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# Distributions of local anesthetics injected into the distal interphalangeal joint and podotrochlear bursa: An experimental study

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**Summary**

Local anesthetic injections into the distal interphalangeal (DIP) joint and the podotrochlear bursa have variable clinical results. The current study evaluates the anatomy of these structures and the diffusion of dye-local anesthetic solution to surrounding structures. The abaxial portions of the collateral sesamoidean ligament (CSL) were nearly encircled by the synovial cavities of the DIP joint. Dye-anesthetic solution diffused from the DIP joint via the distal sesamoidean impar ligament (DSIL) and deep digital flexor tendon. Diffusion of dye-anesthetic solution from the podotrochlear bursa involved portions of the neurovascular bundle, similar to DIP joint injections. From our knowledge of work detailing the sensory nerves in the CSL and DSIL, we believe that the local anesthetic injections into these two synovial cavities are not selective for only their exposed surfaces.

**Keywords:** horse, sensory nerves, podotrochlear syndrome, sesamoidean impar ligament, distal interphalangeal joint

**Verteilung eines in das Hufgelenk und in die Bursa podotrochlearis injizierten Lokalanästhetikums: eine experimentelle Studie**

Injektionen von Lokalanästhetika in das Hufgelenk (distal interphalangeal joint, DIP) und in die Bursa podotrochlearis haben variable klinische Resultate. In der vorliegenden Studie werden die Anatomie dieser Strukturen und die Diffusion von gefärbter Lokalanästhetika-Lösung in die umliegenden Gewebe untersucht. Die abaxialen Anteile des Fesselbein-Strahlbein-Hufbeinbandes (collateral seamoidean ligament, CSL) waren fast vollständig von der Synovialhöhle des Hufgelenkes eingekreist. Gefärbtes Lokalanästhetikum diffundierte aus dem Hufgelenk über das Strahlbein-Hufbeinband (distal sesamoidean impar ligament, DSIL) und die tiefe Beugesehne. Die Diffusion des gefärbten Lokalanästhetikums aus der Bursa podotrochlearis involvierte, ähnlich wie bei der Injektion ins Hufgelenk, Anteile des neurovaskulären Bündels. Anhand unserer Arbeit auf dem Gebiet der detaillierten Untersuchung der sensorischen Nerven im Fesselbein-Strahlbein-Hufbeinband und Strahlbein-Hufbeinband nehmen wir an, daß Injektionen eines Lokalanästhetikums in diese zwei Synovialhöhlen keine selektive Beurteilung ihrer exponierten Oberflächen allein zulassen.

**Schlüsselwörter:** Pferd, sensorische Nerven, Podotrochlose-Syndrom, Strahlbein-Hufbeinband, Hufgelenk

## Introduction

The distal interphalangeal (DIP) joint (articulatio interphalangea distale, N.A.V. 1984) and the podotrochlear bursa (bursa podotrochlearis; N.A.V., 1984) are common sites for many different lameness conditions (*Stashak*, 1987; *Turner,* 1989; *Turner,* 1991). An accurate diagnosis of the conditions affecting these regions depends upon the use of local anesthetics and the interpretation of their effects (*Dyson*, 1991; *Dyson* and *Kidd,* 1993). One common interpretation is that local anesthetics when injected into the DIP joint or the podotrochlear bursa are selective only for desensitization of the exposed surfaces in these synovial cavities (*Gibson* et al., 1990; *Stashak,* 1987; *Turner,* 1989). However, others believe that the effects are more widespread (*Dyson* and *Kidd,* 1993) and still others suggest that local anesthetic may diffuse into the podotrochlear bursa from the DIP joint (*Sack*, 1991). These varying interpretations of the effects of local anesthetics may be due to our incomplete understanding of the DIP joint anatomy, its relationship to the podotrochlear bursa, neurovascular bundle, and the distribution of anesthetics after injection into these cavities. Thus, the present study was undertaken to begin to examine the anatomy and the potential distribution and diffusion of local anesthetics from these two synovial sacs.

