A primary goal of hoof care in horses has always been to trim the hoof so that it provides support and stability to the distal phalanx (hence the bone column), regardless of whether a horse is being shod or left barefoot. To “Balance” a horse’s foot is every farrier’s goal, however actually agreeing on how to achieve balance is still widely debated, even after hundreds of years of humans providing the hoof care needs of horses. The most widely accepted definitions or goals in achieving balance are to make the distal phalanx flat to the ground from side to side, thereby establishing M/L balance. (Figure 1-A) Some people believe that it should be flat to the ground from front to back as well, however the most widely accepted theory is that a slightly positive palmar angle (meaning the distal phalanx is slightly raised in the back) is “normal” or at least desirable. (Figure 1-B) Another common goal in achieving hoof balance is that the ground surface mass should be divided up equally around the center of Rotation of the distal interphalangeal joint (DIP Joint). (Figure 2) The “center of rotation of the DIP joint” is described as the center of the distal condyle of the second pastern bone (PII). From that center point, a vertical line is dropped perpendicular to the ground. From that location, there should be an equal amount of ground mass ahead of that line and behind that line. From a physics or mechanical standpoint, this appears to be an efficiently balanced foot. Of course, there are lots of other less stressed points when hoof care providers and vets talk about balance, but these two are ones that most people seem to agree on. Yet there is still a tremendous amount of debate on how to actually get this done. The old saying, “if you put 6 monkeys in a room with 6 bananas, you’ll see 6 ways to eat a banana” is basically the same when it comes to hoof care. You can have one farrier trim a foot to what he feels is balanced, then have 5 other farriers evaluate the trim, and you’ll get at least 3 different opinions as to what needs to be changed. Many horse owners, vets, and even farriers have been frustrated by the variations and inconsistency of hoof care from one farrier to the next, and a lot of that
frustrations seems to be blamed on insufficient information and lack of consistency when it comes to understanding and achieving hoof balance. However, I believe the real culprit is not in what farriers believe to be good hoof balance, it is in the fact that a lot of farriery work is based upon an “assumption” of where the distal phalanx and center of rotation is within the hoof capsule. Many farriers believe and were taught that the dorsal surface of the distal phalanx maintains a parallel relationship with the dorsal surface of the hoof wall. (Figure 1-C) [A horses that founders (rotates) is believed to be the only exception, in which case radiographs are necessary when trimming and shoeing.] However, the hoof capsule can easily be pulled, bent, shifted and curled in ways which makes that “assumption” incorrect in many cases. (Figure 3) And, if those hoof capsule distortions are not recognized at the time of trimming or shoeing, then the assumption by the farrier is going to make achieving hoof balance very difficult. We believe that the inability of many hoof care providers to recognize basic, common hoof distortions is one of the biggest hurdles facing the hoof care industry today. Actually employing some basic guidelines on how to deal with the distortions is yet another hurdle. So, the issue of “Balance” is not really in question, however it is constantly debated because no one is distinguishing (or even recognizing) the difference between a distorted and a non-distorted foot. If the industry could establish a starting point that had “ACTUAL” references to the internal structures (i.e.; distal phalanx or center of rotation), then much of the debate would subside and the industry would get closer to a more widely accepted and efficient way to balance a horse’s foot.

In the late 1800’s and early 1900’s, a farrier professor by the name of William Russell had many good concepts about locating or visualizing the position of the distal phalanx within the hoof capsule. The difference between his methods and what had been more commonly accepted, is that Russell referenced many structures on the bottom of the foot, while most other methods tend to focus only on the outer hoof wall. For the most part, Russell felt that measuring back from the true (trimmed) frog apex about ¾” (19mm) would put you in the center of the horse’s foot, and you could balance your trim or a shoe around that location. Since that time, many other notable farriers like David Duckett and Gene Ovnicek in the late 1980’s used similar references to a “Center” point on the bottom of the foot, and talk about balancing a trim or shoe around that point. David Farmillo from Australia, and other farriers from around the world also use sole references for balance as opposed to only using the outer hoof wall which, as mentioned earlier, can easily become distorted and lose its relationship to the distal phalanx. A common factor with all of these farriers is the use of the “trimmed” or “true” frog apex as a starting point. It has seemed to be one of the most static references to the distal phalanx that we have. And, for the last several hundred years, those farriers that use this information and look at balance from a center point that references the frog apex have generally been successful and consistent. At least they are not easily being misled by a distorted hoof capsule and they stay close to balancing the foot around the distal phalanx and center of rotation of the DIP Joint.

