# CAUSES OF PROLAPSE AND COLLAPSE OF THE PROXIMAL INTERPHALANGEAL JOINT

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## INTRODUCTION

An understanding of abnormal finger motion depends on a basic knowledge of normal functional anatomy, which can be found in the contributions made by Eyler and Markee (1954), Kaplan (1953), Milford (1968), Stack (1962), Tubiana and Valentin (1963). It is then possible to appreciate that the finger is a combination of two biarticular, bimuscular systems: a proximal system consisting of the metacarpophalangeal joint and the proximal interphalangeal joint, and a distal system consisting of the proximal interphalangeal and the distal interphalangeal joints.

In such a biarticular bimuscular system four combinations of joint positions are found: Extension-extension, extension-flexion, flexion-flexion, and flexion-extension (Stack, 1962).

Movement being a synonym for a change of position, twelve different motions are possible: eight single actions involving only one joint, and four double motions involving two joints.

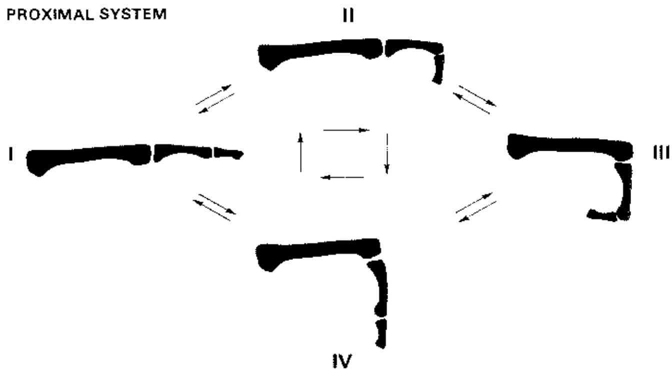


Fig. 1. Proximal biarticular system of the human finger.
In this system twelve motions are possible.
Eight single motions involving only one joint.
Four double motions involving two joints.

In the proximal system (Fig. 1) all twelve actions can be realised. Each of these motions is caused by shortening and lengthening of muscles and active participation of more than one muscle is therefore needed. Electromyographic studies (Landsmeer and Long, 1965) have told us which combinations of muscles are used to effect these changes of position. From their observations the following interesting conclusion can be drawn: The combination of muscles needed to effect a change of position is completely determined by the position the finger reaches, and shows no relationship to the position which the finger leaves (Fig. 2).

In the distal system (Fig. 3) the possibilities are limited since position II is mastered by few of us, and position IV can only be assumed when the flexor digitorum superficialis is predominant—an unusual situation which is also awkward because of the loosened distal phalanx.

Note: The numbering of the four positions here differ from those used by Stack (1962). Ed.

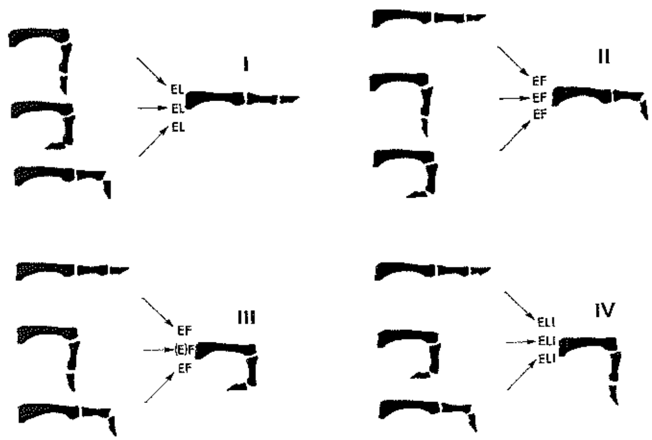


Fig. 2. Combinations of muscles used for motion.
E. is M. extensor dig. comm.
F. is M. flexor dig. prof.
L. is M. lumbricalis.
I. is M. interosseus.
Note co-ordination of proximal interphalangeal and distal interphalangeal joints.

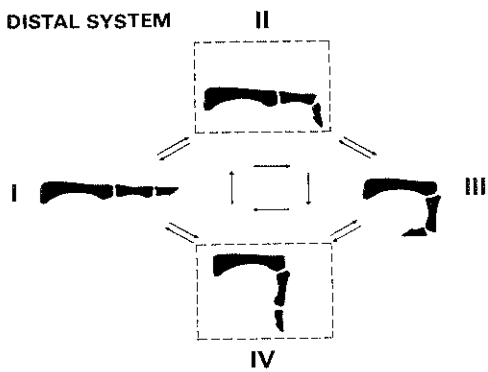


Fig. 3. Distal biarticular systems of the human finger. Normally movement is restricted to the two double motions which are made possible by co-ordinated flexion or extension of proximal interphalangeal and distal interphalangeal joint. Use of the positions II and IV adds an important extra dimension to manual communication. (Thai and Indonesian dances.)

