Anke Niederau

The Big Book of Nail Diseases

Cause • Podiatry diagnosis • Therapy • Prophylaxis

Podologie

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The Big Book of Nail Diseases
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The **nail (Lat.: unguis, Greek: onyx)** is a skin appendage that consists of 100 to 150 horn cell layers which can be between 0.05 millimeters (nail of an infant) and 0.75 millimetres thick.

Nail formation (onychisation) is a cornification process that starts behind the nail fold. The horn cells consist of hard keratin with a high percentage of sulphur double-bond compound and a homogeneous arrangement of keratin filaments (essential component of keratin). Horn substance is primarily composed of chains of protein molecules, the polypeptide chains. The nail grows continuously: fingernails approximately 1 millimetre per week and toenails approximately 1 millimetre per month (see chart 2.1).

Nail formation (onychisation)
Nail formation is a cornification process that foregoes the forming of keratohyalin. Keratohyalin is a protein structure found in granules in the stratum granulosum. These small dense granules are collected in the cells. During further cornification, keratohyalin is first transformed to eleidin (a fat- and protein-rich acidophilic substance) and then keratin. The keratin is transported into the stratum lucidum. This layer has the appearance of a thin line preventing dehydration.

Nail plate (corpus unguis)
The nail plate is formed in the germinal matrix (nail matrix). One third of the horn substance is created by the stratum granulosum (granular layer) of the nail bed and the remaining part of the nail plate is formed by the lunula. The nail is composed of three layers: the dorsal layer (dorsal nail), consisting of hard keratin; the intermediate layer (intermediate nail) made up of keratin with cell structures and cell nucleus residues; and the palmar layer (ventral nail), a soft keratin layer that is connected to the nail bed with longitudinal strings. The nail plate pushes from the germinal matrix on the nail bed towards distal direction. The nail bed exhibits groove-like structures connecting the nail plate to the nail bed.

The nail plate curves in two directions (longitudinal and transverse direction) increasing the nail's stability.

Various factors determine the colour of a nail:
- the capillaries of the nail bed (surface with tiny blood vessels underneath the nail)
- keratin (horn substance) which exhibits a yellowish to greyish colour
- pigment-forming cells (melanocytes) found in matrix and the nail bed area

The thickness of the nail plate increases towards the distal end and is thinner in the germinal matrix area.

Nail matrix (radix unguis)
The matrix (germinal matrix) produces cells that become the nail plate. The lunula (lat.: small moon) is the visible part of the matrix, the whitish crescent-shaped base of the visible nail.

Nail bed (hyponychium, solum unguis)
The nail bed exhibits tiny longitudinal grooves, similar to a corrugated sheet, connecting the nail bed to the nail plate.

Nail wall (perionychium)
The nail wall is the cutaneous fold overlapping the sides and proximal end of the nail.

The crescent-shaped proximal part of the nail with the underlying matrix is covered by the perionychium and the epithelial cuticula (cuticle).

Image 2.1

Image 2.2

Image 2.3

Images 2.1 to 2.4 inscription

1 Nail plate (corpus unguis)
2 Margo liber, free margin
3 Lunula, whitish crescent-shaped-base
4 Radix unguis, nail root
5 Matrix, germinal matrix
6 Lateral Margo liber, lateral free margin
7 Cuticula, cuticle
8 Hyponychium – solum unguis, nail bed
9 Sulcus unguis, nail fold
10 Intermediate nail with papilla grooves
11 Hyponychium – solum unguis, nail bed with papilla grooves
12 Perionychium – Vallum unguis, nail wall
13 Sole horn
14 Bone, phalanx