## Materials and methods

*DIP Joint Anatomy-polymer corrosion casts*

The feet from more than thirty horses and four ponies with ages between several months to 30 years and representing various breeds, euthanized at the Michigan State University Veterinary Teaching Hospital, were examined. In twelve forelimb digits, a corrosion cast was formed by injecting a commercial polymer plastic (10–25 ml) into the DIP joint via its dorsal pouch followed by physical manipulation of the digit back and forth several times. For the local anesthetic-dye injections, 126 feet were obtained from both forelimbs and hindlimbs and injected with local anesthetic, (mepivacaine hydrochloride) with 0.5% Luxol Fast Blue dye as a marker. The DIP joint (5 ml/joint, 81 feet) and the podotrochlear bursa (3 ml/bursa, 25 feet) were injected using standard clinical injection sites. (Note: for the podotrochlear bursa study, fluoroscopic imaging was used to verify initial positioning of the needle prior to injection).

After DIP joint injections, the digits were physically manipulated according to the following protocols: (1) Digits manipulated at one minute intervals for five minutes were either placed in a freezer (minus 20°C), or submerged in an 100% ethanol-dry ice bath (lower than minus 25°C), or in a liquid nitrogen bath, (2) digits manipulated at 15 minute intervals for one hour were placed in a freezer (minus 20°C). After podotrochlear bursa injections, digits were manipulated at one minute intervals for 5 minutes and placed in a freezer (minus 20°C). Once frozen, digits were cut with a band saw and examined for the distribution of the blue dye.

## Results

*DIP joint anatomy*

Injections of the polymer plastic into the DIP joint resulted in the nearly complete distention of the dorsal and palmar pouches along the respective surfaces of the middle phalanx. The dorsal pouch of this joint was not remarkable. The proximal palmar pouch of the DIP joint extended proximally to the digital sheath of the deep digital flexor tendon (DDFT) with these two synovial linings being separated by loose connective tissue. The proximal palmar pouch of the DIP joint bordered the dorsal and proximal surface of the collateral sesamoidean ligament (ligamenta sesamoidea collateralia; CSL) in the mid-sagittal plane of the foot. Abaxially, however, the synovial sac of the proximal palmar pouch extended proximally over the CSL surface to become located both along the dorsal and palmar aspects of this ligament. This relationship of the proximal palmar pouch of the DIP joint to the CSL resulted in the CSL dividing this pouch into two compartments: a cranially located compartment (dorsal to the CSL) between the CSL and the middle phalanx, and a second caudal (palmar) compartment located palmar to the CSL, but dorsal to the DDFT (Fig. 1). These two synovial compartments nearly surrounded the CSL.

*Dye-local anesthetic solution injections*

Injecting the DIP joint with dye-anesthetic solution resulted in the dark blue dye being confined to this synovial cavity. A direct spread of the dye-local anesthetic (dark blue coloration similar to that injected) into the podotrochlear bursa was only observed in one specimen (1 of 81 digits). However, in many of these injections a light blue coloration of the dye-anesthetic solution was observed within the podotrochlear bursa, resulting in, what we have termed, an indirect communication between the DIP joint and the podotrochlear bursa. In these instances, it appeared as though the dye-local anesthetic had diffused into the synovial fluid of the podotrochlear bursa through a "filtering membrane" following a DIP joint injection. The indirect spread, or diffusion, of the dye-anesthetic solution into the podotrochlear bursa was dependent upon the extent of digital manipulation and/or time after the DIP joint injection. Digits manipulated for five minutes (31 feet) or for one hour (20 feet), prior to placement in the freezer, resulted in a light blue coloration within the podotrochlear bursa in 54.8% (17 of 31 feet) and 80% (16 of 20 feet) of the cases, respectively. The diffusion of the dye-local anesthetic into the podotrochlear bursa occurred via two routes: (1) through the DSIL and the intersection between the DSIL and the DDFT, and (2) the loose connective tissue proximal to CSL (Fig. 2). Digits manipulated at one minute intervals for 5 minutes and frozen quickly (dry ice-alcoholic bath; 20 feet, or liquid nitrogen bath; 10 feet) had no blue coloration within the podotrochlear bursa. However, in all four protocols the dye-anesthetic solution was observed to be distributed within the DSIL.

