MODERN TRENDS IN SURGICAL MANAGEMENT OF STAGE III KIENBÖCK'S DISEASE

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ABSTRACT

Kienböck’s disease is the most common pathological condition affecting the lunate carpal bone. Radial shortening performed or limited inter-carpal fusion as methods of lunate unloading are well known procedures used in treatment of the disease. Also direct revascularization using pedicled bone graft from distal radius is a valuable option. Combination of both mechanical and biological approaches gives the patient best chance of lunate revascularization and stoppage of disease. Early results are encouraging, but longer follow-up study is needed.

Key words:

Kienböck’s disease – Lunatomalacia – Lunate bone

INTRODUCTION

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The carpal lunate has been termed the “carpal Key-Stone” because of its well recognized importance to the architecture, stability, motion and function of the human wrist. It is also the bone that is the focus of the attention in a poorly understood condition- i.e. Kienböck’s disease - a disease that affects and disables the wrist of primarily productive young individuals. It is a disorder characterized by sclerosis and collapse of the carpal lunate secondary to avascular necrosis. It was first recognized by Peste 1843. He considered the condition secondary to traumatic lesion. Little work on the subject occurred between Peste's description and the classic paper by Kienböck in 1910. ***(Palmer et al 1998)***

Kienböck’s disease usually affects young active individuals. It is classified into four stages according to the progression of the disease. It was noted that pain, weakness and functional disability were most disturbing during the period of wrist collapse i.e. during the early phase of stage III. ***(Amadio and Moran 2005)***

Treatment of Kienböck’s disease is not only challenging but controversial. Although multiple treatment options have been proposed for avascular necrosis of the lunate (Kienböck’s disease) a consensus on treatment has not been reached. The difficulty in establishing a set treatment algorithm for Kienböck’s disease is in part due to our incomplete understanding of the disease’s etiology. ***(Moran et al 2005)***

As pathological studies proved that changes occurring in the lunate are secondary to avascular necrosis, treatment options aiming at revascularization of lunate whether indirectly through lunate unloading or directly seems logic. These approaches can be performed alone or combined to stop progression of the disease. Aim of our study is to evaluate combination of both direct and indirect revascularization procedures in treatment of stage III Kienböck’s disease.

ANATOMY & BIOMECHANICS OF LUNATE BONE

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• BONY ANATOMY

The lunate bone, approximately semi-lunar, articulates between the scaphoid and the triquetrum in the proximal carpal row. Its rough palmar surface, almost triangular, is larger and wider than dorsal surface. Its smooth convex proximal surface articulates with the radius and articular disc of the distal radio-ulnar joint. Its narrow lateral surface bears a flat semi-lunar facet for the scaphoid. The medial surface, almost square, articulates with the triquetrum and is separated from the distal surface by a curved edge for articulation with the hamate bone in adduction. The distal surface is deeply concave to fit the medial part of the capitate's head. ***(Williams et al 1989)*** (Fig.1-1)

The lunate is covered with articular cartilage on approximately 80% of its external surface. ***Viegas et al*** classified lunates into type 1 and type 2 according to their articulation with the hamate. In studies of normal cadavers, type 1 (with no articular surface for hamate) existed in 34.5% and type 2 in 65.5%. ***(Viegas et al 1990)***

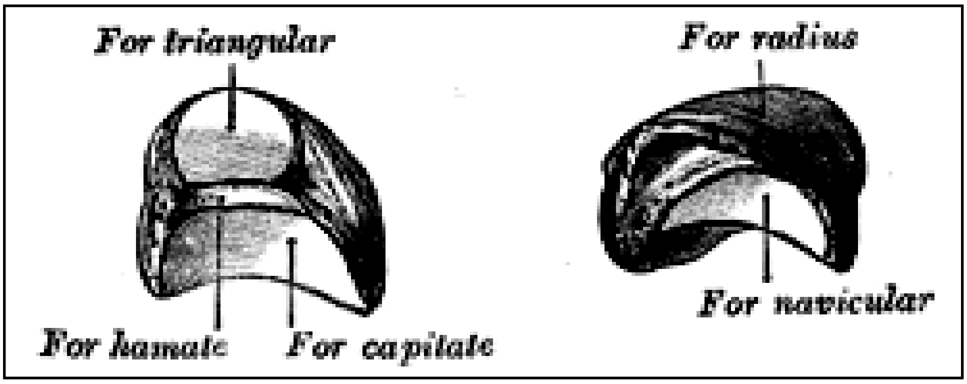


Fig.1-1: Bony anatomy of Lunate bone ***(Gray's Anatomy 1989)***

The shape of the lunate bone when viewed from lateral radiographic projection could be classified into three types: type D lunates have a thinner dorsal segment; type V lunates have a thinner volar segment and type N with equal volar and dorsal segments. ***Watson et al*** noticed that 23% of lunates are thinner palmarly than dorsally (type V as opposed to the classic type D) when viewed on lateral projection (Fig. 1-2). ***(Watson et al 1996)***

