ANATOMY OF A FIST

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The punch is one of the most important ways to strike, so when we saw that there are three general variations on how to make a fist, the question arose if one is superior to the others. For this, we determined that superior would be safest for the striker. We looked at three different fists that have documentation to the use and where to strike. This was then compared to fracture data and what is known of human anatomical structure to see if one could be recommended.

The fist described by Nagamine also is used by many other striking arts, including Krav Maga. It is formed by flexing the fingers and placing the thumb over the middle phalanx of the second and third digits. For the strike, this fist is kept tight. The strike point is the head of the second and third metacarpals. When the strike is complete, the palm is facing downward (Nagamine et al., 1976). (Fig. 1).

The second fist is formed by placing the first phalange over mostly the second but to some degree the third phalange. When the strike is finished the palm is facing downward. The strike point is a combination of the third, fourth, and fifth metacarpal as well as the proximal phalanges of those metacarpals. As described by Floyd "Pretty Boy" Mayweather Jr. in "Self-defense: Throw a punch" (Maxim, February 2007, p. 65).

The third is described by Chuck Sullivan in "Beginner's Guide to Striking: Indomitable Fist." It describes a punch similar to the second punch except for the placement of the thumb, which is suggested to be placed lateral to the second metacarpal. It also differs in that the fist does not rotate but rather stays vertical. Besides Sullivan, we found that some styles of Wing Chun use this fist to strike soft areas of the body.

Introduction

Looking at the histology of osseous tissue, we note that the arrangement of osteocytes and matrix allows for bone to support more compression from the axial (superior to posterior) direction and less as in a transverse compression (Fig.2). Taking the gross structure of bone, we see how the bone is arranged to supports applied force in those directions. We then see how misalignment of bone can lead to clinical fractures. This is supported by clinical data that gives incidence of reported fractures (O'Connor et al., 2005).

Figure 1.

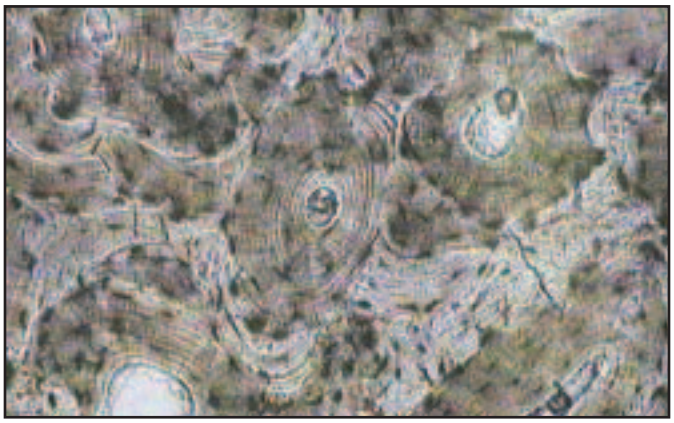

Figure 2.

Anatomy of the hand and wrist

The human hand is made up of the radius and ulna in the distal forearm, seven carpal bones in the wrist, five metacarpals in the palm, and 14 phalange bones in the fingers. These 28 bones will fracture in different ways. (Normal Hand – Fig. A).

Cortex vs. Medulla

All bones of the hand are composed of two regions. The outer region is the cortex and the inner is the medulla.

The histology of the medullary bone is quite different. Grossly, this area of bone looks like a spider-web. It is referred to as trabecular or spongy bone. Looking at all angle of this bone, no symmetry is seen in the entire slide of this bone (Fig. 3).

Methods

We looked at all fractures of the hand and how they were caused. Then we looked at the structure of osseous tissue and the tree-like arrangement of the compact bone osteons to see if the structure gave evidence for why these fractures

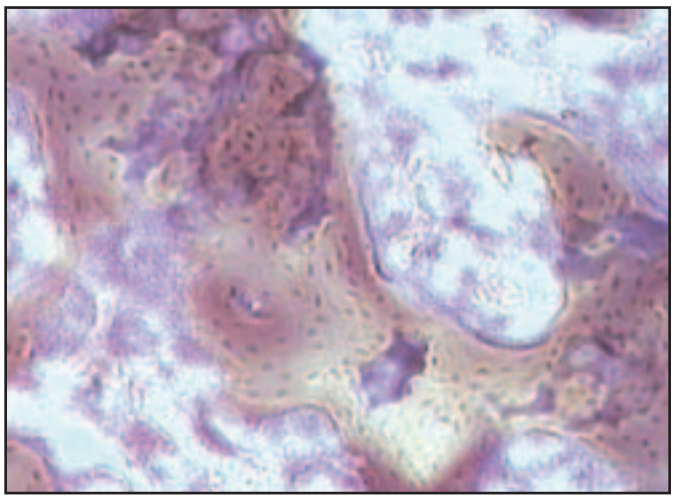

Figure 3.

occurred. We knew that bones such as metacarpals and phalanges are formed from both compact and spongy bone, so we looked at the force for a compression fracture of different sides of bone. Then, we looked at the gross arrangement of the bones in different skeletons and a human cadaver to see which fist would be most stable.