For the last 20 plus years, these techniques have grown in popularity and acceptance. And, although most horses improve with these methods, there are still a small percentage that do not do as well as expected. Over the last 30 years, radiography or X-rays for horses has become quite common place. In the early 1990’s, many vets
like Dr. Barbara Page & Dr. Ric Redden began putting markers on foot radiographs to hopefully gain more information from the X-rays being taken. A common marker used was a thumb tack inserted at the trimmed frog apex, as that was the sole structure often being referenced. It was believed that measuring back from the frog apex ¾” (19mm) would be below the center of rotation of the DIP joint, and measuring forward ¾” to 1” (19-25mm) was the tip of the distal phalanx. However, with a larger number of radiographs being taken with markers, we began to notice some variation with the position of the true frog apex to the tip of the distal phalanx and the center of rotation. (Figure 4 & 5) It was certainly not a majority of horses, but it was a significant number that lead us to believe that this phenomenon may be responsible for the small percentage of horses that did not do as well as the majority.

The Equine Lameness Prevention Organization began offering hoof care education and certifications in 2006. In further developing the trimming and shoeing protocol promoted by the organization, the board of directors and advisors began looking for multiple external references to the internal structures.
They felt that this would improve the consistency and success of the guidelines they were teaching. Over the first 2 years of the certification courses, and dissections done during the courses, the ELPO further developed a Hoof Mapping protocol that seemed to offer better, more consistent results than anything previously used. However, with more answers always come more questions and more scrutiny. In 2008, the Equine Lameness Prevention Organization put together a well designed, scientific study to both answer questions and hopefully generate new thought and research on the subject of hoof balance.

To begin, I’d like to describe the primary differences between “Anecdotal or Field Studies” vs. “Scientific Research”.

**ANECDOAL OR FIELD STUDIES**
- Usually Contain Many Uncontrolled Variables Like:
  - Environment
  - Discipline
  - Breed
- Usually Conducted by One Individual
  - Generally are non-quantitative in nature (meaning no exact or specific measurements taken)
  - Usually observational or opinion based (meaning the subjects or phenomena is watched or tracked and the data or results is subject to the opinion of the researcher).
- Generates Growth & Awareness
- Drives Scientific Research (without Anecdotal or Field Studies, there would be no questions that need answers or theories to design scientific research projects from).

**SCIENTIFIC RESEARCH**
- When it comes to horses or hoof care, these are usually done at the cellular or histological level (meaning under a microscope on tissues or cadaver limbs).
- Variable are controlled
- Methods are Repeatable by Others (either proponents or opponents can duplicate the processes and results)
- Has traditionally been Difficult in Hoof Care Research because:
  - Too many unknown or unrecognized variables
  - No accounting for hoof capsule distortions, hence no controlling the effect of leverage, strain and effort incurred by internal structures.
  - Hoof Balance is always in question.
  - Shoe Placement (ground mass) is never specific to internal anatomy.

Below are some terms or locations you will need to know before we cover the methods of the study.

**Figure 6**
- PIII = Distal Phalanx (PIII)
- PII = Short Pastern Bone
- A = Positive Palmar Angle of PIII (Front Foot)
- B = Negative Plantar Angle of PIII (Hind Foot)
**Figure 7** - Center of Rotation of the DIP Joint

**Figure 8** - Center of Articulation of the DIP Joint

**Figure 9** - Articulating (or Rotational) Surface of the DIP Joint

**Figure 10** - Articulating (or Rotational) Surface of the Distal Phalanx

**Questions/Objectives (Hypothesis or What We Intend to Find Out)**

1. Is the Widest Part of the Foot a Static Reference to the Dorsal Distal Border of the Distal Phalanx (PIII)?
2. Is the Widest Part of the Foot a Static Reference to the Center of Rotation of the Distal Interphalangeal Joint (DIP Joint).
OVERVIEW OF METHODS