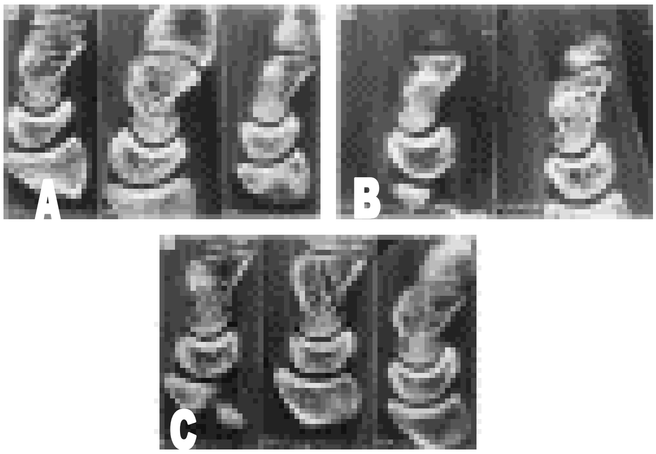


Fig. 1-2: Sagittal images obtained on CT showing various shape patterns affecting the lunate. (A) Type 'D' lunates with thinner dorsal segment. (B) Type 'V' with thinner volar segment. (C) Type 'N' with equal dorsal and volar segment.

In 1966, ***Antuna Zapico*** observed a relationship between the shape of the lunate and the length of the ulna. He described a type I lunate, seen in ulna-minus wrists, as having a proximal pole or crest. Type II and III were more rectangular or square and coexisted with zero and plus variant. He believed that internal lunate architecture -i.e. orientation and concentration of trabeculae – develops in response to ulna length variants in accordance to Wolff's law. In his opinion, the trabecular pattern in type I was the weakest, with a greater potential for bone fatigue and stress fracture under loads. ***(Antuna Zapico1966)*** (Fig. 1-3)

