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Hand infections

S Pillai[1]
E Campbell[1]
A Mifsud[2]
SV Vamadeva[1]
GS Pahal[1]

Author details can be found at the end of this article

Correspondence to:
S Pillai; sujatha.pillai@nhs.net

Abstract

The hand is an extremely versatile organ adapted for fine tasks with various clinicoanatomical compartments. This article reviews the types of common hand infections that present to the emergency department and/or hand surgeon, with relevant investigations and strategies for diagnosis and treatment, with the emphasis on distinguishing between superficial and more serious infections.

Key words: Atypical; Compartment; Felon; Hand; Hand infections; Spaces; Tenosynovitis; Whitlow

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Background

Hand infections are a common problem, and most often occur following traumatic injury. Soft tissue lacerations account for 11% of the 23.57 million annual emergency department presentations in the UK, and a significant proportion develop subsequent infection (Baker, 2017). The seminal work of Allen Kanavel in the early 20th century formed the groundwork for the management of hand infections. His recommendations were largely based on an understanding of the complex anatomy of the hand, with its various compartments that demonstrated the pathways along which deep infections could track, often from seemingly minor trauma. In superficial infections, antibiotics alone can be curative. The mainstay of treating deep infections in the hand is surgery to drain pus or excise infected tissue. Organism-specific antibiotics are important adjunctive treatments and have markedly reduced the morbidity and mortality of hand infections (Koshy and Bell, 2019). However, with the rise of antibiotic resistance, the value of this important treatment modality is being jeopardised.

Epidemiology

The sector of the population that most commonly presents with hand infections is young active people, who often defer treatment owing to the seemingly innocuous nature of the injury. The epidemiology of hand infection includes people in a wide range of professions, from farmers, manual workers, veterinary and medical staff, to immunocompromised individuals such as patients with diabetes, intravenous drug users and patients on long-term chemotherapy or immunotherapy (Flevas et al, 2019).

Aetiology and microbiology

The aetiology of hand infections is important, as it guides the treating physician towards the nature of the organism that may be involved and consequently the immediate and long-term management needed. Table 1 outlines the common aetiologies with their corresponding causative organism(s). In the majority of infections *Staphylococcus aureus* is the most common offending organism, accounting for 30–80% of culture positive infections, followed by *Streptococcus* species, primarily *Streptococcus pyogenes* or Group A haemolytic streptococcus (Flevas et al, 2019). Open injuries, such as those caused by animal or human bites, usually harbour a mixture of aerobic and anaerobic organisms. Injuries to the knuckle following a punch to the open mouth are often followed by mixed infections. Hand infections can be broadly divided into superficial and deep infections. Table 2 illustrates the common types of infections presenting in each group alongside their causative organism(s). Presenting features and management of these infections are outlined later in the article.

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Table 1. Common aetiologies and causative organisms in hand infections

Aetiology	Type of infection	Predominant organisms
Domestic injury	Usually single organism (Gram positive)	*Staphylococcus aureus* *Streptococcus pyogenes*
Animal bite	Usually polymicrobial (Gram positive and negative)	*Pasteurella multocida* (commonly cat bites) *Pasteurella canis* (dog bites) Staphylococci Streptococci Anaerobes including: *Fusobacterium* spp. *Prevotella* spp. *Eikenella* spp. *Capnocytophoga* spp. (quite rare) *Bartonella hensellae* (cause of cat scratch disease. However, quite rare on the hand, where one sees a small lesion, but associated with regional lymphadenopathy) Franciscella (not seen in UK and Ireland)
Atypical (for example, aquamarine or bird handlers)	Atypical mycobacteria	*Mycobacterium marinarum* *Mycobacterium avium intracellulare*
Chronic infections	Fungi	Candida spp. Dermatophytes: Tricophyton Microsporum Epidermophyton Sporothrix
Immunocompromised patient	Fungi, polymicrobial	Candida Dermatophytes: Tricophyton Microsporum Epidermophyton *Capnocytophoga canimorsus* Meticillin-resistant *Staphylococcus aureus* (rare in the UK currently, more prevalent in the USA)

S. aureus is the commonest cause of infections in the hand. In the UK, most strains are susceptible to flucloxacillin and are termed MSSA (methicillin-sensitive *S. aureus*). They are susceptible to most other β-lactam antibiotics such as co-amoxiclav and ceftriaxone. They are usually susceptible to many other chemically unrelated antibiotics such as clarithromycin, clindamycin, co-trimoxazole and tetracyclines. In some geographical locations, such as in parts of the USA, there is increasing incidence of meticillin-resistant *S. aureus* (MRSA). These are resistant to all commonly-used β-lactam antibiotics and are frequently resistant to most other antibiotics, usually only retaining susceptibility to agents such as vancomycin, teicoplanin, daptomycin and linezolid. Risk factors for developing MRSA infections include intensive care unit stay, long-term antibiotic treatment, surgical procedures, lengthy hospitalisation, and immunocompromised individuals, such as those with diabetes mellitus or a history of intravenous drug use. Patients with MRSA often require a prolonged stay in hospital, with the use of stronger antibiotics such as linezolid (Flevas et al, 2019).

Table 2. Common types of infection presenting in the hand

Type of infection	Name of infection	Common associated organisms
Superficial	Cellulitis	*Staphylococcus aureus* *Streptococcus pyogenes*
	Lymphangitis	*Strep. pyogenes* *S. aureus*
	Paronychia	*S. aureus* (most common) Candida spp.
	Felon	*S. aureus*
	Whitlow	HSV1 HSV2
	Onychomycosis	Trichophyton Epidermophyton Microsporum
Deep	Synovial space	*S. aureus* Streptococcus spp.
	Hand spaces	*S. aureus* *Strep.pyogenes*
	Hand compartments	*S. aureus* *S. epidermidis* *Strep. pyogenes*
	Necrotising fasciitis	Mixed flora
	Septic arthritis	*S. aureus* *Neisseria gonorrheae*
	Osteomyelitis	*S. aureus* Streptococcus spp. *Mycobacterium tuberculosis*

Mycobacterial infections of the hand are very rare. When seen, they are commonly present in marine handlers (*M. marinarum*) as an ulceration or discharging sinus that is often resistant to conventional antibiotics that should prompt investigation for mycobacteria.