The positions I and III are the positions most used in this system, extension of both interphalangeal joints, position I, being co-ordinated by the extrinsic-intrinsic extensor system, and flexion of both interphalangeal joints, position III, being linked by the two following circuits:—

1. Flexion of the distal interphalangeal joint.
   Slack of the central extensor slip.
   Flexion of the proximal interphalangeal joint.
   Slack of the lateral extensor slips.
   Flexion of the distal interphalangeal joint.

2. Flexion of the distal interphalangeal joint.
   Tension of the oblique retinacular ligaments.
   Flexion of the proximal interphalangeal joint.
   Slack of the oblique retinacular ligaments.
   Flexion of the distal interphalangeal joint.

The interaction phenomena of the multi-joint system of the human fingers have been explained by Landsmeer (1949) using a biarticular model (Fig. 4). Such a model, controlled by two antagonistic tendons, a flexor and an extensor, has certain characteristics:

1. Lack of control will cause the systems to collapse into a position of flexion of one joint and extension of the other joint: the direction of collapse depending on the ratios of distances of the flexor and extensor tendons with respect to the axes of the two joints.
2. Partial control of the systems by the two tendons will only be possible when one of the joints has reached its terminal position (Excursion-limit).
3. Complete control will be possible when a third muscle is added to oppose the motion of one of the joints towards its terminal position. Then independent control of both joints can be achieved.

The structure of the triarticular human finger (Fig. 5) is such that the direction of collapse for the proximal system is towards extension at the metacarpophalangeal joint (and towards flexion at the proximal interphalangeal joint). For the distal system the direction of collapse is towards flexion at the proximal interphalangeal joint and towards extension at the distal interphalangeal joint.

Fig. 4. Biarticular model with two antagonistic tendons.

Fig. 5. Triarticular finger shows normal tendency towards extension at the metacarpophalangeal joint, flexion at the proximal interphalangeal joint and extension at the distal interphalangeal joint.

Both the retroversion tendency of the intercalated bone in the proximal system and the anteversion tendency of the intercalated bone in the distal system are counteracted by a third force. In the proximal system by the obliquely running interossei and lumbricals and in the distal system by the central slip of the extensor hood which receives fibres from both the extrinsic and intrinsic systems.

Considering the central location of the proximal interphalangeal joint it is not surprising that its position will be affected by imbalance in both systems. Dependent on its cause, prolapse or collapse of the joint may develop.

## PROLAPSE AND COLLAPSE

Why the use of these terms and why are the terms "Buttonhole deformity" and "Swan-neck deformity" avoided when everyone experienced in hand surgery is familiar with them?

The term prolapse is used to indicate that we are not just dealing with flexion of the proximal interphalangeal joint but with a process which results in herniation of the joint and dislocation of the lateral slips. Whether this herniation will be associated with extension of the distal interphalangeal joint depends first of all on its cause. When shortening of the lateral slips or the retinacular ligaments is permitted extension of the distal interphalangeal joint will follow.

When shortening is impossible or counteracted (by deep flexor action) extension will be absent.

The term collapse is used to indicate that what happens is just that the joint collapses. Usually this collapse is associated with flexion of the metacarpophalangeal joint and the distal interphalangeal joint—but not always. One exception being extensor habitus, the condition which is caused by a deep flexor lesion and characterised by extension of the distal interphalangeal joint.

The author prefers to avoid the terms "buttonhole deformity" and "Swan-neck deformity" for several reasons.

1. The term "buttonhole" provides information on the condition of the proximal interphalangeal joint; the term "Swan-neck" does not.

2. The term "buttonhole" gives no information on the position of the distal interphalangeal joint; the term "Swan-neck" does.

3. The term "buttonhole" is usually associated with one cause. The term "Swan-neck" with many causes.

4. The term "buttonhole" negates the fact that flexion of the proximal interphalangeal joint may be present without extension of the distal interphalangeal joint. The term "Swan-neck" that extension of the proximal interphalangeal joint may be present without flexion of the distal interphalangeal joint.