Podotrochlear bursa injections of the dye-local anesthetic, using fluoroscopic guidance, into twenty feet outlined the synovial sac of the podotrochlear bursa and the extent of diffusion of the dye-local anesthetic solution from the bursa. The diffusion of the dye from the podotrochlear bursa surrounded the neurovascular bundle within the digit.

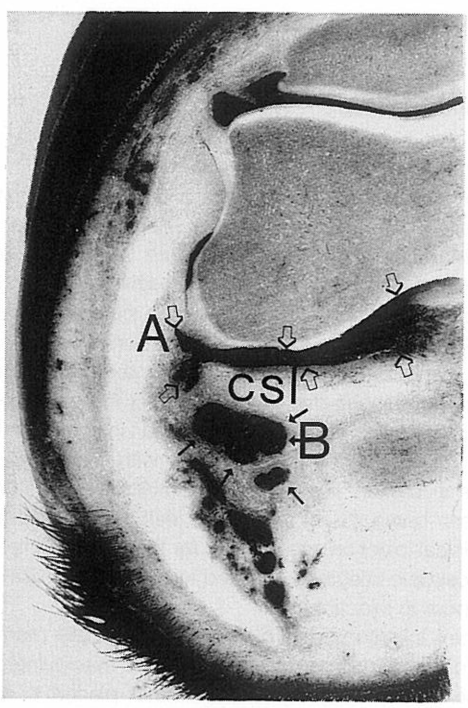


**Fig. 1:** Photomicrograph of coronal section through collateral sesamoidean ligament (CSL) of foot injected with polymer. The proximal palmar pouch forms a cranial (A) and caudal (B) compartment surrounding the CSL.

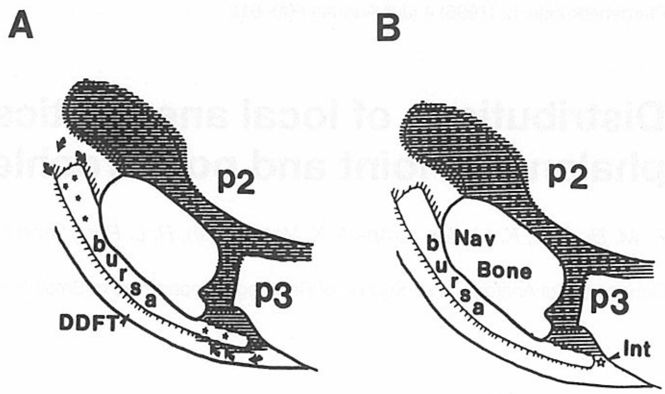


**Fig. 2:** Schematic drawing shows summary of feet injected with local anesthetic and Luxol foot blue dye. In B, the horizontal lines show dye-local anesthetic distribution in feet quickly frozen, which is in synovial lining of proximal palmar pouch and in DSIL. In A, in feet in which dye-local anesthetic diffused into navicular bursa, the DSIL and intersection (Int) and dorsal aspect of DDFT were stained (solid stars in navicular bursa). The second route of entry is via the loose connective tissue proximal to CSL (arrows and solid stars). P2 and P3 second and third phalanx, respectively.