Animal bites show specific organisms as well: *Pasteurella canis* infection almost invariably follows dog bites, *Pasteurella multocida* can follow dog or cat bites. While dog bites present with more open contaminated wounds as a result of shearing, cat bites are innocuous and present with flexor sheath or deep space infections owing to a smaller site of inoculation that allows deeper spread of infection.

In many regions of the northern hemisphere, rabbits can become infected with *Francisella tularensis*. This is a highly contagious organism and any contact with an infected rabbit, including bites, can give rise to infection. In western Europe, this infection is most commonly seen in the forests in Scandinavia. It is not seen in the UK and Ireland. Systemic infection is common and could lead to fulminant sepsis in the immunocompromised patient, although this is rare (Flevas et al, 2019; Schmidt et al, 2019).

Pathophysiology

The pathophysiology of hand infections and their evolution is dependent on the mode of inoculation, and the immune status of the patient. Following inoculation, there is an

inflammatory response. The subsequent immune response and the actions of cytokines and enzymes lead to tissue breakdown and oedema, which contribute to local pressure that further aggravates the pain response. This progresses to a purulent phase, characterised by tissue necrosis. As the point of inoculation is often not visible, the bacterial load is low, and hence the systemic response (fever, rigour, elevated white cell count) is not evident in more than 75% of hand infections (Teo and Chung, 2019). Notably, some pathogens are known to incite severe host response depending on the inoculum load. Low inocula that classically lead to severe infection include *Strep. pyogenes* (Group A streptococci).

The presentation and course of infection varies in immunocompromised individuals, patients with diabetes, patients with HIV or low CD4 counts, and intravenous drug users. They are susceptible to polymicrobial, atypical and fungal infections, and can rapidly progress to fulminant infections, leading to higher mortality and morbidity in cases of delayed or ineffective treatment (Schmidt et al, 2019).

Relevant anatomy

A brief overview of the anatomy of the hand helps understand the methods by which infections can track. The hand is composed of the following anatomical divisions: the nail bed complex, the synovial spaces (flexor and extensor sheaths, radial and ulnar bursae) and potential spaces (dorsal and volar).

Nail bed

Figure 1 illustrates the structure of the nail bed complex comprising the nail plate (translucent portion of the nail) and perionychium. The perionychium is in turn divided into the nail bed and the soft tissue surrounding it (paronychium). The pulp space dorsal to this consists of a closed compartment with various septations that extend to the periosteum of the digit.

Compartments and spaces of the hand

Anatomically, the hand is made up of eleven compartments – thenar, hypothenar, mid-palmar and adductor compartments, with three volar (Figure 2) and four dorsal interosseous compartments (Figure 3). The respective synovial sheath to each of the flexor tendons consists of two layers and communicates with the radial and ulnar bursae in the hand.

At the level of the wrist, there are six extensor compartments, each with their own sheath.

While there can be anatomical variation between individuals (approximately 15%), infection in any compartment will lead to a build-up of significant pressure, that if untreated can cause tendon necrosis and/or rupture.

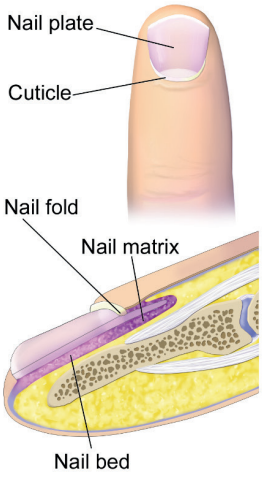

Figure 1. Anatomy of the nail bed.

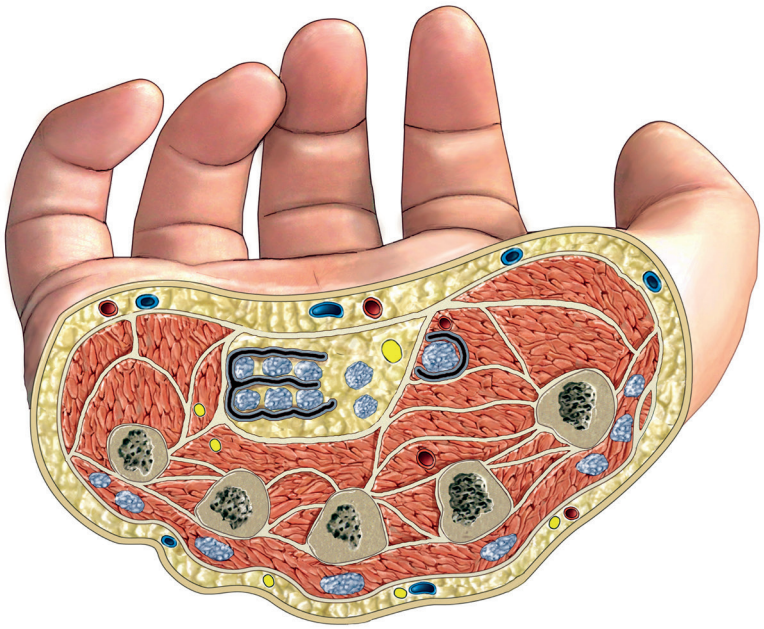

Figure 2. Anatomy of the volar hand compartments.