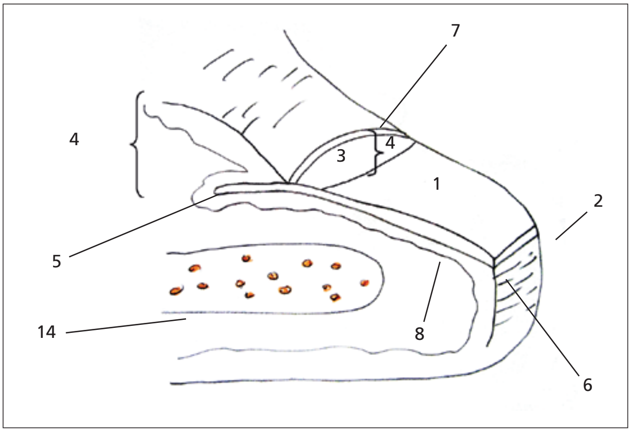


Image 2.4

Image 2.5 The three horn layers of a nail

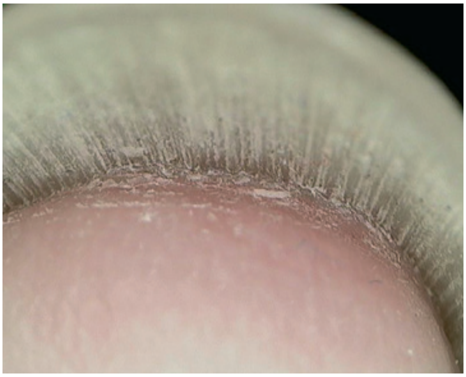


Image 2.6 Distal view of the ventral nail at the transition to the sole horn (PodoCam).

Nail fold (sulcus unguis)
The sulcus unguis is the transition between the nail plate and the nail wall.

Cuticle (cuticula)
The cuticle is located on the proximal perionychium (nail wall). It is located on the back of the nail like a dense, thin fold and acts as a protective seal for the nail sinus. Damaging the cuticle can cause severe nail growth disorders due to bacterial or fungal infections.

Sole horn
The sole horn is located under the distal free margin. It is a horny structure that prevents the detachment of the nail from the nail bed and forms a protective barrier for the nail plate against germs and foreign particles.

Function
The nail has mainly a protective function. It protects the distal phalanx, the fingertip and the surrounding soft tissues from injuries. It also serves to enhance precise delicate movements and functions as a tool, enabling, for instance, a so-called "extended precision grip (e.g. pulling out a splinter) and certain cutting or scraping actions.

Nails grow continuously. Fingernails grow approximately 1 millimetre per week and require, on average, six months to regrow completely. Toenails are thicker and grow at a slower rate. They require about twelve months to regrow completely.

Development of the nail matrix begins towards the end of the third embryonic week when a slightly curved primary nail area forms exhibiting an arc-shaped margin. Granular cells slowly form the nail which grows from distal to proximal direction. At the end of the fifth month, the eponychium and the hyponychium form the matrix. After the sixth month, the nail grows from proximal to distal direction.

Nail growth disorders
Various external and internal factors affect nail development and can cause delayed growth. Some of the causes for nail growth disorders are listed below:

Accelerated growth	Delayed growth
Summer	Winter
Daytime	Nighttime
Pregnancy	
Minor injuries	
Nail biting	
Nail cutting	
Nails on the right hand	Nails on the left hand
Adolescence	Old age
Men	Women
Finger	Toes
Middle finger	Thumb and small finger
Ring finger	
Index finger	

Chart 2.1 Nail growth

Nail growth disorders caused by:

- Exogenous (external) factors (image 2.7)
  Exogenous nail growth disorders are physical traumas caused by injuries, chemical toxins, medication and foot and toe deformities.
- Endogenous factors (image 2.8)
  Endogenous factors generally affect not only the growth of one nail, but of all nails. Skin diseases and various underlying diseases are the cause. Mineral and vitamin deficiencies are also to blame.
- Genetic factors
  Mediana canaliformis nail dystrophy is a nail disorder characterised by a paramedian canal or split in the nail plate of one or more nails. Sandpaper nails are also caused by genetic factors.

Podiatrists and foot care professionals should be able to recognize the causes and appearance of nail diseases to initiate proper treatment.

Properly fitting shoes and socks also play an important role in the prevention of nail deformities. I advise my patients to consider not only the length of a shoe, but also the width plus the flexibility and height of the outer material.

Image 2.7 Toe deformities (hallux rigidus, claw toe D2 to D4, digitus superductus D2)

Image 2.8 Psoriatic nail

I demonstrate the importance of buying the correct shoe and sock size with the help of a caliper (images 2.9 to 2.14). Shoes that are too tight on top often lead to an uncomfortable, incorrectly fitting shoe. Purchasing properly fitting socks is equally important. I place the sock, without pulling on it, on the inner side of the foot and explain to the patient what must be considered when purchasing socks.

Image 2.9 Inside measurement

Image 2.10 Inside measurement

Image 2.11 Carefully remove the measuring device without changing the measuring scale

Image 2.12 The patient places one foot on the index. Conclusion: The shoe is too short.