## Discussion

The present study has demonstrated that in the adult horse (a) the proximal palmar pouch of the DIP joint contains a cranial and caudal compartment which nearly surrounds a portion of the CSL abaxially, and (b) that local anesthetic, as indicated by a blue dye, can diffuse from these synovial cavities into nearby regions, presumably desensitizing these stained structures. These anatomical descriptions of the DIP joint and the diffusion of the dye-local anesthetic solution suggest that while the interpretation of the effects of local anesthetics into these cavities may be more complex than previously thought, the findings do provide an initial basis for more accurate interpretation of the effects of local anesthetics injected into these two synovial cavities. While previous anatomical studies of the equine digit have described the overall foot anatomy and the DIP joint in relation to other clinically relevant structures (*Calislar* and *St. Clair*, 1969; *Sisson,* 1975; *Nickel* et al., 1979; *Gibson* et al., 1990; *Jann* et al., 1991), the synovial extensions along the dorsal and palmar (plantar) surfaces were described in little detail. Usually only the relatively simple mid-sagittal description of the DIP joint has been presented and may have contributed to the long held belief that local anesthetics injected into this joint will desensitize only the joint surfaces. However, the findings that the CSL borders the proximal palmar pouch on both its dorsal and palmar surfaces suggest that the local anesthetic injected into the DIP joint will probably directly desensitize most of the superficial parts of CSL. The finding of dye-anesthetic diffusion into the DSIL suggests that local anesthetic injections will anesthetize the nerves in this structure as well. This relationship of the synovial cavity to the CSL is interesting as many of the sensory nerve fibers to the distal sesamoid bone course within the synovial layer and underlying connective tissue bordering the dorsal and palmar surfaces of the CSL (*Bowker* et al., 1995). Also, many nerves that course through the DSIL will probably be desensitized. Together these findings suggest that much of the distal sesamoid bone and its suspensory apparatus will be desensitized by an injection of local anesthetic into the DIP joint.

The second observation that the dye-local anesthetic can diffuse from the DIP joint and the podotrochlear bursa suggests that the local anesthetic injected for diagnostic purposes may diffuse beyond the confines of the synovial cavity to desensitize other structures in the foot in addition to exposed joint surfaces. In addition to the ligaments mentioned above, structures were found to include the dorsal portions of the palmar digital nerves (PDN) after DIP joint injections, and virtually all of the PDNs with a podotrochlear bursa injection. These observations indicate that the effects of the local anesthetic are not restricted to synovial surfaces but are, in fact, more widespread depending upon the sensory nerves desensitized within the PDN. An assumption that such synovial cavity injections are selective for the surfaces will, in all likelihood, result in gross misinterpretations of the regions of the foot desensitized during a clinical examination.

The present observations reconfirm the relative lack of a direct communication between the DIP joint and the podotrochlear bursa (*Calislar* and *St. Clair*, 1969; *Gibson* et al., 1990). However, the diffusion of the dye-local anesthetic solution into the podotrochlear bursa to form an indirect communication between it and the podotrochlear bursa is consistent with previous clinical observations (*Bowker* et al., 1993). The diffusion path of the dye-local anesthetic solution appears to occur mainly by one of two ways. First, the dye-local anesthetic diffused through the DSIL and its connective tissues to the intersection between the DSIL and the DDFT and then along the dorsal surface of the DDFT, rather than merely diffusing directly into the podotrochlear bursa from the ventral surface of the DSIL. The importance of this diffusion route is that many sensory nerves to the podotrochlear bone and the distal phalanx will be desensitized prior to any accumulation of local anesthetic within the podotrochlear bursa. The second route of local anesthetics into the podotrochlear bursa is via the loose connective tissues proximal and palmar to the CSL. In contrast, control experiments of Luxol fast blue dye mixed with synovial fluid (5 ml) remained within the injected joint.

The diffusion of dye-anesthetic solution from the DIP joint and the podotrochlear bursa into the surrounding connective tissues within the equine foot, especially with the partial to complete desensitization of the PDN and its smaller branches, may account for the different effects of the local anesthesia reported at 5 minutes and at later times of 15–20 minutes (*Dyson* and *Kidd,* 1993). One might assume that the effects observed at 5 minutes post injection would be due to the (more) direct effects of the local anesthetic upon the synovium, any exposed surfaces, and the immediate underlying connective tissues of the joint cavity, while those effects observed much later would be due to the diffusion of the local anesthetic into deeper tissues including portions of highly innervated ligaments (CSL, DSIL) and the small branches from the PDN and thus desensitizing portions of the distal sesamoid bone, the distal phalanx and other more distal structures in the foot.