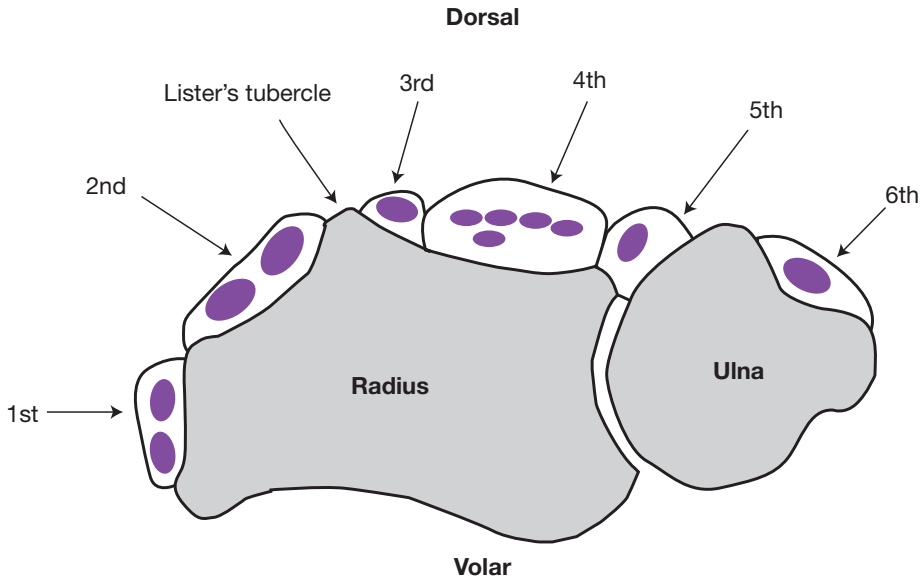

Figure 3. Anatomy of the dorsal hand compartments. 1st = abductor pollicis longus and extensor pollicis brevis: attaches to base of proximal phalanx; 2nd = extensor carpi radialis brevis and extensor carpis radialis longus; 3rd = extensor pollicis longus; 4th = extensor digitorum communis and extensor indicis proprius; 5th = extensor digiti minimi; 6th = extensor carpi ulnaris.

In addition to these compartments, there are spaces within the hand and forearm – thenar, mid-palmar, hypothenar, dorsal and Parona spaces. These spaces are distinct from compartments in that they often encompass more than one compartment and tend to have loose boundaries.

Figure 4 demonstrates the surface anatomy of the mid-palmar and thenar spaces, as well as the ulnar and radial bursae and the space of Parona.

Furthermore, there is the hypothenar space, which contains the hypothenar muscles. Unlike the mid-palmar or thenar spaces, it contains no traversing flexor tendons. Finally,

there is the dorsal subaponeurotic space, which can be divided into superficial, deep and interdigital web zones.

Failure to treat infection within these spaces can lead to propagation of infection into radial or ulnar bursae. From here, infection can spread into other compartments in the hand or ascend proximally into the forearm via the space of Parona (Flevas et al, 2019). If infection spreads from one side of the hand to the other via the space of Parona, a horseshoe abscess can form.

Patient assessment

History

A detailed history is important, as this can guide the clinician to initial antibiotic choice while awaiting results from microbiological samples. Important features to ascertain in the history include the patient's occupation, hand dominance, location and radiation of pain, duration, progression, and presence of systemic signs, aggravating and relieving factors. Recurrent episodes may suggest a different aetiology, such as a reactive arthritis, gout or pseudogout (Ahlawat et al, 2017). It is important to check if antibiotic treatment has been commenced earlier for an indolent infection as this may alert the treating clinician about the need to start a different regimen or investigate further.

Examination

Hand examination should be thorough as subtle clinical signs can help distinguish superficial from deep infections. Superficial infections are often characterised by visible swelling and erythema, which can be used to demarcate the extent of infection and monitor response to therapy. Fluctuance in a swelling is also an important clinical sign, suggesting its amenability

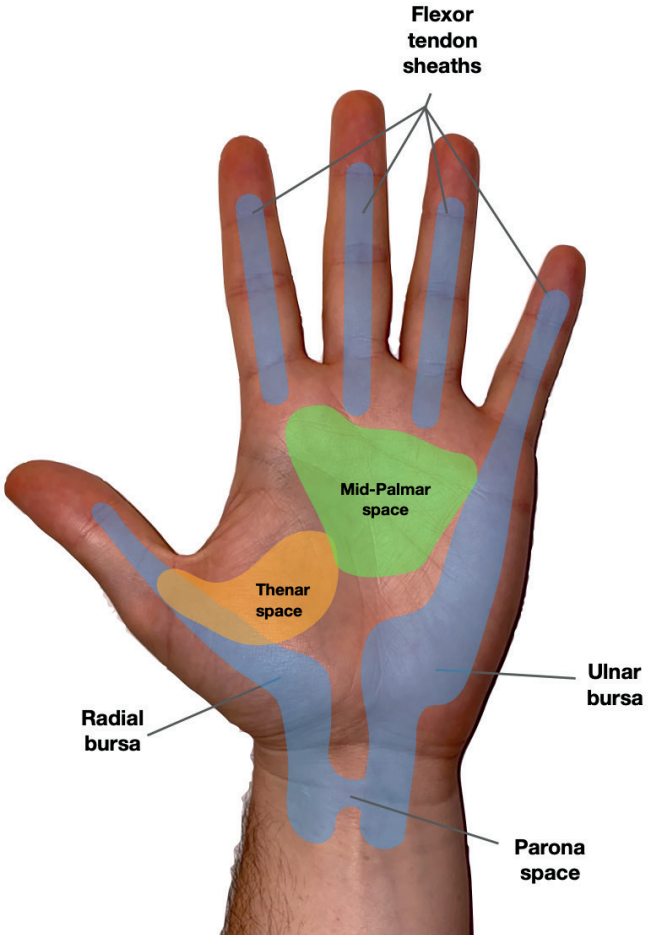

Figure 4. Spaces of the hand.

to surgical drainage. Deeper infections are often associated with restriction of movement and deformities of the fingers, for example a finger held in flexion. Obvious swelling may not be present, although proximal lymphangitis is a warning sign of spread. Kanavel (1921) discussed four cardinal signs suggestive of a flexor sheath infection: tenderness over the flexor sheath, fusiform swelling of the digit, affected finger held in fixed flexion, and pain on passive extension.