Image 2.13 Correctly fitting shoe

Image 2.14 Compressed nail caused by shoes that are too small

Image 2.15 Place the sock next to the foot

Image 2.16 Sock measurement on the hand with a relaxed fist

Image 2.17 Sock measurement: one finger's width above the knuckles of the metacarpus

Image 2.18 These socks are too small

Image 2.19 Toe and nail deformities caused by incorrectly fitting socks

To determine the proper fit of a sock, you place the length of the sock around the patient's relaxed fist without pulling on it. If it overlaps by one finger's width, then the sock fits properly (images 2.15 to 2.19).

The same technique can be used for compression socks (images 2.20 to 2.22).

Image 2.20 Fitting of a compression sock

Image 2.21 Compression sock with soft tip

Image 2.22 Properly fitting compression sock

3.1 Diabetic Neuropathic Onychopathy (DNO)

(As per Dr. Adalbert Strasser, Specialist Surgeon, WundMED, Vienna, Austria)

Definition

Pathological change of the toenails due to diabetic foot syndrome with peripheral polyneuropathy.

Causes

In diabetic foot syndrome, the neuropathic component pathogenetically damages the nerves of the nail matrix causing nail growth dysfunction.

Appearance

The result is uncontrolled growth of the nail whereby the nail plate becomes unusually thick. Horizontal and longitudinal grooves develop on the nail and necrotic tissue deposits form between the underside of the nail and the cuticle.

This disorder is often diagnosed as onychomycosis and, if treated incorrectly, it can have a devastating impact for the patient since, in the worst case, amputation of the end phalanges is the only option.

Patients not only dislike the appearance of their nails, but also experience pain. Often convoluted nail growth is accompanied by pressure pain, cuticle irritation, and inflammation-triggering osseous tissue irritation of the end phalanges. In addition, the thickened nail plate can cause severe pain and foot static dysfunction, thereby changing the patient's movement pattern.

The unphysiological movement pattern caused by the neuropathic foot combined with toe deformity creates atypical pressure points, thereby overstressing the foot and increasing uncontrolled nail growth. Socks that are too small or improper footwear promote the pathological gait pattern. The metatarsal advancement in diabetic foot syndrome also contributes to neuropathic onychopathy.

Complications

Wound healing complications deriving from DNO pose a high risk for diabetics, especially injuries in the nail area.

Images 3.1 and 3.2
Diabetic neuropathic onychopathy

Incorrectly performed foot care damages the sensitive cuticle and can lead to the development of whitlow, non-healing ulcerations, subungual abscesses, fistula formation and osteomyelitis of the end phalanges.

Image 3.3 DNO with subungual ulcer

Image 3.4 DNO with subungual abscess

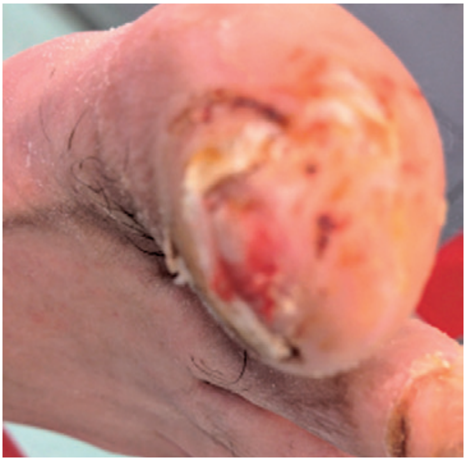


Image 3.5 DNO with subungual abscess-forming ulcer

Image 3.6 DNO with subungual pressure hematoma

Image 3.7 DNO with subungual pressure hematoma

Image 3.8 DNO with fistula-forming osteomyelitis preceded by a pressure ulcer

Image 3.9 DNO with osteomyelitis and abscess- and fistula-forming ulcer

Image 3.10 DNO with detached nail plate

Image 3.11 DNO with abscess-forming and beginning fistula-forming paronychia

Image 3.12 DNO with abscess- and fistula-forming paronychia

Image 3.13 DNO with abscess- and fistula-forming ulcer

Image 3.14 DNO with osteomyelitis of the left big toe's end phalanx showing an abscess- and fistula-forming ulcer

Image 3.15 Paronychia with abscess- and fistula-forming ulcer with osteomyelitis

Image 3.16 DNO with split nail plate

Image 3.17 Unguis convolutus

Treatment

To decrease pressure and pain, the thickness of the nail must be gradually reduced over a period of several months. The painful convoluted nails can be corrected with an adhesive non-wire brace using minimal activation force to avoid sulcus irritation. Applying tamponades aggravates the situation and can lead to the loss of the end phalanx. To rule out mycoses infestation, the affected nails should undergo a DNA analysis. If onychomycosis is present, treatment with Spirularin® is recommended. The active ingredient derives from the spirulina algae which fight bacteria, viruses and fungi. It is a gentle, natural and harmless substance yet very effective, which is proven by the results of many studies and practical experiences worldwide.

