.⁹ This variation could influence surgical outcomes, which was previously shown by Sooriakumaran et al. (2018).²¹ This clinical survey evaluated residual limb quality post-TFA, considering factors such as wound healing, residual limb length, pain, and muscle/fascia cover. The findings revealed differences in residual limb quality among hospitals, suggesting potential differences in surgical practices.²¹ They suggested the standardization of operation reports including details on skin flap design, nerve section method, femur length and contouring, and the use of myodesis and myoplasty.²¹ This standardization would facilitate the evaluation of postoperative outcomes associated with the amputation technique. Our observed variations in surgical practices and the potential effect on surgical outcomes supports this need for comprehensive reporting of surgical details, as currently surgical reports are mostly brief and lack specific information about for example muscle reattachment. Only with a thorough understanding of the surgical procedures undertaken during TFA, it is possible to compare surgical techniques and explore the possible effects on clinical and functional outcomes.

A notable difference observed when comparing our findings with existing literature concerns surgeons' descriptions of the hip positioning during TFA surgery. While the majority of surgeons in our study described holding the hip in flexion (n=9) or neutral (n=12), most available resources on myodesis and myoplasty describe to hold the hip in extension during muscle stabilization.⁹ Despite that it has not been proven that the position of the hip during muscle fixation affects the development of hip flexion contractures, fixating the muscles with the hip in flexion could possibly result in an abnormal muscle pull, potentially increasing the risk of femur deviation. Since the absence of residual limb contractures is related to a better mobility and prosthetic ambulation,^{22,23} hip positioning during TFA surgery should be another point of attention in surgical reports and future research.

Examining surgeons' perspectives on surgical technique selection in TFA surgery revealed a wide range of reasons for choosing between myodesis and myoplasty. Our results show that surgeons mainly use myodesis to avoid femur deviation and to improve function. Previous studies similarly showed that the main reason to opt for a myodesis is the patient's ability to have more control over the femur postoperatively,¹⁷ and to improve residual limb control and maintain the normal femoral anatomic alignment^{2,6,8,24,25} with possible improvements of patients' rehabilitation.⁹ With regard to the use of myoplasty, the current study presents less pronounced reasons. The predominant motivations for opting for myoplasty were mainly practical, with doing what was taught and reducing the amount of actions and operation time as most frequently cited reasons. This corresponds

with the current literature as myoplasty has been previously mentioned to have a shorter surgery time compared to myodesis,^{17,26,27} although this was only objectively measured in one study.²⁷ However, our results did not fully support the importance of age and the ability of patients to walk after surgery, which were previously mentioned as criteria for selecting between myodesis or myoplasty.¹⁷ While eight surgeons acknowledged the influence of age or expected walking ability, four other surgeons explicitly opted for myodesis, also in the older and more fragile patients, as they believed this would result in better outcomes than myoplasty. These contrasting perspectives highlight the absence of compelling evidence regarding the advantages and disadvantages of both techniques, hindering the ability to make evidence-based choices.

Although the current study primarily focused on the selection of surgical techniques for muscle reattachment in TFA, the interviews revealed additional factors worth considering. Variability was observed in the use of drains, the management of nerves, and the use of diathermy. These findings align with those of previous surveys conducted in the Netherlands²⁸ and Denmark,²⁹ which respectively investigated sciatic nerve management in transfemoral and lower limb amputations. The results of these surveys showed variations in nerve ligation,^{28,29} the placement of nerve sheet catheters, and nerve infiltration with local anesthetics.²⁸ Furthermore, similar to our findings, discrepancies were reported in the method of nerve transection, which was done either sharp or with the use of diathermy.²⁸ Considering these and other surgical variations might be important in exploring the potential impact of these factors on postoperative outcomes.

A strength of this interview study is the inclusion of surgeons with various backgrounds, nationalities, perspectives and ideas on the surgical techniques in TFA surgery. Surgeons who positively responded to our invitation could have had specific interests in this topic, resulting in a selection bias. However, considering the different perspectives of the interviewed surgeons, the preferences they showed for both myoplasty and myodesis, and the variation in age, gender and workplace, we believe to have selected a varied group of surgeons. Nonetheless, due to only including one or two surgeons per country outside the Netherlands, the generalizability of the findings is limited on an international level. Another strength of this interview study is its qualitative design, which allows for an in-depth exploration of surgeons' perspectives in TFA surgery and helps setting the focus for future research. However, a limitation of this qualitative approach is the focus on subjective opinions which adds a layer of uncertainty about what is really happening. Additionally, the current study does not report any clinical outcomes or patient follow-ups. In the future, research with a broader scope is needed to further explore surgical practices internationally and gather objective evidence to inform surgical decision-making in this field.