Investigations

Investigations that aid clinical examination include markers of acute inflammation (C-reactive protein, white cell count), blood culture, aspirated fluid or pus where there is a focus of purulent material (swabs of wound should only be submitted if pus cannot be collected), radiographs where there is clinical suspicion of osteomyelitis and/or magnetic resonance imaging.

Management

The mainstay of treatment of infections in the hand is drainage of any pus. However, most hand infections can be managed with antibiotics, splinting and elevation. Antibiotics are commenced at first presentation and changed as required when microbiology results are available. Hand splintage in the 'position of safe immobilisation' is crucial in patients presenting with an infection. This ensures the collateral ligaments of the various small joints of the hand are kept at maximum length and therefore avoids subsequent stiffness and contracture (Dobson et al, 2011). If a patient is systemically unwell, they need admission for intravenous antibiotics and possible surgical intervention, otherwise they can be considered for outpatient management and follow up at 48 hours in a plastic surgery dressings clinic. Tables 3 and 4 outline the presenting features and key management points to consider for the common types of superficial and deep infections of the hand. Figures 5–16 illustrate how these infections present. Some infections warrant surgical intervention, as outlined in the next section.

Table 3. Presentation and management of common superficial hand infections

Infection	Presentation	Management
Bite wound	Localised swelling and erythema with obvious bite wound and/or fluctuance at site (Figure 5)	Debridement of bite wound Antibiotics Splint
Lymphangitis	Swelling and red streaks running along lymphatic vessels from focus of infection (Figure 6)	Hand elevation Resting splint Antibiotics
Paronychia	Swelling and discharge over the soft tissue around the nailbed, localised and tender to touch (Figure 7)	Antibiotics Surgical drainage and/or removal of nail plate
Onychomycosis	Chronic flattening and discolouration of the nailplate. Often no discharge or swelling (Figure 8)	Long-term antifungal therapy
Felon	Swelling of the pulp space of the digit with tenderness out of proportion to swelling (Figure 9)	Elevation Antibiotics Surgical drainage
Whitlow	Painful vesicular eruption near the pulp space (Figure 10)	Aciclovir
Cellulitis	Diffuse swelling and erythema over the affected portion of the limb (Figure 11)	Elevation Splinting Antibiotics

Table 4. Presentation and management of common deep hand infections

Infection	Presentation	Management
Synovial space (flexor tenosynovitis)	Kanavel's signs of flexor sheath infection (described earlier) (Figure 12)	Surgical emergency – needs urgent incision and drainage Antibiotics Splint
Hand compartments	Pain, swelling, tenderness often restricted to the anatomical compartment involved. Thenar – widely abducted and swelling in first webspace (Figure 13) Mid palmar – loss of palmar concavity with partial flexion of ring and middle fingers and extension of those digits Hypothenar – abducted fifth digit with partial flexion and swelling of ring and fifth fingers	Incision and drainage or non-operative management Antibiotics Splint
Hand spaces	More diffuse swelling, pain, erythema and loss of function which may involve more than one anatomical compartment (Figure 14)	Urgent incision and drainage or non-operative management Antibiotics Splint
Necrotising fasciitis	Rapidly evolving erythema, swelling and tenderness of the limb, often accompanied by systemic signs (fever, chills) and localised compartmental pressure in later stages (pain, pallor, decreased pulse, paraesthesia) (Figure 15)	Surgical emergency – needs fluid resus, broad spectrum antimicrobial therapy, sepsis workup, urgent early debridement, repeat debridements until resolution followed by tissue coverage including split skin grafts or flaps
Septic arthritis	Destruction of joint capsule, manifesting with pain, deformity and loss of function (Figure 16)	Surgical drainage to aid diagnosis, appropriate antibiotic therapy, involvement of rheumatology for medical management
Osteomyelitis	Tenderness, formation of a discharging sinus, and relative resistance to short course of antibiotics (Figure 17)	Long-term antibiotic therapy guided by microbial tissue cultures (usually >6 weeks), may require surgical amputation of the affected limb or digit

Surgical management

The following conditions require surgical management: paronychia, felon, flexor tenosynovitis, septic arthritis, necrotising fasciitis, and osteomyelitis. The principles are outlined below.

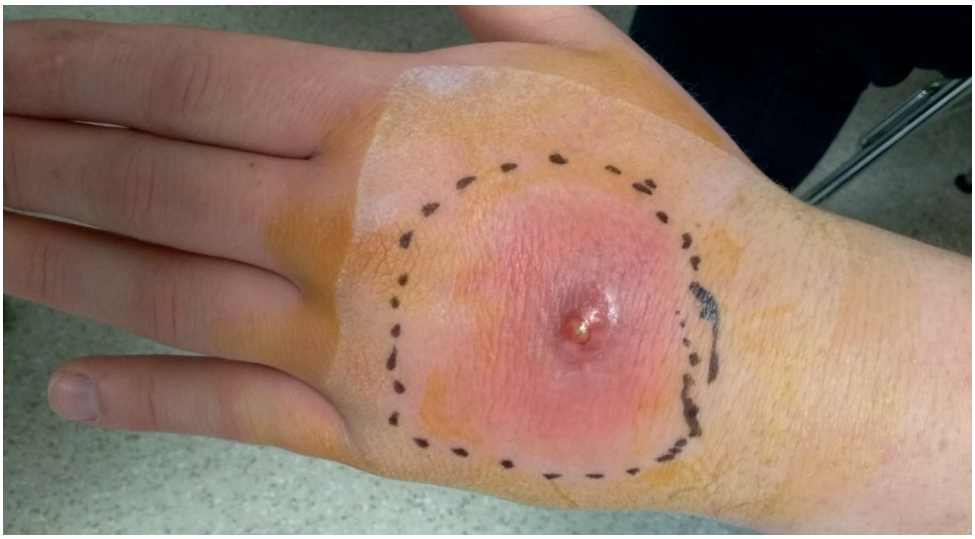

Figure 5. Dog bite on the dorsal aspect of the hand.

