FINAL SCRIPT: APPROVED FOR FILMING

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Title: Vascularized Composite Upper Limb Allograft Harvesting for Proximal Arm Allotransplantation

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Author Questionnaire

1. **Microscopy**: Does your protocol require the use of a dissecting or stereomicroscope for performing a complex dissection, microinjection technique, or something similar? **No**

2. **Software:** Does the part of your protocol being filmed include step-by-step descriptions of software usage? **No**

3. **Filming location:** Will the filming need to take place in multiple locations? **No**

Current Protocol Length
Number of Steps: 22
Number of Shots: 49

Introduction

Videographer: Obtain headshots for all authors available at the filming location.

1.1. **Tanguy Perraudin:** Our research focuses on developing standardized protocols for procuring and preparing proximal upper limb allografts to ensure anatomical fidelity, enable reproducible surgeries, and enhance functional and immunological outcomes in upper extremity vascularized composite allotransplantation.

1.1.1. INTERVIEW: Named Talent says the statement above in an interview-style shot, looking slightly off-camera. *Suggested B-roll: 2.4.1., 2.4.2.*

What technologies are currently used to advance research in your field?

1.2. **Elise Lupon:** Our center focuses on various methods to enhance nerve regeneration, including nerve conduits, nerve wrapping, and stem cell-based therapies. The advances in nerve regeneration we are investigating may be directly applicable to the transplantation step following this protocol, as functional outcomes in VCA largely depend on the extent of neural recovery.

1.2.1. INTERVIEW: Named Talent says the statement above in an interview-style shot, looking slightly off-camera. *Suggested B-roll:4.3*

What research gap are you addressing with your protocol?

1.3. **Tanguy Perraudin:** Upper limb allotransplantation remains a rare and highly specialized procedure. Despite existing literature on procurement techniques, a comprehensive, stepwise protocol is lacking. Establishing such a standardized protocol is essential to ensure reproducibility, optimize graft quality, and enhance surgical outcomes.

1.3.1. INTERVIEW: Named Talent says the statement above in an interview-style shot, looking slightly off-camera. *Suggested B-roll: 3.2.4.*

What advantage does your protocol offer compared to other techniques?

1.4. **Elise Lupon:** Our protocol results from a collaboration with the orthopedic team in Lyon, pioneers in composite tissue allotransplantation with extensive experience in proximal limb transplantation. It benefits from their valuable expertise and long-term follow-up data on patient outcomes.

1.4.1. INTERVIEW: Named Talent says the statement above in an interview-style shot, looking slightly off-camera. *Suggested B-roll:4.1*

How will your findings advance research in your field?

1.5. **Tanguy Perraudin:** The development of a standardized procurement protocol for upper limb allografts will not only improve surgical reproducibility but also facilitate experimental research in vascularized composite allotransplantation by enabling controlled graft harvesting for laboratory-based studies on immunotolerance induction.

1.5.1. INTERVIEW: Named Talent says the statement above in an interview-style shot, looking slightly off-camera.

What research questions will your laboratory focus on in the future?

1.6. **Elise Lupon:** We will focus on *ex vivo* and *in vivo* graft perfusion strategies, along with stem cell–based approaches, to promote immune tolerance and improve outcomes in VCA.

1.6.1. INTERVIEW: Named Talent says the statement above in an interview-style shot, looking slightly off-camera.

Videographer: Obtain headshots for all authors available at the filming location.

Ethics Title Card

This research has been approved by the French National Ethics Committee

Protocol

2. Donor Upper Limb Harvesting for Transhumeral Transplantation

Demonstrator: Tanguy Perraudin, Lilian Pimont, Elise Lupon

2.1. To begin, use a surgical scalpel blade number 15 to make a circumferential fish mouth incision just proximal to the deltoid humeral insertion **[1]**.

2.1.1. WIDE: Talent making a circumferential fish mouth incision proximal to the deltoid humeral insertion with a surgical scalpel blade number 15.

2.2. Using fine needle cautery and a pair of Adson tissue forceps, raise the volar proximal skin flap **[1]**. Ligate proximally and divide the cephalic veins **[2]**.

2.2.1. Talent lifting the volar proximal skin flap using fine needle cautery and Adson forceps.

2.2.2. Talent ligating and dividing the cephalic veins.

2.3. Detach the pectoralis major from the humerus using monopolar diathermy **[1]** to expose the coracobrachialis **[2]**. Then, use a scalpel to recline the deltoid from the clavicle and acromion to access the scapular insertion of the long portion of the biceps brachii **[3]**.

