

SECTION 1: The Chemistry of the Equine Joint

Anatomy/Physiology of the Joint

The cartilage found on joint surfaces that articulate, such as in the fetlock joint, is called hyaline cartilage. Hyaline cartilage has a translucent bluish-white appearance, and is made up of cells embedded within what is called an extracellular matrix. Hyaline cartilage is made up of approximately 75% water, 15% type II collagen, 10% proteoglycans, and 2% chondrocytes.¹

The extracellular matrix is made up of collagen (predominantly type II) and proteoglycans, with a smaller percentage of glycoproteins. The type II collagen arranged in fibrils is responsible for the strength of articular cartilage. These collagen fibrils are arranged at various depths within the cartilage to provide support.

The role of proteoglycans is to attract water into the extracellular matrix to provide the cushioning for the joint. These proteoglycans consist of a central protein core to which 1 or more glycosaminoglycans (GAG) side chains are attached. Much of the cushioning strength and resiliency of cartilage is attributable to these GAG side chains. The precursors of these GAGs are amino sugars, one of which is glucosamine.^{1,2}

Chondrocytes are the cells found within articular cartilage. Their role in joint health is to produce and maintain the extracellular matrix in which they are imbedded. The main proteoglycan found in cartilage is called aggrecan, and chondrocytes produce aggrecan by binding the GAGs to a central protein core of proteoglycans in a specific order.

Joint problems are due to a variety of reasons, with trauma and inflammation of the joint, called synovitis, topping the list. Once inflammation is present it can quickly initiate a “domino effect” of the inflammatory process into surrounding tissues that in turn release substances that further stimulates the inflammatory process. The many factors that are involved in the degradation of articular cartilage are in place.

Damage to cartilage can occur from many sources, to include normal wear and tear, as well as traumatic injury, inflammatory processes or even some drugs. When the articular cartilage is viewed with the naked eye, changes or degeneration of articular cartilage appear as small cracks, referred to as fibrillation, which can progress to form crevices, or vertical clefts, that can reach all the way down to the bone. Once the cartilage is damaged, the

proteoglycan content of the articular cartilage decreases and the collagen breaks down. These changes cause an increase in water uptake into the cartilage, and thus create a “softer” cartilage surface. This softer cartilage is not as tough as normal cartilage, and over time, a total loss of cartilage can occur, referred to as a full-thickness loss.¹ The cells within the matrix, the chondrocytes, can also be affected and will start to die. Chronic progression of these changes leads to chronic changes in the joint referred to as osteoarthritis.

SECTION II: The Role of Nutrient Supplementation to the Equine Joint

Role of Glucosamine

Oral compounds sold as supplements for maintenance of joint health provide components of cartilage and precursors of components of cartilage, such as chondroitin sulfate and glucosamine hydrochloride. Glucosamine has numerous in vitro effects and influences the expression or activity of many mediators of osteoarthritis. An example of this would be a reduction in the destruction of proteoglycans and a slowing of the synthesis and activity of compounds that can damage cartilage tissue.² When evaluated in a laboratory setting, glucosamine has shown an ability to influence the activity of the mediators of osteoarthritis. Glucosamine has also reportedly been shown to increase the production of proteoglycans, including the aggrecan core protein, which augments cartilage’s ability to repair.^{1,2,3} Studies using radiolabeled glucosamine HCl indicate the tagged carbon of glucosamine rapidly appeared in most tissues and organs, but with a special affinity for the articular tissues and bone.⁴ Therefore, the purpose for supplementing the diet with these compounds is to provide the “building blocks” for the extracellular matrix.

Delivery of Supplementation to the Equine Joint

Many factors affect the supply of nutritional supplements to the animal, from the solubility of the nutrient to the rate of passage of the nutrient through the animal. Nutrients with high water or fat solubility are more readily assimilated by the animal into biologically useable forms.

Dose form of the Nutrient

Controlling the delivery of the nutrients from the matrix in which it is supplied to the animal is one way to maximize the utility of nutrient to the animal. If the method of delivery encapsulates the nutrients, allowing them to be absorbed slowly, the likelihood of the animal’s ability to utilize the nutrient

increases. Matrices that meter out nutrients into the gastrointestinal tract intuitively provide better delivery mechanisms than non-protected nutrients.

Rate of Passage--Gastrointestinal Tract

The rate of passage of food through the equine stomach is highly variable, depending on how the horse is fed. The rate at which feed travels through the entire equine digestive tract is affected by the digestibility of the feed, water intake/balance, level of exercise, and any digestive disorders. The total mean retention time has been measured, using 7 different experimental models, as ranging from 26 to 28 hours.⁶

Studies have been conducted to determine the normal pattern of transit time in the equine. When the transit times of both liquid and particulate markers during the first 1.5 h following administration are measured, 75% of the liquid markers leave the stomach by 0.5 h, while 75% of the particulate markers were still present in the gastric contents at 1.5 h. Liquids appear to rapidly leave the stomach and pass through the small intestine whereas particulate markers are retained in the equine stomach for more prolonged periods of time.⁷ It has been reported that the gastric emptying half-time (T50), defined as time it took for 50% of the ingesta to leave the stomach, ranged from 0.56-4.21 hours for a meal of crimped oats to 1.11-2.51 hours for a pellet ration.⁸

Results of a study investigating gastric emptying in ponies indicated that the equine stomach is likely completely empty 24 hours following a roughage meal (hay). The percent of dry matter remaining in the stomach was greatest at 12 hr and that the stomach had emptied at least 99% of dry matter ingested by 18 hr.⁹

Retention times in the small intestine of ponies dosed with a marker of chromic oxide ranged between 76.6 and 84.9 minutes with a mean of 80.8 minutes.¹⁰ Mean retention time of digesta in the cecum and colon of horses ranged from 18 to 23 hours using 2 different markers (CoEDTA and chromium).¹¹ Significantly ($p < 0.01$) longer times have been measured in horses fed restricted amounts of alfalfa compared with ad libitum feeding.¹² Maximum recovery of the marker in the feces occurred between 36 and 48 hrs.¹³

Based on the studies conducted to date, the amount of time a particle of feed remains in the digestive tract depends on many factors, including

individual variability. Studies have shown that liquid can exit the stomach as quickly as 30 minutes following ingestion, but that particles can remain in the stomach for 12 hours, with 99% of the particles having exited at 18 hours. The amount of time for 50% of a feed to exit the stomach ranged from 0.56 to 4.21 hours. Another interpretation of this is that at 4 hours, 50% of the feed was still retained. This correlates with another study cited that indicated that at 1.5 hours, 75% of the particulates were still in the stomach. So, based on this information, it's possible for feed particles to remain in the stomach a number of hours. A conservative estimate would be 4 to 8 hours.

Intestinal transit time is fairly consistent at about 1 ½ hours. Cecal and colon retention times range from 18 to 23 hours. Total mean retention time, evaluating 7 different models that have been conducted, was about 26 to 28 hours.

Positioning: Transit time for an individual can range from 1 ½ to 2 days, with a total mean retention time of 26 to 28 hours. Factors influencing retention time include: water intake, exercise, type of feed, amount of feed fed.

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