

## INTRODUCTION

**T**he hand plays an important role in social functioning, expression, productivity and interactions with our surroundings. (*Lee et al., 2014*).

Minor traumatic injuries can result in a significant stiffness, loss of hand function and long-term consequences for patients' quality of life (*Cheung et al., 2013*).

The fingertip is the part of the digit distal to the insertion of the flexor and extensor tendons into the distal phalanx. It comprises the nail complex and the glabrous pulp, which are richly vascularized and innervated (*Mancini et al., 2013*).

*Miranda et al in 2016* stated that stable, mobile and sensate fingertips are important to the overall function of the hand. Fingertip injuries are as much as 30% of all accidents and emergency department visits. *Lee and colleagues in 2014* mentioned that these injuries can be caused by a variety of factors, including trauma, infection, burn, ischemia and neoplasm. Among these, injuries that are caused by trauma are the most common.

Classification of fingertip was described by many authors but the most common was described by Tamai, Hirase and Allen. Among them, the Tamai classification in 1982 is the most frequently used. Tamai zone I extends from the lunula to

the distal tip, while Tamai zone II extends from the DIP joint to the lunula.

Fingertip injuries may be transverse, oblique, volar or dorsal and may result in an exposed terminal phalanx or extensive loss of soft tissue bulk; both of which warrant a flap coverage (*Garg et al., 2019*).

*Sungur in 2012* mentioned that the primary treatment objectives should include maintaining the length of the finger, soft tissue coverage provision of a bed for growing nails. In addition, the treatment should obtain a satisfactory cosmetic appearance with protection of the joint function. Coverage of the defect must be considered in cases if there's no possibility for replantation (*Gellman, 2009*).

Different fingertip reconstructive methods are reported including skin grafts, local flaps (as V-Y advancement flap and homodigital flap), regional flaps (as cross-finger flap, thenar flap and island flaps), distant flaps(as abdominal and groin flaps), free flaps and partial toe to hand "finger" transplantation (*Lee et al., 2008*).

Various methods of sensate flaps for fingertip reconstruction have been reported and the flap technique is selected based on the defect size, amputation level, plane of injury, nail preservation and donor site defect (*Takeishi et al., 2006*).

In addition, patient age, general medical health and the occupation are also considered when a flap is planned (*Rehim et al., 2015*).

In minor injuries, nonsurgical treatment by occlusive dressing, impregnated gauze dressings also aims to restore fingertip function as regarding fine sensation, skin stability allowing the fingertips to grasp objects, satisfactory appearance (*Lasserre et al., 2010*).

Replantation is the primary option for preserving the function of the finger. Recently, replantation has been very successful and the recent development of related microsurgical techniques has demonstrated good results (*Huan et al., 2016*).

A successful soft-tissue reconstruction isn't measured only by the rate of flap survival or the degree of improvement of hand function, But also by soft-tissue coverage that provides optimal functional, aesthetic outcomes and minimal donor-site morbidity (*Friedrich, 2009*).

In this retrospective study we'll evaluate soft tissue coverage after fingertip injures using different flap techniques and compare results as regarding the incidence of complications and the patient satisfaction from the aesthetic point of view and the functional outcome.

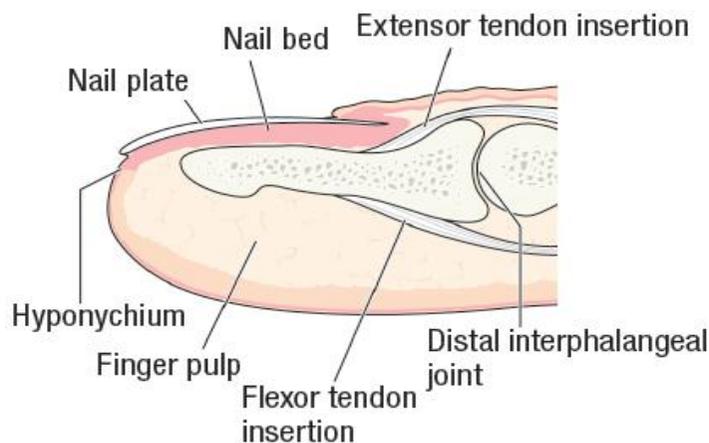
## **AIM OF THE STUDY**

**I**n this study we will assess and compare the outcome of different modalities of soft tissue coverage using flap techniques in cases of fingertip injuries. we will discuss the incidence of neuroma, necrosis, donor site morbidity, joint stiffness, sensory impairment and the patient's satisfaction.