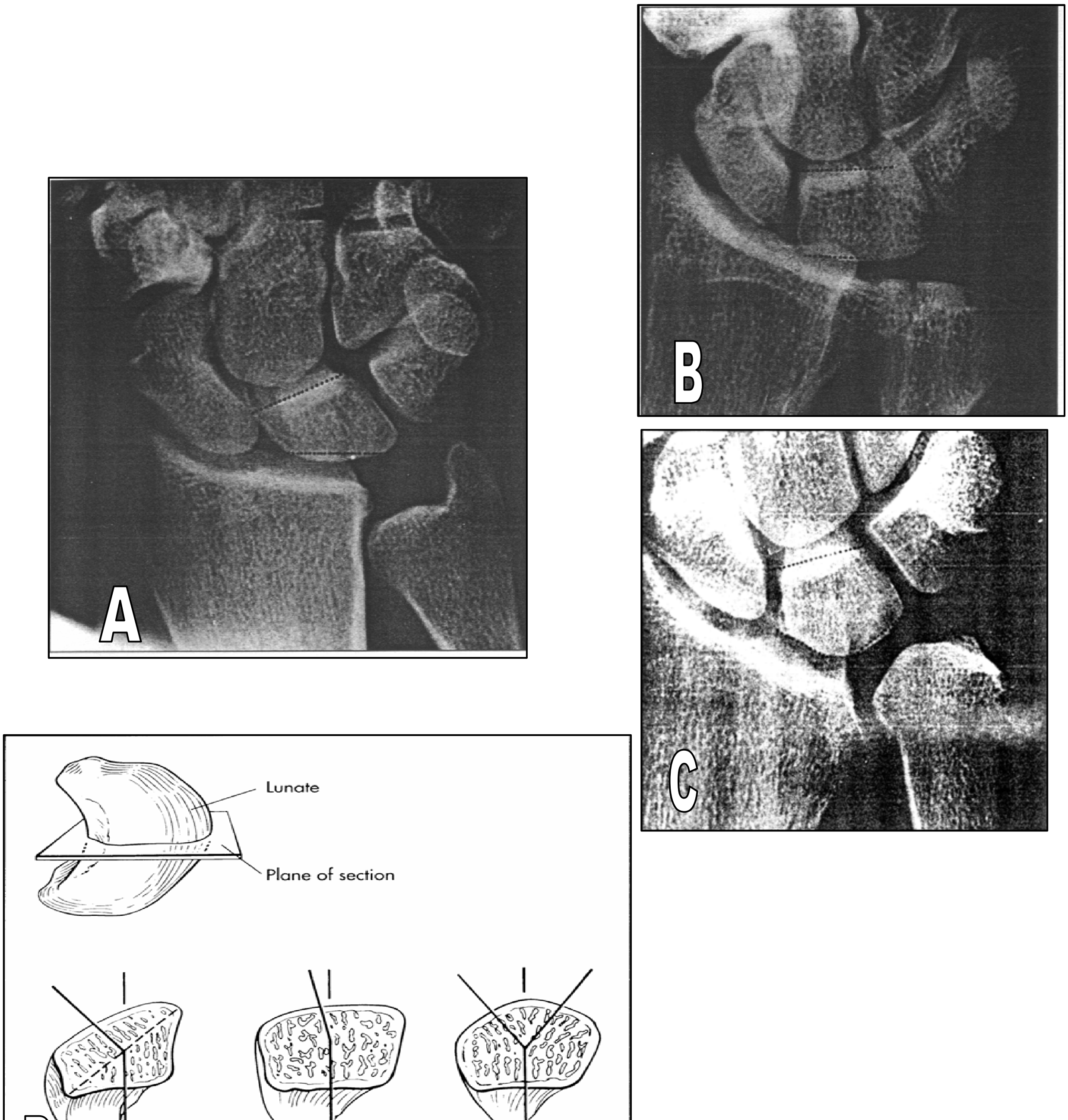


Fig. 1-3: Types of lunate and relationship to ulnar variance. A type I lunate coexist with the ulna-minus variant. B and C, type II and type III lunates coexist with zero and plus variants. D, trabecular patterns for type I, II, III lunates. ***(Amadio et al 2005)***

Approximately 60% of the lunate rests on the radius. The medial portion is supported by the interposition of the TFCC between the ulnar head and the lunate – triquetral articulation. The TFCC varies in thickness in proportion to ulnar variance, with a thicker TFCC being present in an ulna minus situation and a thinner TFCC in a more ulna positive situation. ***(Palmer et al 1998)***

• Vascular Anatomy

The vascular anatomy of the lunate consists of extraosseous system and an intraosseous system. ***(Gelberman et al 1980)***

1. Extraosseous System

The extra –osseous blood supply consists of both dorsal and volar components. The dorsal blood supply arises from vessels on the mid dorsum of the carpus fed by branches from the dorsal radio-carpal arch, dorsal inter-carpal arch and occasionally from posterior branch of the anterior interosseous artery (Fig. 1-4). ***(Botte et al 2004)***

The extraosseous volar component consists of sources from palmar inter-carpal arch, the palmar radio carpal arch, and communicating branches from the anterior interosseous artery and the ulnar recurrent artery. (Fig.1-5). ***(Botte et al 2004)***