The above-mentioned treatment approach has helped me to improve the appearance of nails and to eliminate pain and discomfort for the patient.

The big toe is especially susceptible to pain and inflammation since it must absorb most of the pressure during movement. Close cooperation between diabetologist, orthopedic shoe maker and podiatrist is of the utmost importance.

In the acute phase a forefoot-relief shoe provides comfort for the patient but subsequently, wearing fitting orthopedic shoes is advisable since an arterial microcirculatory disorder aggravates the entire pathology.

Improper treatment can lead to limb loss.

If subungual abscesses with osteomyelitis of the nail plate are present, it is advisable to perform a sequestrectomy.

In addition to following sterile guidelines, frequent examinations, rinsing and strain relief are crucial.

The use of tamponades is discouraged since they host proteus and pseudomona organisms, according to Dr. Strasser's analysis of antibiograms. In case tamponade insertion is indispensable, it should never stay inserted longer than 24 hours and only sterile Ligasano® white tamponade should be applied.

Summary by Dr. Strasser
Due to the serious complications that are involved with nail disorders, diabetic neuropathic onychopathy is associated with diabetic foot syndrome. If fungi infestation is detected, it can be attributed to DNO syndrome.

DNO onychauxis with onychomycosis
With a beginning hallux rigidus and hammer toes, the nail thickness must be gently reduced over a longer period. An antimycotic treatment with spirulina algae extract and toe tape (if the toes are still flexible enough) provides relief.

Image 3.18 Close-up of DNO

3.2 Unguis incarnatus (Greek: onychocryptosis)

The Latin name unguis incarnatus is more frequently used for an ingrown toenail (images 3.20 to 3.26).

Definition

Deeply embedded in the nail bed (image 3.21) with inward curved lateral nail edges (image 3.23) that are covered by the lateral nail wall. The front corners of the nail plate start to grow into the nail wall tissue (image 3.22) causing severe pain and inflammation if left untreated (image 3.23).

Causes

- excessive cutting of the nail corners
- pronounced transverse curvature of the nail plate caused by various factors
- changes of the nail plate's thickness and texture
- a reaction to a long-term inflammation in the nail fold, such as paronychia (tissue folds surrounding the nail), whereby the serous fluid dissolves part of the nail substance generating an uneven, partly jagged nail edge; this uneven edge prevents proper healing
- malpositioning of the foot or the toes, such as with hallux valgus, increase the damage
- wearing improper footwear
- diabetes mellitus, hormonal changes such as puberty or menopause, genetically determined sensitive skin

Various stages

- **Inflamed non-purulent:** Pressure applied by the deep lateral nail margin in the nail fold triggers inflammation displaying the classic signs, such as inflammatory reddening, swelling, pain, overheating and functional impairment in the nail fold and nail wall area.

Image 3.20 Unguis incarnatus with slightly lateral pressure pain

Image 3.22 Unguis incarnatus with painful inflammation

Image 3.21 Unguis incarnatus with slightly lateral and medial pressure pain

Image 3.23 Unguis incarnatus with granulation tissue and suppuration

- **Inflamed purulent:** The progressing inflammation promotes bacteria invasion through the widened nail fold causing acute paronychia (suppuration in the nail fold and under the nail plate). The purulent secretion often drains spontaneously or through applied pressure from the nail fold. The podiatrist can perform the initial treatment but must refer the patient to a physician for further treatment.

Image 3.24 Unguis incarnatus with slight lateral and medial pressure pain and minor inflammatory reaction

Image 3.25 Unguis incarnatus with slight lateral and medial pressure pain

Image 3.26 Unguis incarnatus with granulation tissue and medial suppuration

- **Inflamed purulent with granulation tissue:** In the progressed stage of the unguis incarnatus, granulation tissue develops. During the chronic inflammatory process, granulation tissue with its own blood circulation forms, so-called proud flesh. This granulation tissue has the tendency to grow exuberantly over the nail plate. Here too the podiatrist only performs the initial treatment and refers to the patient to a physician for further treatment.