## Chapter 1

# FINGERTIP ANATOMY

The fingertip is defined as the portion of finger distal to the insertion of the flexor digitorum profundus and the extensor tendons on the distal phalanx, or the flexor pollicis longus when referring to the thumb as shown in *figure (1)*. It provides the tactile and sensory functions that are relayed to the brain (*Weir, 2018*).



**Figure (1):** Gross anatomy of the fingertip (*Maw et al.,2016*).

### **Components of fingertip:**

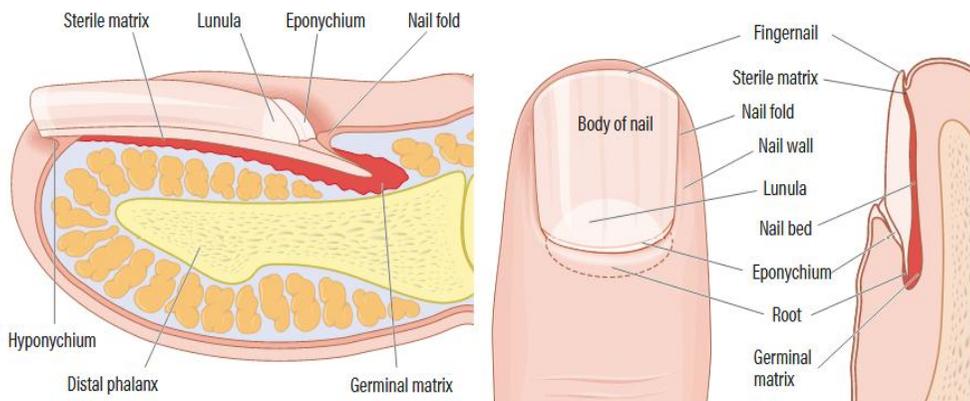
The fingertip is composed of skeletal element, the nail complex and finger pulp. *Yeo in 2010* mentioned that the nail is the most prominent feature of the finger. It shares both the aesthetic and functional role to the fingertip.

The nail is a structure of keratinized squamous cells that acts as a protective barrier and aids in two-point discrimination via counter pressure on the pulp. The nail plate grows distally at a rate of 0.1mm per day (*Maw et al., 2016*).

The nail parts include the eponychium, the paronychium, the hyponychium, the lunula, the nail matrix and the dorsal nail fold as shown in the *figure (2)* (*Yeo et al., 2010*).

- The eponychium (cuticle) is a layer of epidermis extending from the proximal nail fold and adhering to the dorsal aspect of the nail plate.
- The paronychium are the skin folds on each lateral aspect of the nail.
- The hyponychium is junction of the nail bed with the distal edge of the nail (i.e. where the nail bed meets the skin).
- The nail bed consists of sterile and germinal matrix. The germinal matrix is responsible for 90% of the nail growth, and the sterile matrix is where the nail adheres to the nail bed.
- The nail plate is a modified form of stratum corneum, providing a laminated keratinized structure overlying the nail bed and matrix. Its produced by the death of the germinal cells.
- The lunula is the white arc on the nail just distal to the eponychium. Its formed of the nail cell nuclei in the germinal matrix.

- The Germinal matrix is nail bed just distal to the insertion of the extensor tendon and ends at the distal border of the lunula. Its responsible for 90% of the nail growth
- The Sterile matrix is the nail bed just distal to the lunula. Its responsible for 10% of the nail plate growth
- The nail fold is composed of ventral floor which is the site of germinal matrix and the dorsal roof which is responsible for the nail shine (*De Berker, 2013*).