Conclusion

This study reveals great variation in surgical practices among surgeons performing TFA surgery, with different reasons for choosing myodesis or myoplasty. While

myodesis is mainly chosen for its potential favorable outcomes, myoplasty is often chosen for practical considerations. Conflicting perspectives exist regarding the possible advantages and disadvantages of both techniques and the use of myodesis in older, fragile patients. The lack of research and patient follow-ups are two important factors influencing the current technique selection. This underscores the need for more comparative research between myodesis and myoplasty to provide surgeons with evidence-based recommendations. Future studies should also provide detailed descriptions of

surgical procedures to address the existing variations and their potential impact on outcomes.

Conflicts of Interest statement: *The authors have no conflicts of interest to declare.*

Acknowledgments: *We would like to thank all vascular, orthopedic and trauma surgeons who participated in this interview study for their time investment and contributions.*

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Appendix A - Interview guide

This semi-structured interview guide served as a tool for the interviewer to navigate the conversation. To maintain a natural flow and effectively follow up on the surgeons' responses, the sequence of questions was adapted based on the answers provided by the surgeons.

Introduction interview: The interviews we conduct aim to gain insight into the surgical technique used during transfemoral amputations, and the motives and decision-making process that underlies this. We therefore would like to know what your experiences are with performing transfemoral amputations. We explicitly focus on transfemoral amputations and not on knee disarticulations or osseointegrations, and we will focus in particular on the technique used to reattach the transected muscles in the residual limb.

Topic I: Personal experience with transfemoral amputations

1. Can you tell me about how you perform transfemoral amputations? First of all, we are interested in:
 - a) The incision you make
 - b) How you handle the nerves
 - c) Whether or not you use a pneumatic tourniquet (to avoid excessive blood loss)

When it comes to reattaching the muscles in the residual limb, two surgical techniques are distinguished in literature. 1. A myodesis in which you suture the muscles directly to the bone, and 2. a myoplasty in which you suture the muscles to the antagonistic muscle groups.

2. What technique do you use to reattach the transected muscles in the residual limb?
 - a) *If a myodesis is used, can you tell me how you attach the muscles to the bone?*
 - b) *If a myoplasty is used, can you tell me how you stitch the muscles/fascia together?*
3. Can you tell me something about what you do with the adductor magnus muscle?
4. Are there any special measures you take around the surgery and the attachment of the muscles? *For example, around positioning of the patient, or the use of certain assistive devices?*
 - a) *What is the position of the leg during amputation? Are you afraid of the development of contractures?*
5. If you have a choice, at what height do you go through the femur?
 - a) Do you also discuss this with the rehabilitation doctor?

Topic II: Reasons for using a specific technique and influencing factors

1. Do you always use the same surgical technique to reattach the muscles in the residual limb?
 - a) *If so, what are the reasons you use this surgical technique?*
 - b) *If not, what determines your choice to apply one of the two techniques?*
2. Which factors have been of influence in using this particular technique?

For example: Are there patient characteristics that influence the surgical technique you use / choose? Or are there any personal characteristics (experience / age / training you have had) that influence the surgical technique(s) you use?
3. Have there been any changes in the surgical technique you use since the time you are performing transfemoral amputations?
 - a) *If so, can you tell us a bit about this?*
4. Do you think the surgical technique you use would be different if you worked in a peripheral/academic hospital?

Topic III: Open question (to make sure all aspects of influence have been mentioned)

5. Are there other aspects that influence the surgical technique(s) you use?

Topic IV: The advantages and disadvantages of the techniques

6. Are you experiencing difficulties or limitations of the technique you use? Do you think there are things that could be improved?
 7. What, if any, are the benefits of the technique you use?
 8. If we are talking about the two different techniques that can be used for attaching the muscles (myodesis vs. myoplasty), can you tell us something about the advantages and/or disadvantages that must be taken into account when choosing between the two techniques?
 - a) How do you know? *Literature, experience, thoughts?*
 9. **When a surgeon uses both surgical techniques:**
Have you ever experienced differences in outcomes after using the different surgical techniques?
 - a) *If so, could you give an example?***When the surgeon uses one surgical technique:**
Do you have ideas on how the different techniques could influence the outcome of an amputation?
 - b) How do you know? *Literature, experience, thoughts?*
-

Topic V: Outcomes after a TFA

10. Can you indicate what your main goal is while performing a transfemoral amputation to obtain the best possible result for the patient?
 - a) How do you take this into account when performing the amputation?
 11. What are the main postoperative complications you encounter after a trans-femoral amputation? How do you deal with that?
 12. What factors/outcomes need to be improved, before you consider changing the technique you use?
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Topic VI: other questions / input

13. Do you have any questions or other things you would like to share with us?
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