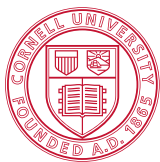


Baker Institute for Animal Health



DIAGNOSIS AND GENETICS
OF

Canine Hip Dysplasia



Cornell University
College of Veterinary Medicine

Hip dysplasia, an abnormal formation of the hip joint, occurs in many mammals. It is a serious medical problem for both humans and dogs, although it is far more prevalent in dogs. In contrast to a one percent incidence in humans, canine hip dysplasia can occur in 50 percent or more of some of the larger breeds of dogs. Unlike human hip dysplasia, the canine condition is not detectable at birth, although it can be identified within the first year of life. It affects dogs and bitches nearly equally. The information here is intended to familiarize dog owners with some of the characteristics of hip dysplasia. A veterinarian should be consulted for specific advice.

What breeds are affected?

Hip dysplasia is prevalent in the large breeds of dogs. It is particularly common in breeds such as the Bernese Mountain Dog, Bloodhound, Boxer, Brittany Spaniel, Chesapeake Bay Retriever, English Setter, English Springer Spaniel, Golden Retriever, Gordon Setter, German Shepherd Dog, Labrador Retriever, Old English Sheepdog, Standard Poodle, Rottweiler, St. Bernard, Welsh Springer Spaniel, and Welsh Corgi.*

Mixed breeds are also subject to hip dysplasia. Not even the toy breeds are spared, although frequency is lower in small dogs. Large dogs that have a relatively low incidence of hip dysplasia include the Borzoi, Doberman Pinscher, Great Dane, Greyhound, Irish Wolfhound, and Siberian Husky.

What are the signs of hip dysplasia?

Hip dysplasia usually begins to manifest itself through decreased activity with varying degrees of joint pain. Often these signs are first observed between the ages of four months and one year. Young dogs may have a swaying and unsteady gait. They may draw their hind legs forward, placing more weight on their forelimbs. Afflicted dogs often run with both hind legs moving together in a gait that has been described as “bunny hopping.”

* www.offa.org/hipstatbreed.html

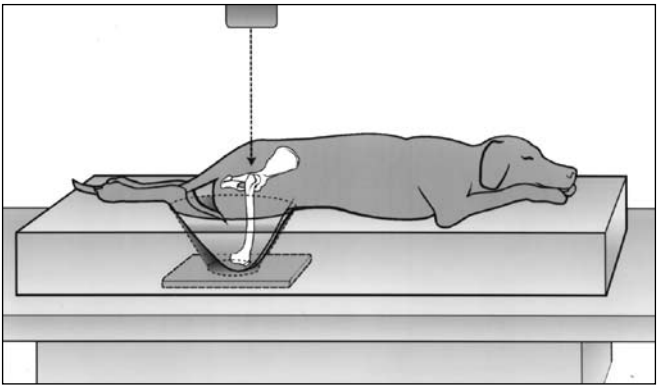


Figure 1. Dog on foam pad, poised for the dorsolateral subluxation (DLS) test.

As the disease progresses, a dog may have difficulty rising after sitting or lying down. Stairs become difficult to climb, and the dog may whimper or snap when an affected joint is manipulated. The disease is progressive and often crippling, but some dogs exhibit little discomfort despite abnormalities in their joints. In most cases, pain limits movement of the joint. Running and intensive activity aggravate the condition and can reveal signs of the disease in dogs that otherwise appear normal.

How is hip dysplasia diagnosed?

Until the genes that cause hip dysplasia are identified, the primary means of diagnosis will remain a preliminary physical examination with confirming evidence provided by a radiographic image. The physical examination may include manipulation to determine pain and range of motion of hip joints, palpation to determine the degree of laxity, and the Ortolani procedure—during which the femoral head can be felt to slip into the joint socket called the acetabulum. A more accurate diagnosis than the traditional hip-extended radiograph can be made using the dorsolateral subluxation (DLS) test that was developed recently at Cornell.

Timing is important. Because the structures of the hip joint do not mature fully until eight months of age, a reliable diagnosis based on radiography cannot be made on younger puppies.