- All Feet were exfoliated to the level of the live sole. (Chalky material removed until waxy appearing surface was visible.) (See Page 10 for “ELPO Live Sole - Hoof Mapping Protocol)
- Feet were “Mapped Out” according the ELPO Hoof Mapping Protocol. (See Page 10 - Figure 11 is Example of Final Mapping)
- Markers were placed at the: (Figure 12)
  - Marked Widest Part of the Sole (BB on Medial [A] & Wire on Lateral [B])
  - Dimple/Back of the Frog [C]
  - Apex of Central Sulcus [D]
  - Well Defined True Frog Apex [E]
  - A location ¼” (6mm) ahead of the Marked tip of PIII [F]
  - A 2” (50mm) Wire was placed on the Dorsal Surface of the Hoof Wall, beginning at the Coronary Band [Figure 13-A]
- Data Collection/Measurement Form filled out on each horse.
- Photos of Each foot (Sole & Lateral View) were taken. (Figure 13)
- Radiographs were taken using a standard, AAEP accepted radiography protocol. (Figure 14)
- All Radiographs were entered into ‘Metron’ software where they were calibrated and measurements taken.
- All horse data & measurements were entered into a database for evaluation & comparison.
SUMMARY OF RESULTS

Sizing Chart (Overall Width of Foot)

- 000-00 = 4.25” - 4.50” [10.8cm - 11.4cm]
- 0 = 4.75” [12.1cm]
- 1 = 5.00” [12.7cm]
- 2 = 5.25” [13.3cm]
- 3 = 5.50” [14.0cm]
- 4 = 5.75” [14.6cm]
- 5 - 6 = 6.00” - 6.25” [15.2cm - 15.9cm]

Number of Feet in this Study: (100 Total)
- Size 000-00 = 20 Feet (7 Front – 13 Hind)
- Size 0 = 32 Feet (15 Front – 17 Hind)
- Size 1 = 18 Feet (11 Front – 7 Hind)
- Size 2 = 18 Feet (11 Front – 7 Hind)
- Size 3-4 (Draft) = 4 Feet (2 Front – 2 Hind)
- Size 4 (Warm Blood) = 4 Feet (2 Front – 2 Hind)
- Size 5-6 (Draft) = 4 Feet (2 Front – 2 Hind)

NOTE: We do not feel that the Averages & Ranges for Feet Sizes 3 & higher are accurate at this time due to the low number of feet available in the study.

Average Distance from WPOTF to the Tip of PIII (by size):
- Size 000-00 = 1.65” (1 5/8”) [41.9mm]
- Size 0 = 1.67” (1-11/16”) [42.4mm]
- Size 1 = 1.74” (1-3/4”) [44.2mm] [Figure 15 - Example]
- Size 2 = 1.82” (1-13/16”) [46.2mm]
- Size 3-4 (Draft) = 1.92” (1-15/16”) [48.8mm]
- Size 4 (Warm Blood) = 2.28” (2-1/4”) [57.9mm]
- Size 5-6 (Draft) = 1.93” (1-15/16”) [49.0mm]

NOTE: The AVERAGE number had a range of +/- 1/8” [+/- 3mm] in approximately 92% of the feet sampled.

Average Distance from WPOTF to Center of Rotation (by size):
- Size 000-00 = - 0.15” (- 1/8”) [-3.8mm]
- Size 0 = - 0.27” (- ¼”) [-6.9mm]
- Size 1 = - 0.25” (- ¼”) [-6.4mm]
- Size 2 = - 0.24” (- ¼”) [-6.1mm] [Figure 16 - Example]
- Size 3-4 (Draft) = - 0.27” (- ¼”) [-6.9mm]
- Size 4 (Warm Blood) = - 0.13” (- 1/8”) [-3.3mm]
- Size 5-6 (Draft) = - 0.41” (- 11/16”) [-10.4mm]

NOTE: The size of the foot did not seem to have much influence over the relationship between the Center of Rotation & the WPOTF.
Average Distance from WPOTF to Center of Rotation (by conformation):
- Negative 1° - 3° = - 0.46” (- 7/16”) [- 11.7mm] [Figure 17 - Example]
- Zero Palmar/Plantar Angle = - 0.31” (- 5/16”) [- 7.9mm]
- Positive 1° - 5° = - 0.19” (- 3/16”) [- 4.8mm]
- Positive 6° or greater = + 0.11” (+ 1/16”) [+2.8mm] [Figure 18 - Example]
- Average Hind Foot Conformation = - 0.09 (Basically Flat)
- Average Front Foot Conformation = + 0.8 (Positive 1° - 5°)
- NOTE: The Palmar/Plantar Angle of PIII definitely has an influence on the relationship between the Center of Articulation & the WPOTF!