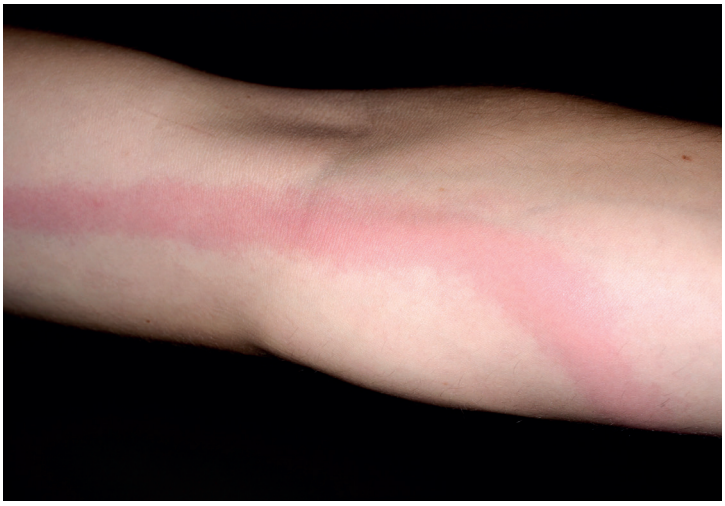

Figure 6. Lymphangitis.

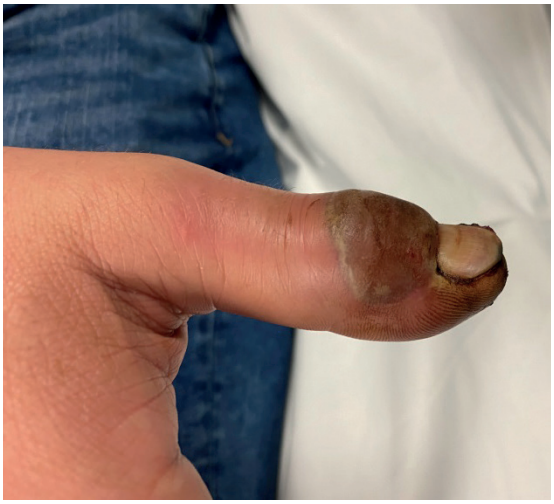

Figure 7. Paronychia.

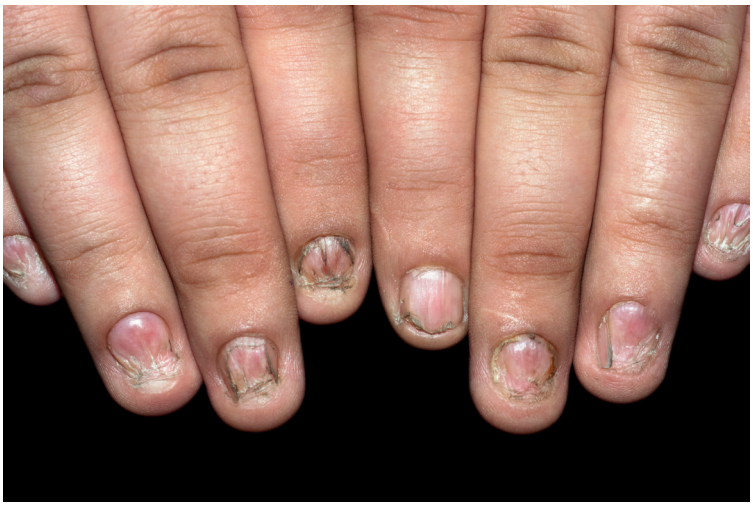

Figure 8. Onychomycosis.

Paronychia

This is arguably the most common superficial infection of the hand, and can present in an acute or chronic fashion, often following a trivial penetrating injury to the finger. The infection involves the soft tissue surrounding the nail bed, and often presents with an oedematous swelling around the nail that in the acute setting can be managed with surgical drainage under a digital block with antibiotics (Figure 7). A more complex infection or a chronic, recurring form (often seen in people who work as dishwashers, with multiple organisms), may necessitate removal of the nail with marsupialisation of the soft tissue if required, and use of antibacterial or antifungal agents.

Felon

The pulp space of the finger is composed of subcutaneous tissue divided by septa that extend from the epidermis to the periosteum, with a nutrient artery supplying the epiphysis of the bone before dividing into smaller interseptal branches. A felon, which is an acute pulp space infection of the finger (Figure 9), can result in compartmental pressure that may result in thrombosis of the interseptal vessels and diaphyseal necrosis if not managed adequately. This often manifests with swelling of the pulp space and an acute throbbing pain that disturbs the patient from sleep. Radiographs may be useful to detect any underlying foreign body. Treatment involves hand elevation, warm soaks, surgical drainage, and antibiotics tailored by culture results of any purulent material expressed. A pulp space infection with a focal bulbous fluctuation can be incised to reduce the incidence of digital ischaemia and

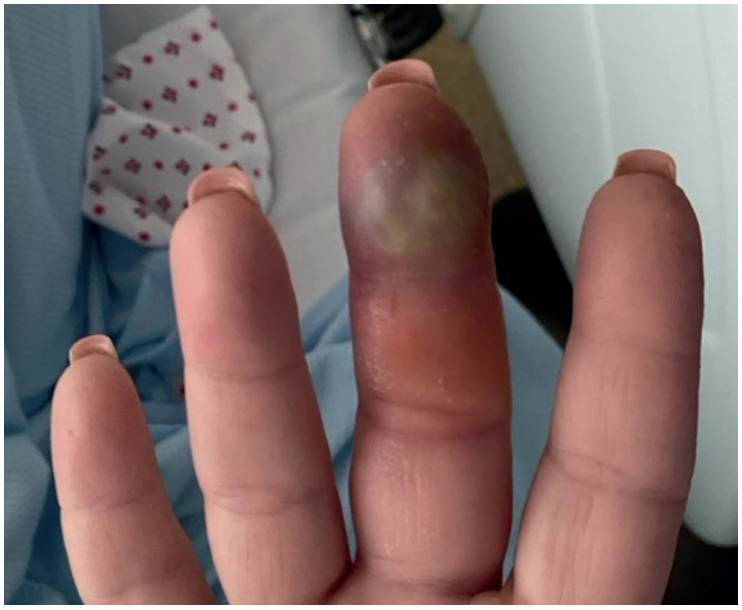

Figure 9. Felon.