In preparation for the DLS X-ray picture, the dog is first anesthetized or deeply sedated. It is placed on its stomach in a soft foam frame, allowing the stifles to

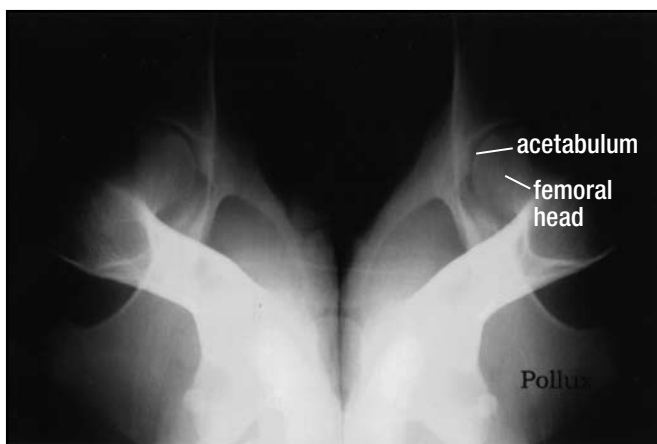


Figure 2. Normal Hip Joint. Dorsoventral radiograph (showing weight-bearing position used to determine the DLS score) of a Greyhound with a DLS score of 63 percent for the left hip and 67 percent for the right hip.

protrude through the frame and make contact with the radiographic table so that the weight of the dog is transferred down the legs to the knee joint. (See figure 1.)

In a normal hip joint (see figure 2), the head of the femur fits congruently into the acetabulum. In a dysplastic joint (see figure 3), the femoral head conforms poorly to the acetabulum. More space is evident between the bones. Displacement of the femoral head is the hallmark of the disease. In Labradors, Greyhounds, and their crossbreed offspring, normal joints have a DLS score greater than 55 percent. (See figures 2–6.) A DLS score of less than 55 percent at eight months of age indicates that the dog is at risk for developing an abnormal hip joint and is susceptible to osteoarthritis. A dog with a DLS score less than 45 percent has a 40-times-greater chance of developing hip osteoarthritis than a dog whose score is greater than 55 percent.

What is the nature of the disease in dogs?

Hip dysplasia is the development of a poor fit of the femoral head in the acetabulum that allows loose movement and altered pressure. This results in joint damage, inflammation, and pain. The volume of synovial fluid in the joint increases, and the round ligament that binds the femoral head to the acetabulum becomes enlarged. The normally smooth articular cartilage covering the ends of the opposing femoral head and

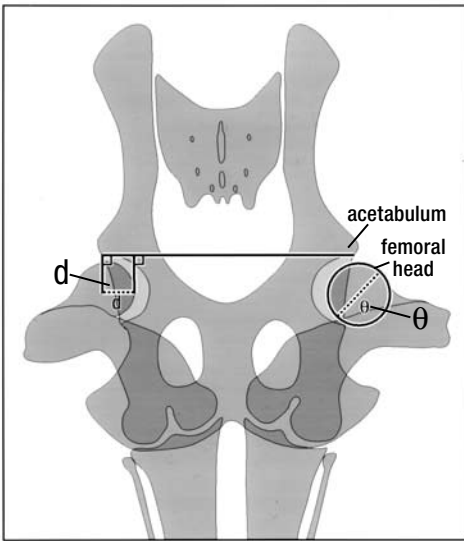


Figure 3. Abnormal Hip Joint. Radiograph of a dysplastic Labrador Retriever with a DLS score of 44 percent for the left hip and 41 percent for the right hip.

acetabulum is abraded and weakened, and the joint capsule becomes inflamed and thickened. Muscles in the region of the hip joint diminish in bulk and may be affected in other ways as well. As the disease progresses, the bones are also damaged, and spurs called osteophytes grow at the bone-cartilage interface. The whole joint is structurally weakened and painful. Taken together, these are the features of osteoarthritis, also known as degenerative joint disease.

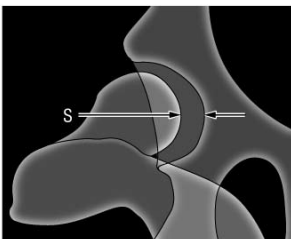
Hip dysplasia once was thought to be an abnormality involving only the tissues in the region of the hip joint. But evidence indicates that the shoulder and knee joints and the joints between vertebrae often show similar changes. That observation suggests that hip dysplasia is simply the most conspicuous manifestation of a more generalized abnormality affecting the joints.