## CAUSES OF IMBALANCE

Landsmeer and Long (1965) state clearly that while a description of the location of a tendon in relation to a centre of rotation may contribute to an understanding of the functional significance of this muscle in a system, its activity can neither be predicted nor explained entirely on the basis of its location properties in a model alone. In the human hand there are different factors which determine how a certain muscle will behave under conditions of use such as:

1. Tonic properties; force of musculotendinous structures.

2. Location properties; position of musculotendinous structures.

3. Rheological properties; visco-elasticity of musculotendinous and supporting structures.

4. Structural properties; form of musculotendinous and supporting structures.

5. Inertial properties; mass of bony structures.

Normally these properties function in harmony to maintain balance of the finger. Disharmony will usually result in prolapse or collapse. Which of these two deformities and to what extent can be difficult to predict (Fig. 6).

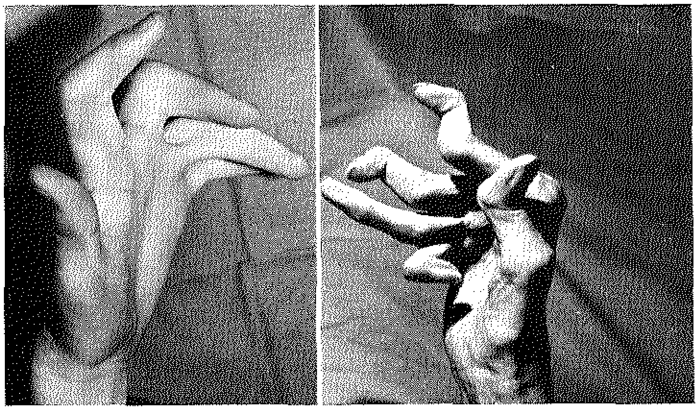

Fig. 6. Two examples of severe prolapse and collapse:—
a. prolapse b. collapse.

**TABLE 1**

**CAUSES OF PROLAPSE**

Loss of balance leading to prolapse of the proximal interphalangeal joint may be caused by:

| | | |
|---|---|---|
| 1. Dorsal minus forces | | |
| Skin | Destruction | Lesion |
| Central extensor tendon | Decreased traction | Lesion<br>Adhesions<br>M.P. Hyperextension |
| Lateral extensor tendon | Decreased traction | Intrinsic paralysis<br>Adhesions<br>Lumbrical dysplasia? |
| Dorsal retinacular ligament | Relaxation | |
| 2. Dorsal minus forces and/or volar plus forces | | |
| Joint | Deformation | Rheumatoid arthritis |
| 3. Volar plus forces | | |
| Lateral extensor tendon | Increased traction | Dislocation<br>Adhesions |
| Lateral retinacular ligament | Contracture | |
| Oblique retinacular ligament | Contracture | |
| Collateral ligament (volar part) | Contracture | |
| Fascial structures | Contracture | Dupuytren |
| Flexor tendons | Increased traction | Vascular disorders<br>Nervous disorders<br>Adhesions |
| Skin | Contracture | Lesion<br>Dysplasia<br>(Camptodactyly)<br>Scleroderma |

**TABLE 2**

**CAUSES OF COLLAPSE**

Loss of balance leading to collapse of the proximal interphalangeal joint may be caused by:

1. Dorsal plus forces

| | | |
|---|---|---|
| Skin | Contracture | Lesion |
| Central extensor tendon | Increased traction | Metacarpophalangeal flexion<br>Terminal Extensor tendon lesion<br>Adhesions |
| Lateral extensor tendon | Increased intrinsic traction | Terminal extensor tendon lesion<br>Adhesions |
| | Increased lumbrical traction | Deep flexor tendon lesion<br>Adhesions |
| | Ischaemic intrinsic retraction | Vascular disorders |
| | Non-ischaemic retraction | Rheumatoid arthritis<br>Parkinson |
| Dorsal retinacular ligament | Contracture | |
| Oblique retinacular ligament | Contracture | Dislocation |

2. Dorsal plus forces and/or volar minus forces

| | | |
|---|---|---|
| Joint | Deformation | Rheumatoid arthritis |

3. Volar minus forces

| | | |
|---|---|---|
| Lateral retinacular ligament | Relaxation | |
| Collateral ligament (volar part) | Relaxation | |
| Volar capsule | Relaxation<br>Rupture | <br>Lesion |
| Superficial flexor tendon | Decreased traction | Lesion<br>Adhesions<br>Paralysis |
| Deep flexor tendon | Decreased traction | Lesion<br>Adhesions<br>Paralysis |

**SUMMARY**

The physiopathology of prolapse and collapse of the proximal interphalangeal joint are reviewed on the basis of modern knowledge of the functional anatomy of the finger.

Use of the terms buttonhole deformity and Swan-neck deformity is criticised. A more exact terminology is advocated.

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