Complications

Lymphatic vessel inflammation (lymphangitis often incorrectly identified as sepsis) can lead to necrosis of the toe if the inflammation is left untreated. The irritation of a sharp nail corner increases cell division and aggressive granulation tissue develops. For patients who suffer from diabetes mellitus or circulatory disorders, prolonged paronychia can lead to toe amputation.

Wound documentation

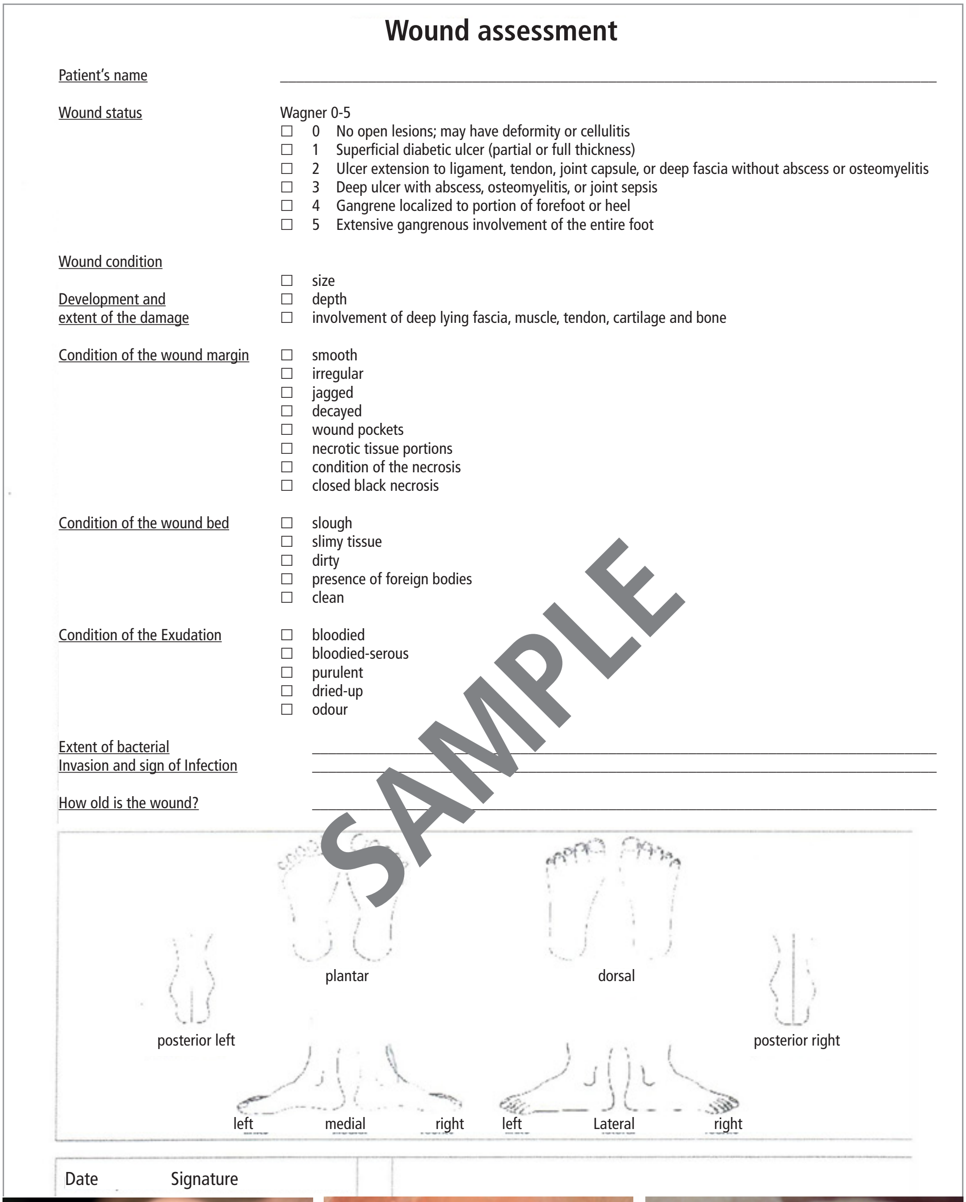
Every wound care treatment must be documented (image 3.27 see following page) in writing, a photo can be added to complete proper documentation (images 3.28 to 3.30).