2.3.1. Talent detaching the pectoralis major with monopolar diathermy.

2.3.2. A shot of the exposed coracobrachialis.

2.3.3. Talent reclining the deltoid using a scalpel to reveal the scapular insertion of the biceps brachii.

2.4. Isolate and detach both the long and short portions of the biceps brachii and the coracobrachialis **[1]**. Detach the pectoralis minor from the coracoid process to access the brachial plexus **[2]**.

2.4.1. Talent isolating and detaching the long and short heads of the biceps brachii and coracobrachialis.

2.4.2. Talent detaching the pectoralis minor from the coracoid process.

2.5. With scissors, dissect and transect the median **[1]**, ulnar **[2]**, radial, and musculocutaneous nerves in their proximal third or at the cord level **[3]**. Cut the axillary nerve to allow muscular involution of the deltoid **[4]**.

2.5.1. Talent dissecting and transecting the median with scissors.

2.5.2. Talent dissecting and transecting the ulnar with scissors.

2.5.3. Talent dissecting and transecting the radial and musculocutaneous nerves with scissors.

2.5.4. Talent cutting the axillary nerve.

2.6. Expose the brachial artery and veins up to the axillary vessels **[1]** and tag them **[2]**. Make a longitudinal mark along the bicipital groove to facilitate accurate rotational alignment during osteosynthesis **[3]**. Then, use an oscillating saw to perform a transverse osteotomy of the humerus at the preoperatively planned level **[4]**.

2.6.1. Talent exposing the brachial artery and veins up to the axillary vessels.

2.6.2. Talent tagging the exposed brachial artery and veins.

2.6.3. Talent marking a longitudinal line along the bicipital groove.

2.6.4. Talent performing a transverse osteotomy of the humerus with an oscillating saw.

2.7. Raise the dorsal proximal skin flap using fine needle cautery and a pair of Adson tissue forceps **[1]**. Clip any superficial veins proximally using hemostatic clips **[2]**.

2.7.1. Talent lifting the dorsal proximal skin flap with fine needle cautery and Adson forceps.

2.7.2. Talent clipping superficial veins using hemostatic clips.

2.8. Use a scalpel to isolate and detach the long and lateral heads of the triceps brachii from their proximal origins and the posterior head of the deltoid from the scapula **[1]**.

2.8.1. Talent detaching and isolating the long and lateral heads of the triceps brachii from their proximal origins with a scalpel.

2.9. Ligate the axillary vessels proximally and divide them **[1]**.

2.9.1. Talent ligating and dividing the axillary vessels.

3. Donor Upper Limb Harvesting for Transplantation at the Glenohumeral Level with Shoulder Reconstruction

3.1. Make a double ogival-shaped incision with the proximal extremity at the coracoid level and the base 10 centimeters more distal **[1]**. Create a superior acromio-clavicular flap delimited by the deltopectoral interval **[2]** and an inferior axillary flap **[3]**. Extend the incision proximally to the sterno-clavicular joint, then continue 10 centimeters up to the posterior border of the sternocleidomastoid muscle **[4]**.

3.1.1. Talent making a double ogival-shaped skin incision from the coracoid process, extending 10 centimeters distally.

3.1.2. Talent creating a superior acromio-clavicular flap, showing the deltopectoral interval.

3.1.3. Talent creating an inferior axillary flap

3.1.4. Talent extending the incision proximally to the sterno-clavicular joint and then continuing the incision to the posterior border of the sternocleidomastoid.

3.2. Using a scalpel, detach the anterior head of the deltoid from the clavicle **[1]**. Then, detach the middle head from the acromion **[2]** and the posterior head from the scapula **[3]**. Cut the posterior head perpendicularly to the scapular spine, 10 centimeters from the acromion **[4]**.

3.2.1. Talent using a scalpel to detach the anterior head of the deltoid from the clavicle.

3.2.2. Talent detaching the middle head of the deltoid from the acromion.

3.2.3. Talent detaching the posterior head from the scapula.

3.2.4. Talent cutting the posterior head perpendicularly to the scapular spine.

3.3. Now, detach the pectoralis minor from the coracoid process **[1]**. Then, detach the short head of the biceps brachii **[2]** and the coracobrachialis from the coracoid **[3]**.

3.3.1. Talent detaching the pectoralis minor from the coracoid with a scalpel.

3.3.2. Talent detaching the short head of the biceps brachii from the coracoid.

3.3.3. Talent detaching the coracobrachialis from the coracoid.

3.4. Detach the clavicular insertion of the pectoralis major **[1]**. Make a subcutaneous dissection to expose the pectoralis major, then using monopolar diathermy, transect through the muscle belly, leaving all the tendons on the humeral insertion with an additional 10 centimeters of muscle **[2]**.