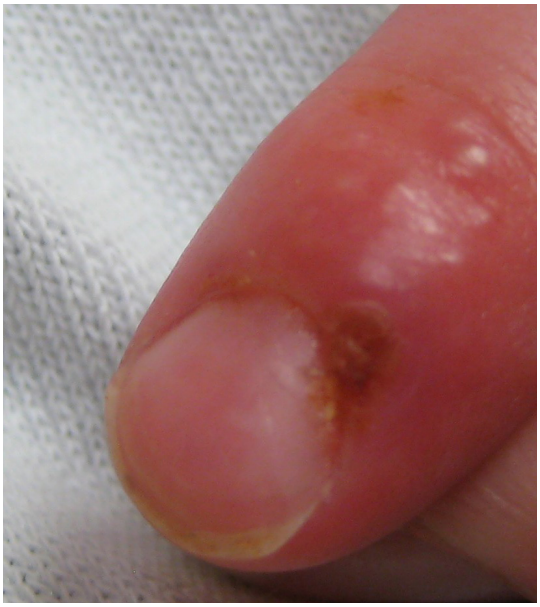

Figure 10. Whitlow.

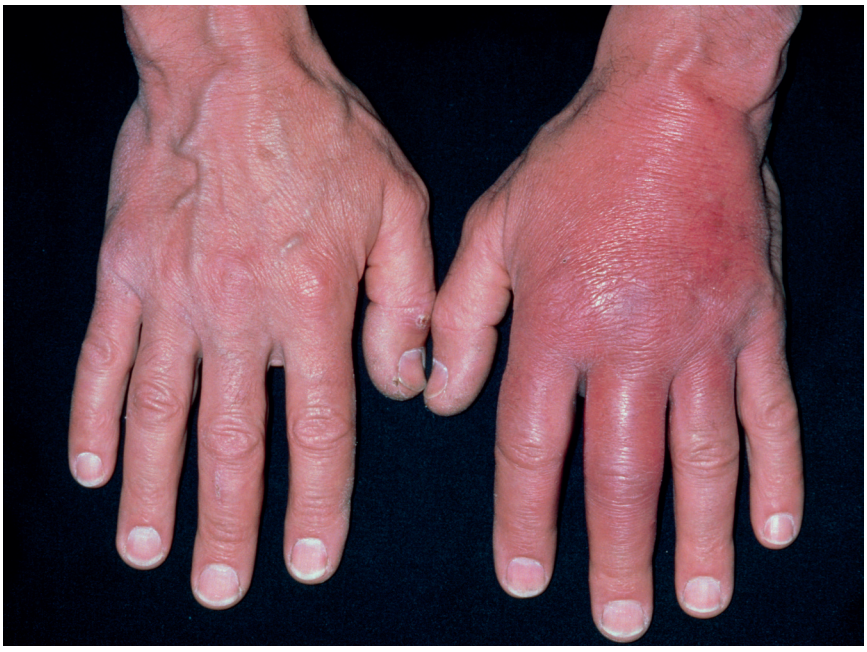

Figure 11. Cellulitis.

necrosis, with care taken to incise parallel to the course of the digital artery and release fascial septations (Ahlawat et al, 2017).

Synovial infections

These include pyogenic tenosynovitis, detected clinically with the cardinal signs of Kanavel. The synovial sheaths are in communication with the radial and ulnar bursae, and are a hotbed for microbes to proliferate, as they are poorly vascularised. While synovial sheath infections in their earlier stage are restricted to their specific anatomical compartments in the hand, lack of recognition and delayed treatment can lead to rupture into the spaces of the hand. Surgical drainage of the affected space is often required for successful resolution: this can be via a single incision with open washout or a couple of smaller incisions with closed space irrigation (Giladi et al, 2015). Factors that lead to poorer outcomes include late presentation, diabetes, peripheral vascular disease and ischaemic compromise on presentation (Osterman et al, 2014; Ahlawat et al, 2017; Flevas et al, 2019).

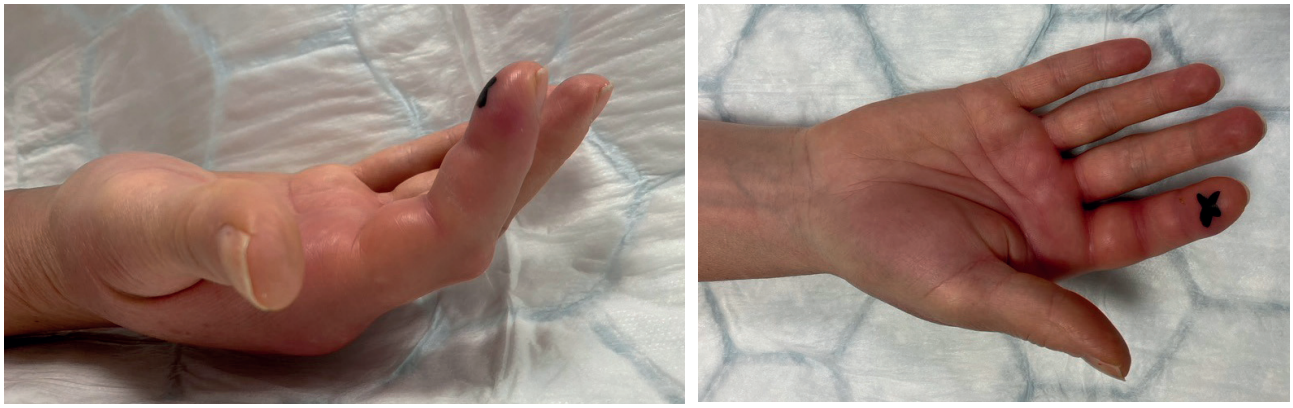

Figure 12. Flexor sheath infection of the index finger. a. Finger held in flexion. b. Fusiform swelling of affected index finger.