Hip dysplasia is not obvious in very young dogs. The joints of newborn pups seem to be structurally and functionally sound and do not show the characteristic abnormalities revealed by X-ray photographs of older dogs. There are no obvious anatomical abnormalities in the shapes of the bones of the joints of growing dogs that are destined to develop hip dysplasia.



$$\text{DLS score (\%)} = d/\theta(100)$$

Figure 4. A drawing showing how the DLS score is derived from a dorsoventral radiograph. A straight horizontal line is drawn as illustrated above; then perpendicular lines are drawn from the end of the horizontal line and at the edge of the femoral head. The distance between these two perpendicular lines is measured in millimeters (d). The DLS score (percentage of the femoral head medial to the cranial acetabular rim) is determined by dividing d by the diameter (mm) of the femoral head (θ) from the same hip [DLS score (%) = d/θ(100)].



S=subluxation (displacement);
range: 0–12 mm

Probability of Hip Dysplasia	S
Low	<2mm
High	>2 mm

Figure 5. A simple estimate for determining affected or nonaffected joints can be made by measuring the distance between the medial edge of the femoral head and the edge of the acetabulum. On a properly positioned DLS radiograph of an eight-month-old dog, if the distance is less than 2 mm, the dog has a low probability to be dysplastic. When the distance is greater than 2 mm, the femoral head is considered displaced and the dog is at risk for hip dysplasia.

Is hip dysplasia a hereditary disease?

Yes. It has long been known that hip dysplasia is a complex, or quantitative, trait with both an environmental and a genetic component. Recently, scientists at the Baker Institute and Cornell's College of Veterinary Medicine have begun to define the regions on the dog genome that contain the genes that contribute to hip

Table 1. Sensitivity and specificity of DLS score and Ortolani test for predicting hip dysplasia in eight-month-old dogs.

Test	Cut-off for HD (+)	SE	SP	NPV	PPV
DLS %	< 55%	100%	53%	100%	50%
Ortolani	+	100%	39%	100%	39%

75 dogs including Labrador Retrievers, Greyhounds, and Labrador Retriever-Greyhound crossbreeds were examined at eight months and by standard extended hip radiography at 24 months.

HD=hip dysplasia; SE=sensitivity; SP=specificity; NPV=negative predictive value; PPV=positive predictive value

Table 1 shows that a DLS score of less than 55 percent has a sensitivity of 100 percent. Sensitivity is the percent of affected dogs that were identified correctly by the test. The specificity (53 percent) indicates the percent of unaffected dogs that were identified correctly. The negative predictive values also were very high. One-hundred percent of dogs identified as unaffected at eight months of age were unaffected at two years; however, predicting the presence of hip osteoarthritis at eight months of age was only 50 percent accurate. The table also shows the high degree of reliability of the Ortolani test at eight months in identifying unaffected (normal) dogs.

dysplasia. These regions are known as quantitative trait loci (QTL). The problem is that these QTL chromosomal regions are initially defined very broadly, containing hundreds of genes in addition to the ones that contribute to hip dysplasia. The goal of continuing research is to apply the rapidly developing new techniques for genetic analysis to separate the genes that contribute to hip dysplasia from the remaining genes within the QTL. There are at least two and possibly as many as 12 canine chromosomes that harbor QTL for hip dysplasia. Since offspring can inherit genes in multiple combinations of favorable and unfavorable alleles, it is easy to understand that two “normal” dogs could unexpectedly produce a dysplastic puppy.

Identifying the QTL that either confer protection or increase the risk of canine hip dysplasia will lead to genetic markers that will provide veterinarians with better tools with which to recommend useful measures early in a dog’s life to reduce the frequency of disease. Identifying the mutation(s) causing hip dysplasia will lead to an understanding of the underlying biochemical mechanism and ultimately to the development of more effective therapies for this orthopedic disease of dogs.

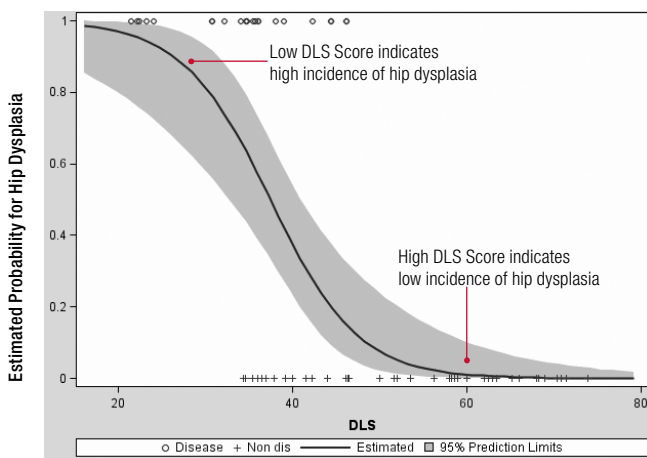


Figure 6. This statistical logistic regression model relates measurements of DLS scores in eight-month-old dogs to the probability of a dog having hip dysplasia. As listed in table 1, the 55 percent DLS score cut-off for unaffected and affected dogs, respectively, is an appropriate criteria for selecting both disease-free and dysplastic dogs. The confidence limits shown by the shaded areas in the figure illustrate that no test is 100 percent accurate in all cases. Some overlap occurs.