**Figure (2):**Anatomy of fingertip and fingernail (*Weir, 2018*).

The volar pulp is supplied by specialized sensory Pacinian, Meissner corpuscles and Merkel cells which provide detailed discrimination of touch and feel sensations. The high density of Vater-Pacini bodies and the branches of the palmar digital nerves usually provide dynamic two-point discrimination between 3 and 4 mm. (*Cerny et al., 2018*).

Fingerprints are present on the volar surface comprise a uniquely individualized pattern formed by grooves and ridges. Its formed by the thick epidermis and the deep papillary ridges in the skin pulp region (*Cerny et al., 2018*).

The pulp is consisted of multiple fibrous trabeculations arising from the periosteum to the epidermis that divides the pulp into separate septal compartments containing fat. The architecture of the subcutaneous tissue and fascia of the pulp withstands substantial pressure and shear force (*Cerny et al., 2018*).

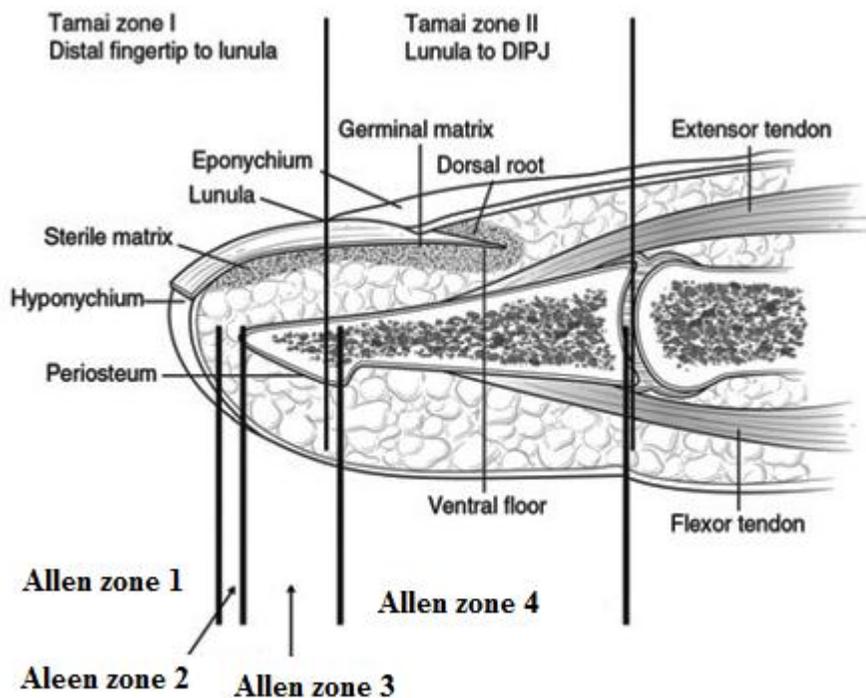
## **Classifications of fingertip injuries:-**

### **I. Classifications based on the level of amputation:-**

#### **A) Tamai classification: (Tamai, 1982).**

It's the most common classification used for distal fingertip amputations as shown in *figure (3)*.

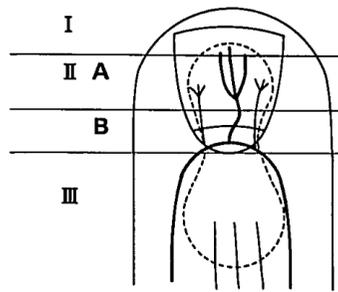
- Zone I: Distal to lunula.
- Zone II: DIP Joint to lunula.



**Figure (3):** Level of fingertip amputation according to Tamai and Allen classifications (*Lee et al., 2013*).

*B) Hirase classification: (Hirase, 1997).*

- Zone I: Distal to digital artery termination.
- Zone II A: Distal to the terminal division of central artery.
- Zone II B: nail fold to the distal terminal branches of artery.
- Zone III: DIP joint to the nail fold as shown in *figure (4)*.