We chose to use data from reported fractures found in medical text books and primary literature. Many hand and wrist fractures are possible so we removed the fractures that would not occur in the three fists described in this paper. For this we compared articles and text using those figures that were most constant with the other sources.

The common fractures of the metacarpals include both the Boxer's and Bennet's fracture. The

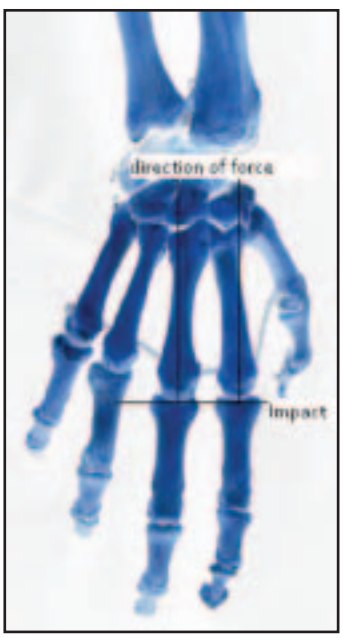

Figure A.

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Boxer's fracture consists of mid-shaft fractures in the fifth metacarpal but can include the fourth. The Boxer's fracture is caused by punching a solid object with a fist using those metacarpals. It has a lifetime incidence of 2.5 percent (O'Connor et al., 2005)

The Bennet's fracture consists of the base of the first metacarpal (most common fracture of the thumb) with dislocation of the carpometacarpal joint. This fracture is caused by having the thumb struck on the head of the proximal phalanx (O'Connor et al., 2005).

We include fractures of the second and third metacarpals that were caused by force acting on the dorsal or palmar aspect of the metacarpals as we could not find the incidence of head fractures of these bones other than that they were rare. This was done to see more potential damage as very little was found to compare this fist to the others.

Data

While all fractures of the hand were looked at, I will discuss only those that can occur when a punch is attempted with each fist; percents are given for those who wish to check our math.

- **Carpal fractures**: 18 percent of all hand fractures
- **Metacarpal fractures** (O'Connor et al., 2005)

More than 14 percent of all Emergency Room visits account for 30–40 percent of all hand fractures and 10 percent of all fractures. The neck of the fifth metacarpal accounts for more than 10 percent of all fractures in the hand alone. These are caused by a direct blow or crush type injury.

- **Transverse fractures**: Caused by force to the intrinsic muscles of the hand.
- **Oblique or spiral fractures**: Caused by torsional force.
- **Metacarpal head fractures**: A rare fracture that occurs from axial force on the metacarpal. No incidence given for this fracture in our literature search.
- **Metacarpal neck fracture** (Boxer's fracture): Involves the fifth metacarpal and may be combined with the fourth in the majority of cases. It accounts for 10 percent of all hand fractures and can be seen in the ideal path of some punches.
- **Thumb Fractures** (both Bennet's partial articular fracture and Rolando's complete articular fracture): Thumb fractures have an incidence of 25 percent of all metacarpal fractures. This can be seen in a missed punch.

Wrist Anatomy

To understand how forces are transmitted though the carpal bones, it helps to look at the wrist as three columns. These three columns are referred to as the Radial, Central (or force-bearing), and the Ulnar (or control) columns. Understanding these will enable us to see how the hand may survive better due to a strike.

The Radial column is formed by the radius, the Scaphoid, Trapizium, trapezoid, and the first metacarpal. The Central column is made up of the distal end of the Radius, the proximal two-thirds of the scaphoid, the lunate, the capitate, trapezoid and the second and third metacarpals. The Ulnar Column is formed by the hamate, triquetrum and the fourth and fifth metacarpals.