Can the disease be prevented?

The time of appearance and rate of progression of hip dysplasia are influenced by the growth rate of dogs. Studies at the Baker Institute and elsewhere have shown that slowing growth rate during the early months of life can lessen the severity of hip dysplasia and perhaps even prevent it.

One study followed two groups of susceptible pups from eight weeks of age until two years and beyond. Pups in the first group were fed 24 percent less food than those in the second group, which were permitted to eat all of the food they wanted of the same diet. At the end of two years, the group whose diet had been restricted had a 46 percent lower occurrence of hip dysplasia than the group that had fed freely. It would be desirable to devise a less restricted dietary regimen that would have as much effect in preventing the condition. Feeding dogs to limit weight is advisable. This action, however, does not alter the genetic susceptibility for hip dysplasia.

What is the treatment?

Practical measures can give comfort to dysplastic animals. Mild exercise such as walking, swimming, or slow running is beneficial, but excessive activity such as jumping and prolonged running should be avoided. Some

analgesic and anti-inflammatory drugs can relieve the pain. However, such medications do not arrest the destructive changes in the joint. Injections and even oral administration of carbohydrate polysulfates have shown promise in clinical use as a treatment for dysplastic dogs. So has supplementing the diet with the nutraceuticals chondroitin sulfate and glucosamine sulfate, as well as Omega 3 fatty acids. These natural products can prevent pain and aid in remodeling to improve the contour of the hip joint. These compounds do not cure hip dysplasia, but many dogs receive some benefit from this treatment.

Surgical procedures have been devised to treat dogs with pain and lameness. Operations that can be performed on dogs with severe hip dysplasia include procedures that rearrange the bones of the pelvis or the femoral head to improve joint function. In some cases, creation of a false joint by removing the femoral head can relieve pain and restore mobility for a dog. Replacement of the acetabulum and the femoral head by prostheses is another option.

What research is being done?

Although it is known that the underlying cause of hip dysplasia is mutations in the genes, neither the specific genes nor the biochemical mechanism controlled by the genes is yet understood. Current research is focused on identifying in more detail the QTLs involved and then identifying genes that have a role in the process of initiating and perpetuating the disease.

In conjunction with Rory Todhunter in the Department of Clinical Sciences at the College of Veterinary Medicine, Baker Institute scientists George Lust and Nancy Burton-Wurster are seeking to achieve the following goals:

- Determine the underlying biochemical mechanism responsible for hip dysplasia in dogs;
- Identify a genetic marker in the DNA (e.g. of white blood cells) that can be used to distinguish normal and affected animals regardless of age. Such a marker also may identify those clinically normal dogs that pass hip dysplasia alleles to their progeny;
- Unravel the influence of environmental affects, such as nutrition, on genetics;
- Devise new therapeutic procedures to arrest the disease.

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George Lust, professor of physiological chemistry at the Baker Institute, received his undergraduate degree from the University of Massachusetts and his PhD in biochemistry from Cornell University. His research is on joint diseases of dogs, with emphasis on hip dysplasia and the osteoarthritis associated with that disease.

Nancy Burton-Wurster, senior research associate at the Baker Institute, received her bachelor's and master's degrees from New York University and her PhD from NYU's School of Medicine. Her research is on osteoarthritis with special emphasis on mechanical factors contributing to the initiation of cartilage degradation.

Rory Todhunter, associate professor of surgery in the Department of Clinical Sciences at the College of Veterinary Medicine, earned his veterinary degree from the University of Sydney (Australia), his master's degree from Michigan State University, and his PhD from Cornell. His collaborative research efforts with Baker Institute faculty include the areas of hip dysplasia and osteoarthritis.

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Baker Institute for Animal Health
College of Veterinary Medicine
Cornell University
Ithaca, New York 14853
phone: (607) 256-5600
fax: (607) 256-5608
e-mail: Baker_Institute@cornell.edu
web: bakerinstitute.vet.cornell.edu



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