While our findings support the clinical observations of *Dyson* and *Kidd* (1993) that suggest local anesthetics may not be selective for only the DIP joint, and the podotrochlear bursa, they do not suggest that such injections are not clinically useful. The fact that the patterns of distribution and diffusion of the dye-local anesthetic are remarkably consistent with manipulation and time after the injection suggests that these injections may in fact be valuable in diagnosing problems associated with the podotrochlear suspensory apparatus and other foot regions. However, these dye-local anesthetic experiments are, in our opinion, viewed as only preliminary to determining the actual distribution and diffusion of the local anesthetic using radiolabelled compounds.

### References

*Bowker, R. M., Rockershouser, S. J., Vex, K. B., Sonea, I. M., Caron, J. P.* and *Kotyk, R.* (1993): Immunocytochemical and dye distribution studies of nerves potentially desensitized by injections into the distal interphalangeal joint of the navicular bursa of horses. JAVMA 203, 1708–1714.

*Bowker, R. M., Rockershouser, S. J., Linder, K., Vex, K. B., Sonea, I. M.* and *Caron, J. P.* (1994): A silver impregnation and immunocytochemical study of innervation of the distal sesamoid bone and its suspensory ligaments in the horse. Equine vet. J. 26, 212–219.

*Bowker, R. M., Linder, K., Sonea, I. M.* and *Holland, R. E.* (1995): Sensory innervation of the navicular bone and bursa in the foal. Equine vet. J. 27, 60–65.

*Calislar, T.* and *St. Clair, L. E.* (1969): Observations on the navicular bursa and the distal interphalangeal joint cavity of the horse. JAVMA 154, 410–412.

*Dyson, S. J.* (1994): A comparison of responses to analgesia of the navicular bursa and intra-articular analgesia of the distal interphalangeal joint in 102 horses. Internatl. Symp. on Podotrochleosis. In: Verlag der Deutschen Reiterlichen Vereinigung, Warendorf, pp. 152–164.

*Dyson, S. J.* and *Kidd, L.* (1993): A comparison of responses to analgesia of the navicular bursa and intra-articular analgesia of the distal interphalangeal joint in 59 horses. Equine vet. J. 25, 93–98.

*Gibson, K., McIlwraith, C.* and *Park, R.* (1990): A radiographic study of the distal interphalangeal joint and navicular bursa of the horse. Vet. Radiol. 31, 22–25.

*Jann, H., Henry, G., Berry, A.* and *Cash, L.* (1991): Arthrographic observations of the equine distal interphalangeal joint (Articulationes interphalangeae distalis manus) and navicular bursa (Bursa podotrochlearis). Anat. Histol. Embryol. 20, 30–36.

*Nickel, R., Schummer, A., Seiferle, E., Frewein, J.* and *Wille, K. H.* (1979): Locomotor System of the Domestic Mammals, Vol. 1, Springer-Verlag, New York, pp. 198–201.

*Rijkenhuizen, A. B. M., Nemeth, F., Dik, K. J.* and *Goedegebuure, S. A.* (1989): The arterial supply of the navicular bone in the normal horse. Equine vet. J. 21, 399–404.

*Sack, W. O.* (1991): Rooney's Guide to the Dissection of the Horse, 6th Edition. Veterinary Textbooks, Ithaca, NY, pp. 139; 145–146.

*Stashak, T. S.* (1987): Lameness. In: Adam's Lameness in Horses, 4th Edition, *Lea* and *Febiger,* Philadelphia, pp. 486–558.

*Turner, T.* (1989): Diagnosis and treatment of navicular syndrome in horses. Vet. Clin. N. Amer. Equine Practice 5, 131–144.

*Turner, T.* (1991): Navicular disease. In: Equine Medicine and Surgery, 4th edn. Eds: *P. Colahan, I. G. Mayhew, A. Merritt* and *J. Moore.* American Veterinary Publications, Goleta, pp. 1346–1350.

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