**CONCLUSIONS**
- The dorsal distal border of the distal phalanx is a reliable distance ahead of the widest part of the foot.
- The widest part of the foot is Not Always directly below the Center of Rotation of the DIP Joint.
- The Angle (Palmar/Plantar) of PIII **Does** effect the Position of the WPOTF with respect to the Center of Rotation of the DIP Joint.
- The widest part of the foot **Does** fall beneath the Rotational Surface of DIP Joint.
- If your objective is to use the Tip of the Frog to find the Center of Rotation of the DIP Joint, the measurement of 1” (25mm) is much more reliable than ¾” (19mm).
- Using 2 or more ways to locate/verify reference structures is always recommended.
- It can be postulated that knowing where the Distal Phalanx is within the hoof capsule can help you recognize and deal with hoof distortions.

**WHAT DOES THIS RESEARCH PROJECT MEAN TO THE HOOF CARE INDUSTRY**

The information gleaned from this project answers many questions and offers possible direction for the hoof care industry. From a future research standpoint, the information provided in this study will at least help to eliminate a few variables when it comes to true quantitative research of horse locomotion and biomechanics. If researches in the future can take the time to accurately map feet and standardize how the feet are prepared and how shoes are applied according to the map (according to the internal anatomy), the results of their research will be much more meaningful. The inconsistency of hoof balance and the lack of control over how each foot is trimmed and/or shod has always been one of the biggest unknown or uncontrolled variables in every locomotion study done. It is fairly well known that how feet are prepared and how shoes are applied directly influences the mechanics and locomotion of the horse. Again, regardless of the “method” used for trimming feet or applying
shoes within a given study, at least by incorporating the hoof mapping protocol into their study and recording where feet are trimmed and where shoes are applied will have much more meaning. It really offers a controlled baseline for hoof care in future locomotion or biomechanics studies done with horses.

Secondly, and more importantly, the fact that farriers have available a protocol by which they can map out feet and located the distal phalanx within the hoof capsule to around a 92% accuracy is a tremendous step up on where we have been in the past. Regardless of where they choose to trim the foot or place a shoe with respect to the distal phalanx, at least they know where they are at. Without an accurate map or multiple external structures that can guide them to the internal anatomy, some farriers can find themselves in the dark when it comes to trying to achieve equilibrium in and around the DIP joint. From a simple, straightforward, and repeatable mapping protocol, the ELPO believes that the quality and consistency of farriery can improve on an industry wide scale. Granted, many farriers feel that shoeing horses hasn’t changed in hundreds of years, so why try fixing something that isn’t broken. However, farriery has changed several times over the last few centuries. Trends in hoof preparation and shoe styles have been constantly updated to adapt to how horses are being used and what their expectations are. One hundred years ago, horses were used as modes of transportation and a labor force. The types of lameness, pathology, and breakdown, as well as the expectations of the horse, were much different than they are today. Fifty years ago, horses were used less for labor and began to be used as pleasure animals, however the majority of their tasks still kept them going in straight lines for the most part. Today, almost all horses are used for pleasure riding or sport. However, more confinement and less activity offers many great challenges for the overall health and function of the horse. Coupled with the fact that most horses are now asked to turn circles constantly, and many times at high speeds, challenges the distal limb considerably. The fact that the PIP and DIP joints are hinge joints, with little leniency for lateral movement offers a prime opportunity for damage and pathology to be incurred from these activities. Therefore, the notion that farriery hasn’t changed in hundreds of years, or shouldn’t change because it is working, needs to be reconsidered. Vet clinics and universities are congested with severe to moderately lame horses, the majority suffering from pathology due to leverage and strain caused by the activities they perform. A large part of the excess leverage is simply due to hoof capsule distortions that have gone unrecognized. Fifty years ago, many horses could get by without serious complications from minor distortions and a little extra leverage, because they were not asked to turn circles and do complicated maneuvers. Today horses don’t have that luxury. Hoof distortions and excess leverage are a factor in the life of the modern day horse. We have the technology to see how these factors and demands on horses affect the internal structures. We also have the technology to deal with excess leverage and strain, as long as the distortions can be recognized and dealt with. This project is only one contribution among many over the last few hundred years that can help the hoof care industry keep up with the challenges in the horse industry. Like all the tools that have helped mold the art and science of conventional farriery, we hope that this contribution will lead to further improvements to meet the futures challenges in the horse industry.

