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Canine Hip Dysplasia: The Disease and Its Diagnosis

University of Pennsylvania
Amy S. Kapatkin, DVM, DACVS
Hilary H. Fordyce, VMD
Philipp D. Mayhew, BVM&S, MRCVS
Gail K. Smith, VMD, PhD

KEY FACTS

- Canine hip dysplasia (CHD) causes variable degrees of disabilities in affected dogs.
- There are no means to determine with absolute certainty whether a dog is genotypically free of the susceptibility for CHD.
- The PennHIP® method uses the distraction radiographic view to predict an animal's susceptibility to CHD and conventional ventrodorsal, hip-extended radiographs to make a definitive diagnosis.

ABSTRACT: Canine hip dysplasia is a highly prevalent, genetic, osteoarthritic disease that causes mild to severe pain and variable degrees of disability in dogs afflicted with the condition. Except for the most severe forms of the disease, most dogs with canine hip dysplasia show minimal to no clinical signs. Understanding the disease helps veterinarians make evidence-based medical decisions tailored to individual patients.

In 1937, Schnelle published the first radiographic description of canine hip dysplasia (CHD), and the disease, which was believed to be rare, was termed *bilateral congenital subluxation*.[1] In 1966, Henricson and colleagues defined CHD as "a varying degree of laxity of the hip joint permitting subluxation during early life, giving rise to varying degrees of shallow acetabulum and flattening of the femoral head, finally, inevitably leading to osteoarthritis (OA)."[2] This long history notwithstanding, until recently the association between joint laxity (i.e., subluxation) and degenerative joint disease (DJD) has been an empirical one. Its general acceptance has formed the basis for CHD diagnostic scoring systems worldwide.

Despite the availability of well-intentioned CHD control programs, the prevalence of CHD remains high. The disease is a major concern to dog owners and breeders, sportsmen, working dog agencies, and veterinarians because the associated hip DJD can cause discomfort, disability, and decreased work longevity. Severe morbidity, however, is an uncommon finding. Although CHD is an extremely prevalent disease (as high as 74% in some breeds[3]), it is not a devastating disease. Most dogs with CHD—particularly those with milder forms of DJD—show no overt clinical signs until their geriatric years, if ever. Dogs that are genetically predisposed to CHD are born with normal hips and develop radiographic evidence of joint laxity after 2 months of age and DJD usually some time after 4 to 6 months of age (and often much later).[2–14] It had been previously hypothesized that DJD occurred in a biphasic fashion (high frequency of OA before 2 years of age and then again when dogs are geriatric); however, new evidence suggests that the incidence of DJD occurs linearly as dogs age.[15] Pain and lameness associated with radiographic OA may or may not develop, making clinical signs of radiographic OA indeterminable, particularly in the milder variants of the disease. It is the latent development of the characteristic disease phenotype, namely DJD, that makes early diagnosis of CHD unreliable and that has led most CHD control programs to require radiographic certification at 1 year of age worldwide and in the United States at 2 years of age.[10] As will be discussed later, new research indicates that even 2 years of age is too young to predict with accuracy the hip phenotype at the end of life.[16]

CHD DIAGNOSIS

Polygenic Disease

It is important to emphasize at the outset that there is no gold standard for CHD diagnosis. That is, while veterinarians patiently wait for a definitive molecular genetic test, there are no means to determine with absolute certainty whether a dog is genotypically free of the susceptibility for the disease. This situation arises because of the polygenic nature of CHD. The expression of a polygenic disease[17] (termed *quantitative* or *metric* disease or more recently, "a disease of complex inheritance") can be profoundly influenced and confounded by environmental factors, such as diets that promote weight gain. For example, it has been shown that dogs carrying the genes for hip dysplasia (i.e., genotypically abnormal), if fed a protective diet, could appear phenotypically normal until beyond 8 years of age.[18] The standard pass/fail system of hip scoring, commonly used worldwide, would likely score such dogs as normal and certify them for breeding, when in fact the dogs carried a sufficient frequency of bad genes to make them phenotypically abnormal were they not protected by the dietary/environmental factor. The obvious consequence of this scenario is that diseased genes can be unwittingly passed to the next generation, rather than the presumed normal genes from interpretation of the 2-year radiographic phenotype. By definition, a quantitative trait, such as hip dysplasia, expresses itself on a continuous scale from normal to severely abnormal, and the expression is a reflection of both the frequency of bad genes in the genotype and the many and varied influences imposed by the environment in which the dog lives. In general, pass/fail scoring systems at 1 or 2 years of age cannot adequately represent the continuity and complexity of such a quantitative trait. This article emphasizes the polygenicity of CHD, the attendant uncertainty of CHD expression and how such uncertainty influences diagnostic methods, and the decision on the part of surgeons to suggest corrective or preventive surgical procedures.