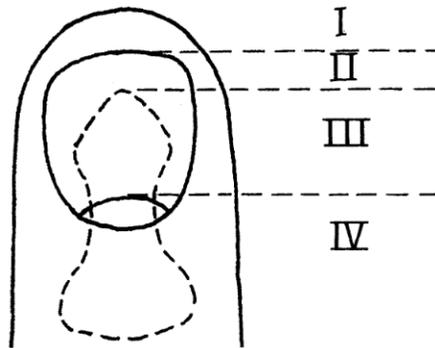


**Figure (4):** Level of Amputation according to Hirase's classification (*Hirase, 1997*).

C) Allen's classification: (Allen, 1980).

For treatment purposes, the Allen classification is the most useful; it describes the specific location of amputation based on bony and nail bed anatomy as well as the possibility of vessel anastomosis during repair as shown in *figures (3 & 5)*.

- Type 1: involves only the pulp, distal to the bony structures of the digit and the distal phalanx is preserved.
- Type 2: involves the pulp and nail bed and is complicated by the bony exposure of the distal phalanx.
- Type 3: involves the nail matrix (distal to the lunula) and usually results in the loss of the entire nail bed and partial loss of the distal phalanx
- Type 4: involves the lunula, distal phalanx, pulp and nail loss.



**Figure (5):** Level of Amputation according to Allen's classification (*Allen, 1980*).

Treatment of zone I injuries is usually conservative, such as leaving the wound open for secondary healing. Wound healing is facilitated by the use of topical antibiotic ointments and by monitoring of the injury to avoid the development of excessive granulation tissue. However treatment of type 2, 3 and type 4 often require flap coverage (*Peterson et al., 2014*).

*D) PNB classification: (Evans and Bernadis, 2000)*

PNB classification separates the injury into its effect on the three components of the fingertip: pulp, nail and bone. This provides a three digit number that accurately describes the injury as shown in table (1). It can be used to record and document injuries, without having to resort to lengthy description. It could also be used to provide detailed instructions for treatment and indications for referral.

**Table (1) : The PNB classification of fingertip injuries (*Evans and Bernadis, 2000*)**

Pulp

0	No injury
1	Laceration
2	Crush
3	Loss ± distal transverse
4	Loss ± palmar oblique partial
5	Loss ± dorsal oblique
6	Loss ± lateral
7	Loss ± complete

Nail

0	No injury
1	Sterile matrix laceration
2	Germinal sterile matrix laceration
3	Crush
4	Proximal nail bed dislocation
5	Loss ± distal third
6	Loss ± distal two thirds
7	Loss ± lateral
8	Loss ± complete

Bone

0	No injury
1	Tuft
2	Comminuted non-articular
3	Articular
4	Displaced basal
5	Tip exposure
6	Loss ± distal half
7	Loss ± subtotal (tendon insertions intact)
8	Loss ± complete

## **II. Classification based on the nature of amputation:-**

### *Yamano Classification: (Yamano, 1985).*

He classified fingertip amputation by mechanism and severity.

1. Guillotine: A clean cut amputation (e.g. knife).
2. Crush: Moderately crushed amputation (e.g. saw).
3. Crush avulsion: severe crush and/or avulsion injury (e.g. machine press or door).

