NP = Neuroma Pain
PLP = Phantom Limb Pain
RLP = Residual Limb Pain

DIAGNOSTIC

Assessment of Medical History

- Date of Amputation
- Cause of Amputation
- Revision Surgery
- Current Socket & Prosthetic Fitting
- Frequency of Physio & Occupational Therapy
- Medications
- K-Levels
- Motivation & Expectations of the Patient

Pain Assessment
- Characteristics (Adjectives)
- Intensity (NRS 1-10)
- Frequency
- Motivate Patient to Describe Pain using Adjectives

Examination
- Physical Examination: Inspect and palpate the residual limb (wounds, signs of infection), assessment of ROM, assessment of gait and posture with prosthesis, perfusion, screening for Hoffmann Tinel sign
- Laboratory-chemical Examination: Infection parameters (C reactive protein, leukocytes), liver function parameters (incl. albumin in serum), kidney function parameters (creatinine, electrolytes)
- Imaging Techniques: X-Ray, CT, MRI, high-resolution ultrasound

PLP is the perception of pain or discomfort in a limb that is no longer there. NP is neuropathic pain and can originate from severed nerves in the residual limb. RLP is localized in the residual limb. NP is categorized as RLP.



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INDICATION

Neuroma?

Diagnostic Criteria from the AWMF S3 Guidelines:

All three of the following criteria must be met:

1. Pain exhibiting at least three of the following characteristics: burning, cutting, shooting, electrifying, paraesthesia, numbness, or cold intolerance
2. Symptoms confined to a specific neuroanatomical region
3. A history of an actual or suspected nerve injury

At least one of the following criteria must be met:

1. Positive Tinel's sign (for cutaneous nerves)
2. Response to infiltration with a local anesthetic.
3. Confirmation of a neuroma through imaging (neurosonography, MRI)

High Probability for Neuroma

1. Sonographic visualization of the possible neuroma
2. Infiltration of the neuroma with a local anesthetic
3. If there is a temporary reduction/ elimination of pain, this is considered a reliable diagnostic criterion

Surgery?

Combination? NP & PLP

There is a strong correlation between NP and PLP: patients affected with PLP show a higher presence of NP or other qualities of RLP in comparison to patients without PLP. Neuromas can not only trigger PLP but can also cause localized allodynia, hyperalgesia, and pain hindering prosthesis use. Furthermore, other factors such as wound healing disorders, osteitis, osteomyelitis, circulatory disorders, hematoma, and seroma can also contribute to RLP. Improper residual limb preparation, bone length misalignment, absence of fat pad, and structural changes in the residual limb and surrounding tissues over time can also lead to RLP. Additionally, hyperhidrosis of the residual limb, mechanical stress, and compensatory movements to adjust to the missing limb can contribute to musculoskeletal pain disorders. It is important to distinguish RLP from other pain conditions such as piriformis syndrome, myofascial trigger points, radiculopathy, lower back pain, and osteoarthritis of adjacent joints.

Phantom Limb Pain?

Prevention is better than cure: If feasible surgical technique reducing the prevalence? Occurrence of PLP and any approaches to prepare the residual limb properly should be applied within primary amputation. (De Lange et al. (2022), Dumanian et al. (2019), Yuan et al. (2022))

Diagnostic Criteria

1. Pain exhibiting at least three of the following characteristics: burning, cutting, shooting, electrifying, paraesthesia, numbness, or cold intolerance
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If no further pathology can be identified primary non-surgical treatment should be considered

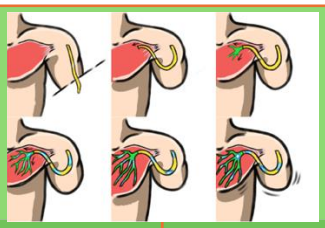
Please see section non-surgical treatment options for PLP (medicaments, therapeutical, empowerment, etc.)

SURGERY

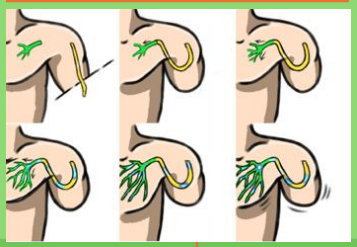
Patient must be appropriate candidate for surgical intervention (consent and overall health status)

- TMR
- TSR
- RPNI

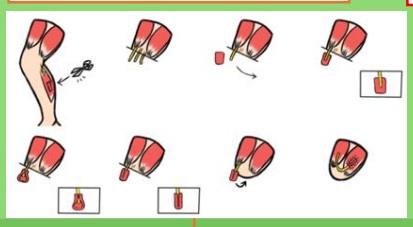
Targeted Muscle Reinnervation
A major mixed or sensory nerve is transected, and the proximal end of the mixed or sensory nerve is then transferred and coapted to the distal nerve end of a transected motor nerve by end-to-end neurorrhaphy. This provides the nerve with a guide structure via which it grows into the muscle and reinnervates it.



Targeted Sensory Reinnervation
In contrast to TMR, with TSR the nerve transfer is not to a muscle branch but directly to a defined sensitive skin branch. An area of skin is specifically reinnervated through end-to-end coaptation of a sensitive donor nerve.



Regenerative Peripheral Nerve Implantation
A major nerve is transected, and the end of this nerve is then sutured into a non-vascularized autologous muscle graft taken from the amputated limb. The graft is wrapped around the nerve end and closed with sutures.



If other pathologies are present (bony prominences, insufficient soft tissue coverage, etc.) they should be targeted in the same revision surgery

POST-OP CARE

After Surgery

Follow up from a specialized multiprofessional team should be established (first year at least after 3, 6 and 12 months, then annually or if problems or pain occur)

Prosthetic fitting

In general: Earliest and most functional prosthetic fitting

Prosthesis

If available: Myoprosthetic fitting using (reconstructed authentic) motor control signals generated from the residual limb (after TMR & RPNI)

-> Pain-reducing effect
-> Restoration of integrity
-> Support of the “embodiment”
-> Reduction of sensorimotor incongruence through tactile and visual stimuli

Feedback System

If available: Fitting of (commercially available) feedback systems at the skin area of the reinnervated skin

-> Improved function, safety & mobility
-> Increased sense of agency and ownership

Reduction or Prevention of Phantom Limb Pain and Neuroma Pain

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