Treatment

- Working with sterile instruments is of utmost importance.

> Cooperation with a physician is crucial.

- After thorough disinfection (e.g., with octenisept or Prontoman), check the nail margin for irregularities, hyperkeratosis and clavi with a probe, a double-end instrument or a blunt nail knife.
- Smooth out minor irregularities with a nail splitter, gauge, corner file or diamond-fissure grinding instrument.
- Cut the skin-penetrating nail tip in a V-shape and remove with a corner nipper, gouge, nail splitter or diamond-fissure grinding instrument making sure



Wound assessment

Patient's name ______________________

Wound status

Wagner 0-5
- ☐ 0 No open lesions; may have deformity or cellulitis
- ☐ 1 Superficial diabetic ulcer (partial or full thickness)
- ☐ 2 Ulcer extension to ligament, tendon, joint capsule, or deep fascia without abscess or osteomyelitis
- ☐ 3 Deep ulcer with abscess, osteomyelitis, or joint sepsis
- ☐ 4 Gangrene localized to portion of forefoot or heel
- ☐ 5 Extensive gangrenous involvement of the entire foot

Wound condition

Development and extent of the damage
- ☐ size
- ☐ depth
- ☐ involvement of deep lying fascia, muscle, tendon, cartilage and bone

Condition of the wound margin
- ☐ smooth
- ☐ irregular
- ☐ jagged
- ☐ decayed
- ☐ wound pockets
- ☐ necrotic tissue portions
- ☐ condition of the necrosis
- ☐ closed black necrosis

Condition of the wound bed
- ☐ slough
- ☐ slimy tissue
- ☐ dirty
- ☐ presence of foreign bodies
- ☐ clean

Condition of the Exudation
- ☐ bloodied
- ☐ bloodied-serous
- ☐ purulent
- ☐ dried-up
- ☐ odour

Extent of bacterial Invasion and sign of Infection ______________________

How old is the wound? ______________________

plantar
dorsal
posterior left
posterior right
left
medial
right
left
Lateral
right

Date Signature

SAMPLE

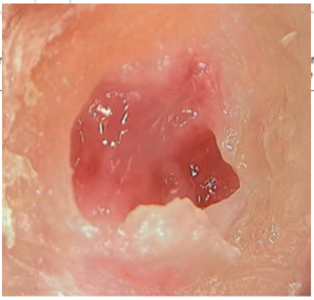


Image 3.27 Written wound documentation

Images 3.28 to 3.30 Wound documentation examples

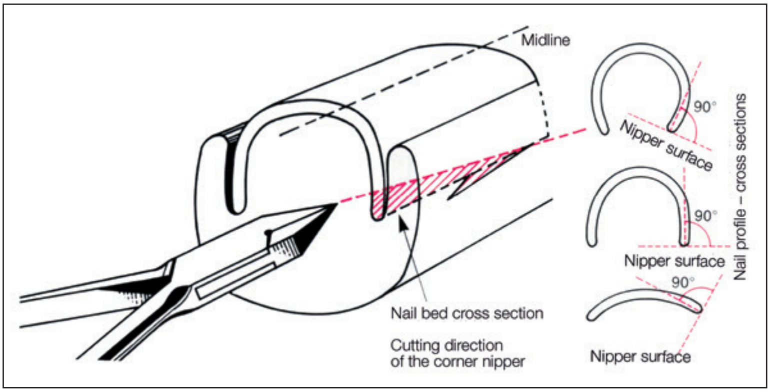


Image 3.31
Corner nipper cutting direction

Source:
Klaus Grünewald, Theorie der medizinischen Fußbehandlung, tome 1, 4th ed. 2012, Verlag Neuer Merkur

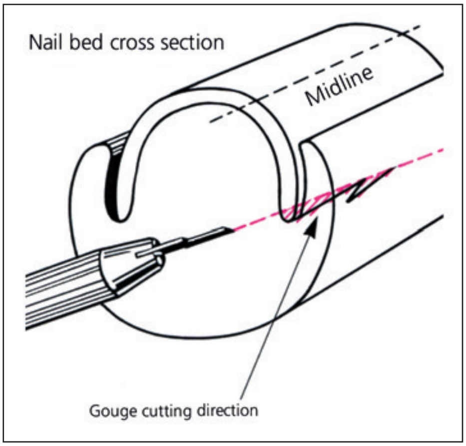


Image 3.32 Gouge cutting direction

Source: Klaus Grünewald, Theorie der medizinischen Fußbehandlung, tome 1, 4th ed. 2012,, Verlag Neuer Merkur

not to remove too much and not to leave sharp nail edges behind (images 3.31 to 3.34).