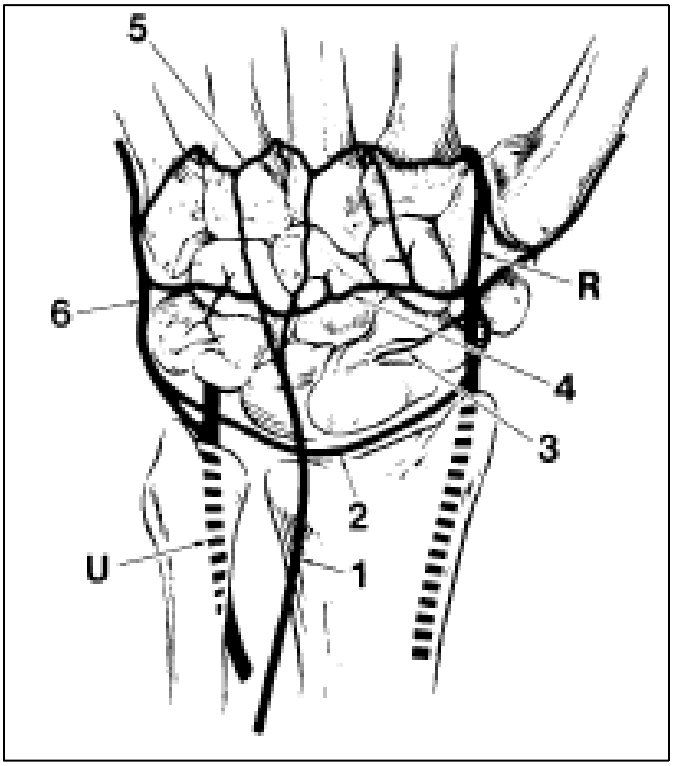
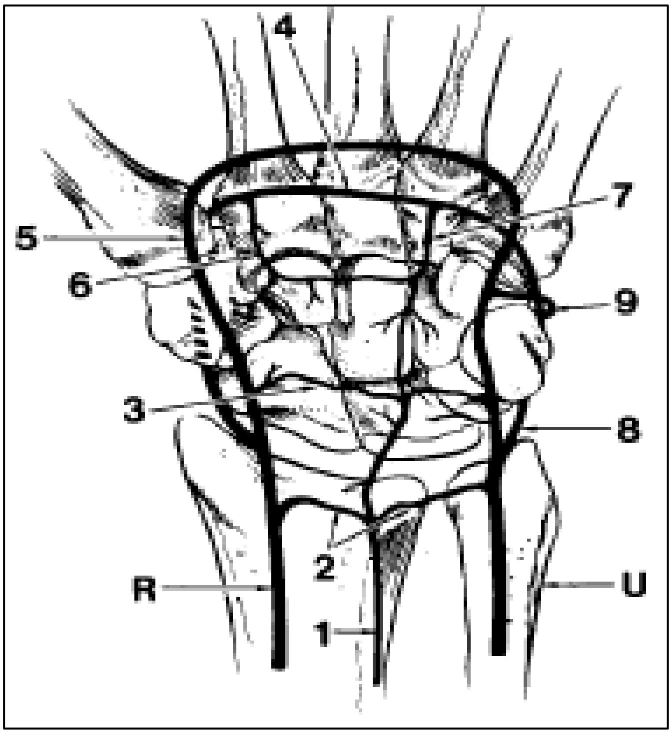


Fig. 1-4: Schematic drawing of the arterial supply of the dorsum of the wrist.
R _ radial artery
U _ ulnar artery
1. Dorsal branch, anterior interosseous artery
2. Dorsal radiocarpal arch
3. Branch to the dorsal ridge of the scaphoid
4. Dorsal intercarpal arch
5. Basal metacarpal arch
6. Medial branch of the ulnar artery. ***(Freedman et al 2001)***

Fig. 1-5:.Schematic drawing of the arterial supply of the palmar aspect of the wrist.
R - Radial artery
U - Ulnar artery
1. Palmar branch, anterior interosseous artery
2. Palmar radiocarpal arch
3. Palmar intercarpal arch
4. Deep palmar arch
5. Superficial palmar arch
6. Radial recurrent artery
7. Ulnar recurrent artery
8. Medial branch, ulnar artery
9. Branch of ulnar artery contributing to the dorsal intercarpal arch. ***(Freedman et al 2001)***



2. <u>Intraosseous System</u>

The vessels that enter dorsally are slightly smaller than those entering palmarly. Major vessels branch proximally and distally after entering the bone and terminate in the subchondral bone. The dorsal and palmar vessels anastomose intraosseously just distal to the mid portion of the lunate. The proximal pole has relatively less vascularity.

There are three major intraosseous patterns. These patterns are formed in the shape of the letters **Y**, **I**, or **X**. the Y shape is the most common and occurs in 59% of studied specimens. The stem of the Y occurs dorsally or palmarly, with equal frequency. The I - shaped pattern occurs in approximately 30% of specimens and consists of a single dorsal and a single palmar vessel that anastomose in a straight line. The X - shaped pattern, which occurs in 10% of specimens, consists of two dorsal and two palmar vessels that anastomose in the centre of the lunate, thus forming the X pattern. (Fig 1-6) ***(Botte et al 2004)***