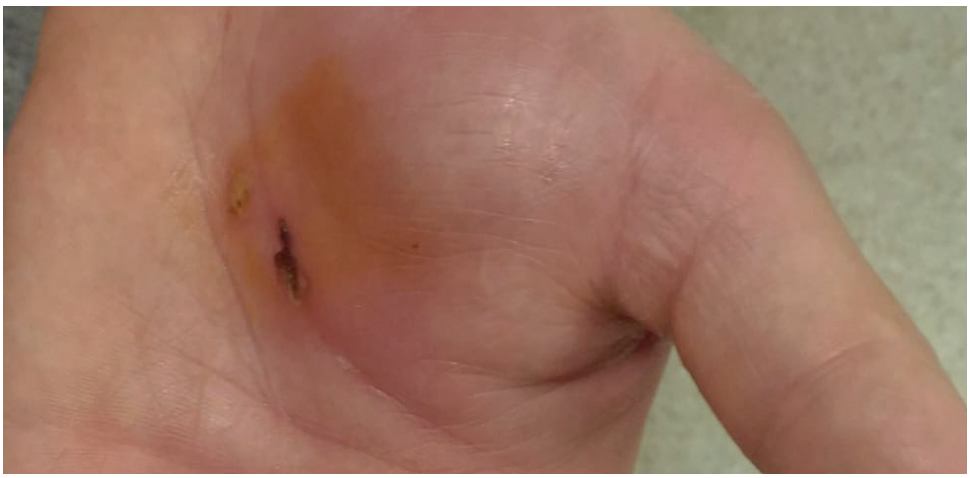

Figure 13. Thenar space infection (with visible swelling over the thenar space and abducted thumb).

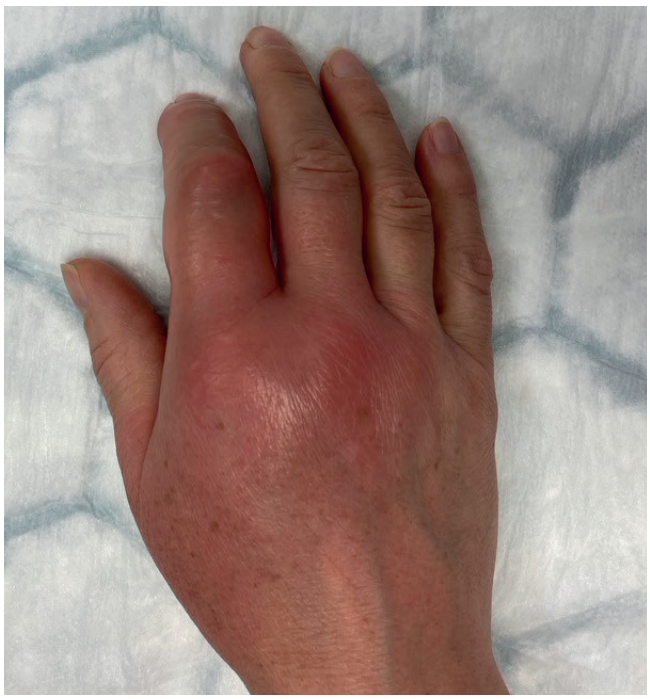

Figure 14. Dorsal space infection. Note the spread from the dorsal space over the index finger.

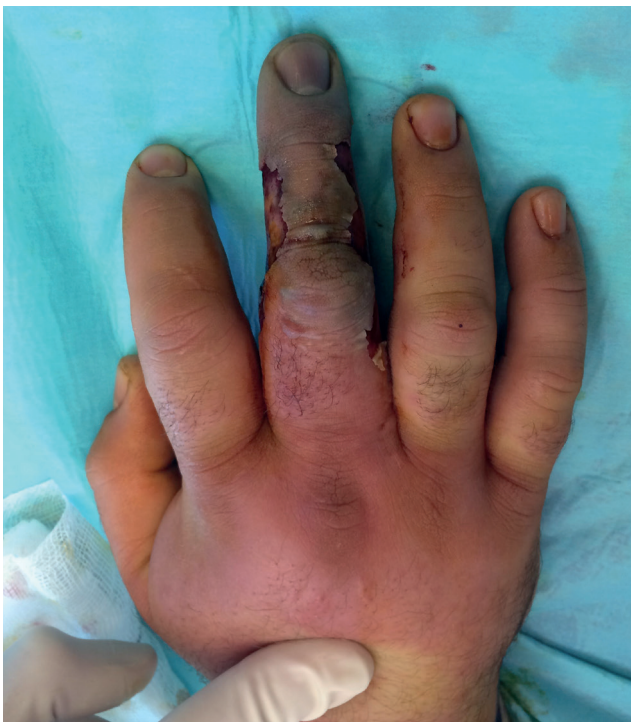

Figure 15. Necrotising fasciitis of the right middle finger.

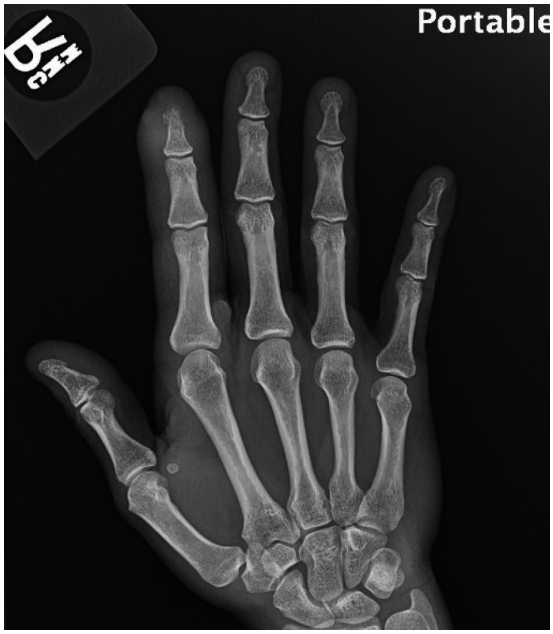

Figure 16. Osteomyelitis.