3.4.1. Talent detaching the clavicular head of the pectoralis major.

3.4.2. Talent transecting through the muscle belly with monopolar diathermy.

3.5. Perform an osteotomy of the clavicle to access the proximal portion of the vessels and the brachial plexus **[1]**.

3.5.1. Talent making an osteotomy of the clavicle to expose the proximal portion of the vessels and the brachial plexus.

3.6. Dissect and place vessel loops around the subclavian artery **[1]** and vein at a proximal level **[2]**.

3.6.1. Talent dissecting around the subclavian artery and securing it with a vessel loop.

3.6.2. Talent dissecting the subclavian vein and placing a vessel loop around it

3.7. Identify the lateral, medial, and posterior cords of the brachial plexus and transect them proximally to the origins of their terminal branches using scissors **[1]**.

3.7.1. Talent identifying and transecting the three cords of the brachial plexus with scissors.

3.8. Dissect the subclavian vessels down to the axillary vessels using scissors **[1]** and tag them **[2]**.

3.8.1. Talent dissecting the subclavian to the axillary vessels.

3.8.2. Talent tagging the dissected subclavian vessels.

3.9. Ligate all collateral arteries and veins from the axillary vessels destined for the thorax using hemostatic clips or braided absorbable sutures **[1]**.

3.9.1. Talent ligating collateral branches from the axillary vessels.

3.10. Using a scalpel, isolate and detach the long head of the biceps brachii from its proximal origin for future humeral tenodesis **[1]**.

3.10.1. Talent detaching and isolating the long head of the biceps brachii at its origin.

3.11. Incise the tendon of the subscapularis with a scalpel **[1]**. Then, incise the glenohumeral joint capsule at the neck of the scapula **[2]**. Transect the tendons of the supraspinatus, infraspinatus, and teres minor muscles posteriorly to the joint at the same level **[3]**. Disarticulate the glenohumeral joint to harvest the humeral head with the graft **[4]**.

3.11.1. Talent using a scalpel to incise the subscapularis tendon.

3.11.2. Talent making an incision through the joint capsule at the scapular neck.

3.11.3. Talent transecting the tendons of the supraspinatus, infraspinatus, and teres minor muscles posteriorly to the joint.

3.11.4. Talent disarticulating the glenohumeral joint.

3.12. Mobilize the humerus laterally **[1]**. Detach the long head of the triceps from its proximal origin with a scalpel **[2]** and remove the latissimus dorsi and teres major from their humeral insertions **[3]**.

3.12.1. Talent moving the humerus laterally.

3.12.2. Talent detaching the long head of the triceps from its proximal origin with a scalpel.

3.12.3. Talent removing the latissimus dorsi and teres major from their humeral insertions.

3.13. Finally, ligate and divide the axillary and subclavian vessels proximally **[1]**.

3.13.1. Talent ligating and dividing axillary and subclavian vessels.

Results

4. Results

4.1. The average diameters of major vessels and brachial plexus cords at the coracoid level during glenohumeral transplantation were calculated **[1]**.

4.1.1. LAB MEDIA: Figure 4.

4.2. Among these structures **[1]**, the axillary artery has the greatest diameter **[2]**, followed by the axillary vein **[3]** and lateral cord **[4]**, with the medial cord having the smallest diameter **[5]**.

4.2.1. LAB MEDIA: Figure 4.

4.2.2. LAB MEDIA: Figure 4. *Video editor: Highlight the red dot on the red plot.*

4.2.3. LAB MEDIA: Figure 4. *Video editor: Highlight the dark blue square on the dark blue plot.*

4.2.4. LAB MEDIA: Figure 4. *Video editor: Highlight the green triangle on the green plot.*

4.2.5. LAB MEDIA: Figure 4. *Video editor: Highlight the yellow diamond on the yellow plot.*

4.3. The average diameters of vessels and nerves at the humeral neck level during transhumeral transplantation are presented **[1]**, with the brachial artery having the greatest diameter **[2]**, while the cephalic vein displays the smallest **[3]**.

4.3.1. LAB MEDIA: Figure 5.

4.3.2. LAB MEDIA: Figure 5. *Video editor: Highlight the red dot on the red plot.*

4.3.3. LAB MEDIA: Figure 5. *Video editor: Highlight the light blue triangle on the light blue plot.*

Pronunication Guide:

1. Allograft

- **Pronunciation link:** https://www.merriam-webster.com/dictionary/allograft
- **IPA:** /ˈælə˧græft/
- **Phonetic Spelling:** AL-uh-graft

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2. Allotransplantation

- **Pronunciation link:** https://www.howtopronounce.com/allotransplantation
- **IPA:** /˧ælətʊ˧trænsplænˈteɪʃən/
- **Phonetic Spelling:** AL-oh-trans-plan-TAY-shunapp.jove.com