Ideal Travel of a Punch

As described earlier, the fist is used to strike in a way that will have the same linear path. Looking at the bones in the metacarpal involved in the strike, we see that the first punch under the ideal strike has the following potential faults: 1) Potential to fracture the trapezoid. This makes up less than 1 percent of all carpal fractures, a smaller number of the total hand fractures possible; 2) Another fracture that can occur is a second and third metacarpal head fracture. These are two extremely rare fractures with no data obtainable of fractures for metacarpals two and three fractures; 3) Lateral fractures and spiral fractures are avoided due to the axial direction of the force.

In the second and third fist with an ideal path and the correct point of impact, the force is in the third to fifth metacarpals. This makes a torsional force on all the metacarpals involved, thus leading to fractures in all three metacarpals. This punch has the disadvantage of using the fifth metacarpal, which has an incidence of 10 percent of all hand fractures. The torsional direction of force along the third and fourth metacarpal also can lead to a fracture. Minimal damage to carpal bone will be seen in these punches though there will be potential damage to the Hamate, a carpal bone.

Off Path Punch

In the first punch, if the second and third metacarpal are missed and force travels in the Ulnar direction to the fist, no damage will occur. If the force is directed into the fourth and fifth metacarpal, a Boxer's fracture may occur, though at a different angle. These punches also may cause damage to the Hamate.

In the second fist, if the target is missed in the Ulnar direction, the target will be missed. If missed in the Radial

direction, either a punch like the first only with the force traveling in a transverse manner, and may result in fracture of second and third metacarpals, or, due to the thumb's loose association with the rest of the fist, the first metacarpal may be damaged.

The third punch is similar to the second, with the exception that the thumb placement makes it extremely prone to damage to the first metacarpal as either a Bennet's fracture or Rolando's fracture depending on the amount of articular damage; thus, for this, we will deal with the same fracture.

Results

Looking at the more common fractures of the hand and combining the histological structure and the gross anatomy of the hand, we can determine that the fist used by traditional Okinawan karate is safer for the striker than the gloved boxers punch and Sullivan's punch when used bare-fisted. This may be due mainly to the arrangement of bone that allows its axial compression strength to be almost three times that of its lateral compression strength.

Discussion

We could not give exact numbers for the heads of the second and third metacarpals since our research could not find values other than "rare." We talked to Emergency Room technicians and physicians who had never seen the second or third metacarpal fracture but had seen many other hand fractures. This was mostly the Boxer's fracture.

Besides the anatomical positioning of these bones, we found that the hand is divided into three pillars. The pillar consisting of the second and third metacarpals to the radius was more stable than the rest of the hand, and had more rigidity. This led to it being referred to as the support column of the hand.

There is constant damage that can happen to all fists in a punch. Of the constants that can occur in all fists equally, such as the wrist bending or fracturing fingers, we will deal only with specific fractures seen in clinics. For any fracture to occur, you must be hitting something hard with enough force to break bone, such as the skull in self-defense. We talked to some Wing Chun practitioners who used the fist written about by Sullivan and found that in that art it is used for torso and throat strikes, making it safe, as there is nothing as hard as the skull. For head strikes, open hand techniques were preferred.

When looking at Mayweather's punch, he is telling people how he punches when his hands are wrapped and gloved. We know that in that case, his hands will be protected. We understand that he was asked how he punches and as a respectable athlete, he is not involved in street or bare-fisted fights. The problem is that many take sports as if they were a proving ground for martial arts. Mayweather himself experienced a broken hand in the sixth round of his fight with Carlos Baldomir.

We looked at the strength of compact bone and noted that the axial compression strengths tends to be more than three times stronger that the lateral compression strength. This could lead to protection of the bone if lined up properly. An important fact that we did not address is bone strengthening exercises that are done by some martial artists. These include repetitive trauma to the hands, either by directly hitting a hard target or hitting the hands with hard objects to "toughen" the hands. We may accept that this may decrease the chance of fractures but at the cost of trauma to the cartilage, thus increasing the chance of cartilage calcification, bone spur formation and eventually a disabling osteoarthritis of the metacarpo-phalangeal joints.

We also did not address points brought up by Tony Partlow about chances of dislocation due to angle of force in both Mayweather's and Sullivan's fists, nor did we deal with the mobility of the fourth and fifth metacarpals and the stability of the second and third metacarpals. This was not addressed due to inability to find the incidence of dislocation. This would make an interesting future project.

This data may be helpful to society in many ways, such as military application for hand-to-hand fighting, providing effective and safe techniques in women's self-defense courses, and in recreational martial arts with breaking demonstrations.