Contributions to the Equine Lameness Prevention Organization have made this project possible. Many of the certified members of the ELPO have all committed to contributing at least 1 more horse each year to the project. Within the next two years, the number of feet included in the database should exceed 300. The more numbers of feet included in the study, the more accurate and precise the results will become.

**Contributing Hoof Care Providers**

| Ed Bullock, CNBBT, CNBF, CLS | Steve Foxworth, CNBBT, CNBF, CLS |
| Beckie Mabbutt, CNBBT, CNBF, CLS | Isaac Kerr, CNBBT, CNBF, CLS |
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**Contributing Veterinarians & Vet Techs**

| Dr. Gene Naugle |
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| Dr. Jeremy Ley |
| Dr. Becky Mouncey |
| Meg Shank |
| Valerie Perino |
4 Step E.L.P.O. Live Sole – Hoof Mapping Protocol

1. Recognize the Distortions of: (Note any distortions or non-distortions you see!)
   - The Heels (Mark the Dimple in the Back of the Frog to Assess Heel Position relative to the Back of the Foot)
   - The Frog (Narrow, Long & Stretched, Diseased, etc.)
   - The Bars (Excessive Curve, Laid Over, etc.)
   - The Toe (Pointed on Front Foot, Seems Long, etc.)

2. Exfoliate the:
   - Frog
     * Identify the True Apex.
     * Only loose tags.
     * Clean Central Sulcus
     * Trim corners so they don’t interfere with the rasp when trimming the heels.
   - Sole – Chalky Material
     * Quarters (Extremely Important!!)
     * Heels (Seat of Corn or ‘V’ between hoof wall and bars)
     * Pillars or Toe Quarters (Be very specific as this is your primary M/L Balancing Structure)
     * Across the Toe or Top of Sole Callus (be conservative if a barefoot trim)
   - Bars – Fractures, Excessive Curves, Laid Over, Bacteria Traps, Etc.

3. Mark the: (Continued)
   - True Apex of the Frog
   - Widest Part of the Foot (Use all 3 Methods to locate)
     * From the True Apex of the frog, measure back (rearward) about 1” (on a size #0 to #2 foot) and draw a line. This is generally the widest part of the foot.
     * Find the position where the bars terminate into the frog commissures. If you run a hoof pick up the commissures (from the back forward), you will find a raised hump or swell. The center of that hump or swell general indicates the termination of the bars. A line across the foot at that position generally represents the widest part of the foot.
     * Mark an arc about 2” long in the quarters at the sole/wall junction on both sides of the foot. Slide a straight edge sideways and you should be able to visually see the peak of the arc on each side of the foot. This is the widest part of the sole.

4. Evaluate the Ratios: (Illustrate where current heel & breakover is, as well as where you hope to get them!)
   - From the Widest Part of the Foot to the Rear Most Weight Bearing Structure (Before/Current & then for the After/Goal mark, use the Frog Buttress)
   - From the Widest Part of the Foot to the Point of Breakover (Before/Current & After/Goal)
   - Do you have Attainable Goals? – 50/50 Ratio or Slightly More to the Back 60/40 (Yes or –No?)

*This Hoof Mapping Procedure is the initial stage of both the E.L.P.O. Barefoot Trimming Protocol & the E.L.P.O. Shoeing Protocol. Continued hoof preparation using either of those protocols is recommended!*