- Remove hyperkeratosis carefully from the sulcus with Prontoman spray (allow the spray to take effect for two minutes and, if needed, insert a thin spray-impregnated tamponade in the nail fold).
- For wound treatment in the sulcus area, use the following disinfectants: ProntoMan gel, octenisept, Dolerma antiseptic nail fold oil, isopropyl 70 %, Calendula or colloidal silver.
- To stop potential bleeding, insert Clauden gauze or a gauze impregnated with a Policresulen concentrate solution, Copoline, fleece or cellulose strip into the fold and remove after three minutes. Nasal drops can also be used and are especially suitable for diabetic patients.
- After straightening the nail margin and removing sharp edges, insert Copoline or Ligasano tamponade in the nail fold.
- Apply nail correction braces, such as adhesive braces (BS brace, Gold brace (Goldstadt brace), Onychoclip brace, Erki brace) or spring-wire braces (Ross Fraser, 3TO, VHO, ORa). For how to properly attach the individual braces, see chapter 5.
- Apply a sterile dressing on the tip of the toe and ensure that there is no pressure applied to the toe.
- See the patient every day until the infection has subsided; following sterile guidelines is crucial.
- To promote faster healing, the patient can apply Spirularin nail serum on the nail and take frequent footbaths with sage, camomile, bran, thyme, horsetail or sea salt (one tablespoon in five liters of water at 37° to 38° C).

Prophylaxis

- correct cutting of the nail
- wearing properly fitting footwear
- careful cleaning of the sulcus with hyperkeratosis and clavus removal

Hygiene

- All infections are vulnerable to the invasion of the MRSA bacterium (methicillin-resistant Staphylococcus aureus). According to the Robert Koch Institute (German federal government agency and research institute responsible for disease control and prevention), the Staphylococcus bacterium has multiplied substantially. In 20% of the population, it is constantly detectable and in 50% of the population it is temporarily detectable. MRSA poses a high risk for patients with wound infections and a weakened immune system.

The German Federal Ministry of Health reports: "In Germany alone 400,000 to 600,000 people acquire nosocomial infections. These commonly called hospital-acquired infections are acquired during in-house or out-patient treatments claiming the lives of 7,500 to 15,000 people annually while traffic accidents are responsible for 3,475 deaths."

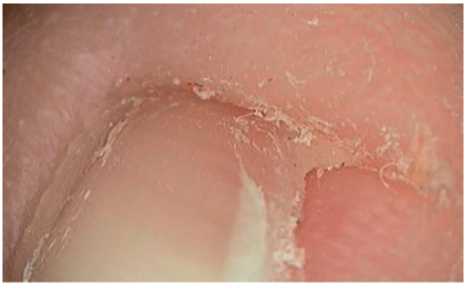


Image 3.33 Unguis incarnatus with painful inflammatory response (medial)

Image 3.34 After removal of the ingrown nail corner

Image 3.35 Pressure relief

Images 3.36 and 3.37
Improperly performed Emmert's procedure

Risk factors for the practice

1. latent risk to the podiatrist's own health and the health of other patients due to infection and bacteria transfer
2. the detection of MRSA within a practice can lead to its temporary closing; infected staff members must take sick leave and are not allowed to be in the practice environment
3. following the hygiene guidelines for patients infected with MRSA is crucial

The above risk factors demand the following special treatment and hygiene standards:

- full anamnesis
- MRSA hygiene plan and implementation of hygiene measures in the practice environment
- offering and recommending care and medical products (e.g., Spirularin foot gel, mousse and cleaning lotions, skinicer® sedative shampoo) to patients and staff members since these products protect against Staphylococcus aureus and, in particular, MRSA.
- Proper preventative measures, such as frequent hand disinfection and following standard infection control guidelines, help prevent the spread of MRSA infections (image 3.38).

The guideline "At home follow-up care recommendation for patients with unguis incarnatus" can be found on the following page.

Image 3.38 Hand disinfection