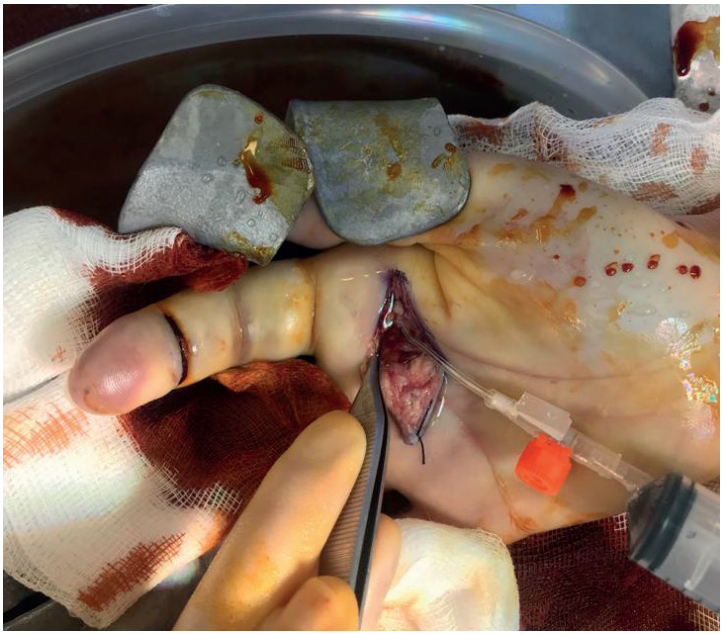

Figure 17. Irrigation of a flexor sheath infection of the index finger.

Hand space infections

There are three spaces in the hand – thenar, mid-palmar and hypothenar – which can be involved in hand space infections, each with distinct manifestations. Thenar space infections present with a widely abducted thumb, swelling in the first web space and severe pain on further abduction (Figure 13). Drainage can be made with a volar or dorso-volar incision, with care to avoid the neurovascular bundle. Mid-palmar space infections present with loss of palmar concavity with partial flexion of the ring and middle fingers, with pain on extension of these digits. Drainage is achieved through a palmar incision: however, it is worth noting that these infections may rupture into Parona's potential space in the ventral forearm (Koshy and Bell, 2019). Hypothenar infections present with less swelling and often do not involve digits or tendons, with drainage being achieved by a volar longitudinal incision (Teo and Chung, 2019).

Necrotising fasciitis

This is the most emergent of infections in the hand and is almost always bacterial in origin: the term is reflective of a fulminant infection around and deep to the fascia, resulting in oedema and, often, necrosis of the muscles. This can evolve into rapid proximal spread or focally into deeper compartments, resulting in raised intra-compartmental pressure with subsequent thrombosis of the vessels, neural compromise, and loss of function. Investigations, both biochemical and radiological, aid the clinical suspicion of necrotising fasciitis (Figure 15), which often manifests similar to cellulitis: however, severe pain, lack of response to antibiotics, bullae, systemic signs and rapid spread should prompt emergent recognition with initial fluid resuscitation, blood cultures, broad spectrum antimicrobial therapy and surgical drainage with or without fasciotomy. Repeated drainage and dressing is often required until resolution and healing occurs, and if there is significant loss of tissue, a secondary procedure may be required to reconstruct the defect (Ahlawat et al, 2017).

Septic arthritis

This is a deep space infection of the fingers that results following proximal spread from a paronychia or a felon and involves the distal or proximal interphalangeal joints. It results in restricted mobility of the finger, with a deformity, and is often difficult to treat. Septic arthritis of the fingers and hand is a rare entity, and care must be taken to distinguish from mimics such as gout, pseudogout and Lyme disease, particularly in recurrent cases. Clinicians should have a high index of suspicion in patients presenting with a small puncture wound over the metacarpophalangeal joint and history of an altercation: this is a 'fight

Key points

- Hand infections are common: prompt diagnosis and management are essential to prevent significant functional morbidity.
- Treatment of superficial infections is typically conservative with antibiotics and elevation alone.
- Deep space infections are often the result of inadequately recognised or treated superficial infections and commonly require surgical intervention.

bite' with inoculation of bacteria into the joint requiring surgical washout until proven otherwise. While antibiotic therapy is guided by results of fluid cultures, and surgical drainage is a valuable aid to those cases with deep-space purulent loculations, patients must be warned that a degree of joint stiffness is likely to persist permanently despite optimal medical management.

Osteomyelitis

This is often the result of a deep space infection in the hand or finger that is inadequately treated, or where the organism is resistant to broad-spectrum antimicrobial therapy. Radiology reveals involvement of the underlying bone (Figure 16), with a classic mottled appearance on radiographic imaging or magnetic resonance imaging and overlying soft tissue shadowing. Clinical manifestations include warmth, swelling, bony tenderness and, on occasion, sinus tracts. While an attempt has been made by some authors to salvage the digit with long-term antibiotic therapy (>6 weeks), more often than not surgical debridement with or without amputation of the offending digit is required followed by antibiotic therapy for at least 4–6 weeks (Patel et al, 2014; Teo and Chung, 2019).

Conclusions

Hand infections are a common cause of morbidity in young, active patients. Prompt diagnosis and initiation of appropriate treatment is essential to prevent worsening infection, sepsis, and loss of function. This article provides an overview of the common hand infections seen by the hand surgeon and includes the general management principles of which frontline clinicians should be aware.

Author details

[1]Department of Plastic Surgery, Royal London Hospital, London, UK

[2]Department of Microbiology, Whipps Cross Hospital, London, UK

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Conflicts of interest

The authors declare no conflicts of interest.

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