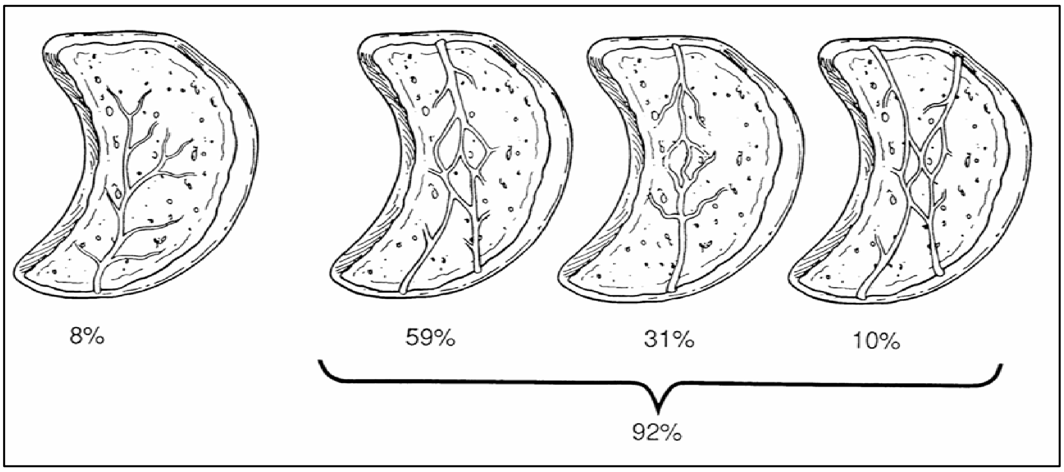


Fig. 1-6: Vascularity of the lunate suggested by Gelberman and Gross. Eight percent of lunates have only palmar vessels. The remaining 92% can be divided into three different patterns of intraosseous anastomosis: the Y pattern (59%), the I pattern (31%), and the X pattern (10%). ***(Gelberman et al 1986***)

In 8% of studied specimens, a single palmar supply was present. This pattern consisted of a single large vessel that enters on the palmar surface and branches within the lunate to provide the sole blood supply.

Because of the relatively limited blood supply to the lunate, ***Gelberman et al*** have included the lunate as one of the carpal bones vulnerable for post-traumatic avascular necrosis. (Other carpal bones at risk include the scaphoid and capitate). These anatomic findings correlate with the relatively high occurrence of avascular disorders of the lunate when compared with most of other carpal bones. ***(Gelberman et al 1986***)

• Pertinent Biomechanics

To facilitate positioning of the hand to manipulate objects, lift loads, or perform specific tasks of daily living, the wrist needs to be highly mobile and yet be able to sustain substantial forces and torques without yielding. This can only be achieved through a perfect interaction between wrist motor tendons, joint surfaces, and soft tissue constraints. In the past, different theories have been proposed to explain the intricate mechanism of the wrist. What follows is a brief review of wrist biomechanics, based on the more recent findings on both normal carpal motion (carpal kinematics) and force transmission across the wrist (carpal kinetics). ***(Elias et al 2005)***

Carpal Kinematics

Except for the pisiform, the proximal carpal row has no direct tendinous attachments. Hence, the moments generated by muscle contractions result in rotational motion starting always at the distal carpal row. The bones of the proximal row start moving later, when tension of the ligaments crossing the mid carpal joint reaches a certain level.

In normal wrists, very little motion exists between the bones of the distal carpal row. The bones of the proximal row appear to be less tightly bound to one another than the bones of the distal carpal row. Although moving synergistically (in the same direction), considerable differences in the direction and amount of rotation exist among the scaphoid, lunate and triquetrum. ***(Elias et al 2005)***

Carpal Kinetics

When the hand is grasping or pinching an object, the joints of the wrist need to sustain considerable compressive and shear forces. Such loads are not only the result of the external force being applied but also from contraction of the different muscles necessary to ensure finger stability. Studies on force transmission have disclosed that the total compressive forces being transmitted by all the metacarpals to the distal carpal row can reach values greater than ten times the applied force at the tip of the fingers. Therefore, if the average maximum grip strength is 52 kg for a male subject and 31 kg for a female, we can estimate that the wrist may bear loads as high as 520 kg in males and 310 kg in females. ***(Elias et al 2005)***

Within the wrist, such loads are distributed following specific pattern. According to the latest studies, at the mid carpal level, about 60% of the load borne by the distal row is transmitted across the capitate-scaphoid-lunate (CSL) joint. More proximally, the forces distribute as follows: radio-scaphoid (RS) joint, 50-56%; radio-lunate (RL) joint, 29-35%: ulno-lunate (UL) joint, 10-21%. These figures vary substantially with wrist position: the lunate fossa is increasingly loaded with ulnar deviation, and the scaphoid fossa is overloaded with radial deviation. The so-called functional position which involves extension and radial deviation, results in an increased force through the lunate. . ***(Elias et al 2005)***

ETIOLOGY

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PATHOLOGY