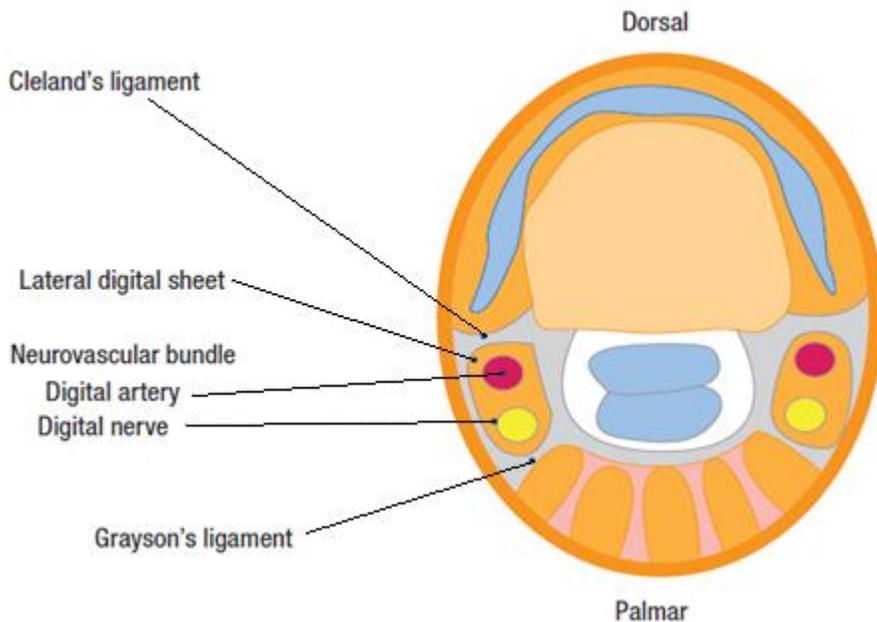
### **Arterial anatomy:**

The common palmar digital artery usually emerges from the superficial palmar arch at the mid-palm level, where it is volar (superficial to the corresponding common digital nerve). The artery-to-nerve relationship changes approximately 2.5 cm distal to the superficial palmar arch, where the artery becomes deep (dorsal) relative to the nerve and exhibits a few direct cutaneous perforating branches (*Omokawa et al., 2009*).

Each common digital artery divides into two proper digital arteries at the web spaces. Notably, each of the radial and ulnar digital arteries can supply blood to the whole finger independently (*Omokawa et al., 2009*).

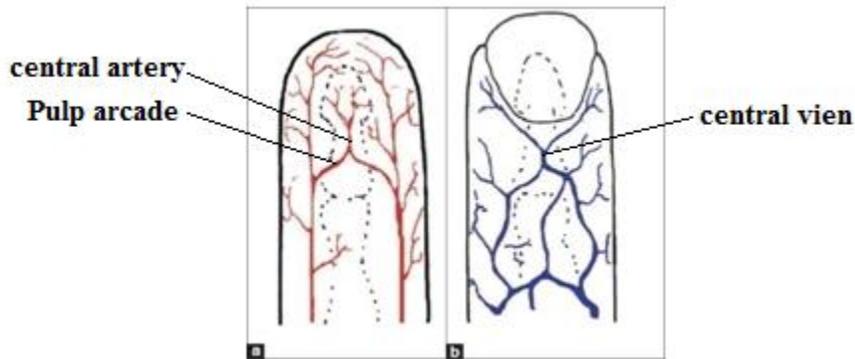
Furthermore, inside the finger, the neurovascular bundles are running in between 2 ligaments the Cleland ligament

dorsally and Grayson's ligament ventrally, which together hold it in place during the finger's movement as shown in *figure (6)* (*Godfrey and Rayan, 2018*).



**Figure (6):** Compartments of the digit showing Grayson's and Cleland's ligaments (*Maw et al., 2016*).

The diameter of the vessels and the wall thickness decrease as we proceed distally. The two palmar digital arteries join in the midline at the level of lunula to form the pulp arcade as shown in *figure (7)* (*Venkatramani and Sabapathy, 2011*).



**Figure (7):** Blood supply of fingertip. (a) Arterial anatomy at the fingertip (b) Dorsal venous anatomy at the fingertip (*Venkatramani and Sabapathy, 2011*).

This arcade gives multiple branches adjacent to the periosteum. The central artery is usually the largest and is fit for end-to-end anastomosis. The diameter of these branches ranges from 0.3–0.7 mm. There is significant tortuosity seen in the course of these arteries, which is useful for the gaining extra length after dissection (*Venkatramani and Sabapathy, 2011*).

### **Venous anatomy:**

The superficial dorsal veins are the main channels for venous drainage from the fingertip. The venules commence at the sides of the fingernail and converge proximal to the nail bed, forming a central vein. The vein divides into two or three branches after passing 2 to 4 mm proximally. These branches converge again after passing over the DIP joint. The diameter of the dorsal veins in this region ranges from 0.4 to 0.7 mm. Veins on the lateral sides of the distal finger segment are 0.2