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3. Coracobrachialis

- **Pronunciation link:** https://www.howtopronounce.com/coracobrachialis
- **IPA:** /˧kɔːrəkoʊ˧breɪkiˈælɪs/
- **Phonetic Spelling:** KOR-uh-koh-bray-kee-AL-iss

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4. Diathermy

- **Pronunciation link:** https://www.merriam-webster.com/dictionary/diathermy
- **IPA:** /ˈdaɪə˧θɜrmi/
- **Phonetic Spelling:** DYE-uh-ther-mee

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5. Musculocutaneous

- **Pronunciation link:** https://www.howtopronounce.com/musculocutaneous
- **IPA:** /˧mʌskjəloʊkjuˈteɪniəs/
- **Phonetic Spelling:** MUS-kyuh-loh-kyoo-TAY-nee-uhs

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6. Osteosynthesis

- **Pronunciation link:** https://www.howtopronounce.com/osteosynthesis
- **IPA:** /˧ɒsti.oʊˈsɪnθəsɪs/
- **Phonetic Spelling:** OSS-tee-oh-SIN-thuh-sis

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7. Tenodesis

- **Pronunciation link:** https://www.howtopronounce.com/tenodesis
- **IPA:** /˧tɛnəˈdiːsɪs/
- **Phonetic Spelling:** TEN-uh-DEE-sis

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8. Subscapularis

- **Pronunciation link:** https://www.howtopronounce.com/subscapularis
- **IPA:** /˧sʌb˧skæpjəˈlærɪs/
- **Phonetic Spelling:** SUB-scap-yuh-LAIR-iss

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9. Supraspinatus

- **Pronunciation link:** https://www.howtopronounce.com/supraspinatus
- **IPA:** /ˌsuːprəspaɪˈneɪtəs/
- **Phonetic Spelling:** SOO-pruh-spy-NAY-tuhs

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10. Infraspinatus

- **Pronunciation link:** https://www.howtopronounce.com/infraspinatus
- **IPA:** /ˌɪnfrəspaɪˈneɪtəs/
- **Phonetic Spelling:** IN-fruh-spy-NAY-tuhs

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11. Teres Minor

- **Pronunciation link:** https://www.howtopronounce.com/teres-minor
- **IPA:** /ˈtɛriːz ˈmaɪnər/
- **Phonetic Spelling:** TER-eez MY-nor

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12. Latissimus Dorsi

- **Pronunciation link:** https://www.howtopronounce.com/latissimus-dorsi
- **IPA:** /ləˈtɪsɪməs ˈdɔːrsaɪ/
- **Phonetic Spelling:** luh-TISS-ih-muhs DOR-sigh

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13. Ligamentoplasty

- **Pronunciation link:** https://www.howtopronounce.com/ligamentoplasty
- **IPA:** /ˌlɪgəˈmɛntəˌplæsti/
- **Phonetic Spelling:** LIG-uh-men-toh-plas-tee

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14. Peroneus

- **Pronunciation link:** https://www.howtopronounce.com/peroneus
- **IPA:** /ˌpɛrəˈniːəs/
- **Phonetic Spelling:** PER-uh-NEE-uhs

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15. Tenorrhaphy

- **Pronunciation link:** https://www.howtopronounce.com/tenorrhaphy
- **IPA:** /tɛˈnɒrəfi/
- **Phonetic Spelling:** ten-OR-uh-feeapp.jove.com

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16. Myocutaneous

- **Pronunciation link:** https://www.howtopronounce.com/myocutaneous
- **IPA:** /ˌmaɪoʊkjuˈteɪniəs/
- **Phonetic Spelling:** MY-oh-kyoo-TAY-nee-uhsapp.jove.com

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17. Anastomoses

- **Pronunciation link:** https://www.merriam-webster.com/dictionary/anastomosis
- **IPA:** /əˌnæstəˈmoʊsiːz/
- **Phonetic Spelling:** uh-NAS-tuh-MOH-seez

18. Ischemic

- **Pronunciation link:** https://www.merriam-webster.com/dictionary/ischemic
- **IPA:** /ɪˈskiːmɪk/
- **Phonetic Spelling:** iss-KEE-mik

19. Perfusion

- **Pronunciation link:** https://www.merriam-webster.com/dictionary/perfusion
- **IPA:** /pərˈfjuːʒən/
- **Phonetic Spelling:** per-FYOO-zhun

20. Immunotolerance

- **Pronunciation link:** https://www.howtopronounce.com/immunotolerance
- **IPA:** /ˌɪmjʊnoʊˈtɒlərəns/
- **Phonetic Spelling:** im-YOO-noh-TOL-er-uhns