Origin of Diagnostic Techniques

In the 60 or so years since its first description, the definitive diagnosis of mild forms of CHD has remained elusive. Numerous diagnostic methods, including the use of history and clinical signs, palpation, and radiography, have been advocated. From experimental studies, histopathologic findings have been used largely to confirm hip status derived from noninvasive diagnostic methods. It was found that the radiographic changes of the hip are less severe or lag behind those seen on histopathologic testing. For obvious reasons, this testing is not practical in a clinical situation.[14,19]

Clinical signs associated with CHD are highly variable and often nonspecific; therefore, clinical signs do not provide key diagnostic criteria. Similarly, palpation of hip laxity[20–22] (Bardens,[22] Barlow,[21] Ortolani,[20] or subluxation/reduction methods), although mentioned frequently in non–peer-reviewed articles, has not been shown to provide salient diagnostic or prognostic information.[20–23] Although newer diagnostic modalities (e.g., computed tomographic scanning, ultrasonography, magnetic resonance imaging, force plate, kinematics, molecular techniques) are currently under investigation, radiography has become the accepted convention for the diagnosis of CHD.[24–32]

Importance of Accurate Diagnosis

Accurate CHD diagnosis is integral to understanding the true prevalence of the disease. Likewise, diagnostic accuracy is essential in the genetic control of the disease. For surgeons treating end-stage hip disease, hip radiography usually corroborates the clinical picture because the advanced DJD, which is responsible for the observed clinical signs, is usually obvious on the conventional hip-extended radiograph. However, young dogs destined to become dysplastic—particularly those destined to become only mildly dysplastic—typically do not have such overt clinical or radiographic signs. Over the past 2 decades, surgical techniques have been introduced that purport to prevent hip DJD. It deserves mention, however, that to date no data exist to support that any surgical technique in animals or humans can prevent DJD. Should such a technique become available, surgeons would require a reliable method to determine which animals are at risk and, therefore, which animals are candidates for prophylactic surgery. In this case, more important than accurate diagnosis is the accurate prediction of disease (and its magnitude) long before any clinical or radiographic signs manifest.

CHD Prevalence Figures

The true prevalence of CHD by breed in the general population is unknown. Most hip registries worldwide permit voluntary submission of hip radiographs. Understandably, this practice encourages prescreening of films such that only the best (most normal-looking) films get submitted for evaluation. The resulting bias in the registry understates the true prevalence of CHD within breeds of pedigreed dogs. Data suggest that this bias is large and breed dependent. A random sampling of subjectively scored hip radiographs from 200 golden retrievers and 132 rottweilers showed the prevalence of CHD to be 74% and 69%, respectively.[3] These figures are 2 to 3 times higher than comparable figures reported in the United States by the Orthopedic Foundation for Animals (OFA).

Influence of Diagnostic Criteria on Prevalence

The specific radiographic criteria used to diagnose CHD profoundly affect our understanding of hip dysplasia prevalence. Two primary criteria for the diagnosis of CHD are subluxation (hip laxity) and radiographic evidence of DJD. Not surprisingly, variations in the subjective interpretation of these criteria may lead to wide variation in estimates of disease prevalence. A recent study[4] demonstrated wide between-examiner variation in radiographic hip score. Among board-certified radiologists asked to subjectively interpret the same set of 65 hip radiographs, diagnostic agreement was shown to be poor: Kappa values were very low (ranging from 0.04 to 0.20), indicating poor diagnostic agreement.[4] Of the four radiologists included in the study, the one invoking the strictest criteria diagnosed 46% of the pool of dogs to be dysplastic as compared with the OFA, which diagnosed 15% of the dogs to be dysplastic, a threefold difference in disease prevalence. Some of this apparent discrepancy can be explained by distinct differences of opinion as to definitive radiographic signs of DJD. For example, a caudolateral, curvilinear osteophyte (CCO) on the caudal margin of the femoral neck, sometimes called *Morgan's line*, is interpreted by some radiologists to be an early sign of DJD while others dismiss it when other features of the hip look normal.[33–36] A recent study of the relationship between CCO and DJD showed that dogs with this radiographic sign were 7.9 times more at risk to show contemporaneous signs of DJD.[37] A recommendation was made from the results of the study that until the meaning of the CCO is definitively investigated, the gene pool would benefit if this radiographic sign were considered a precursor to DJD. Dogs showing the sign should be excluded from breeding.

Accurate Diagnosis as a Tool in Genetic Control of CHD

Accurate and precise diagnosis is essential in the control of genetic diseases. The preferred diagnostic phenotype to be used to direct selective breeding is the phenotype with the highest heritability. This concept is discussed in more detail in the Relationships (Correlations) Between Diagnostic Methods section.

Functional Versus Passive Hip Laxity

From its first description, hip dysplasia has been associated with hip laxity.[1] The factors that cause hip laxity have not been identified, but synovial fluid volume is believed to play a role.[38] Laxity and synovial fluid volume, however, cannot adequately explain the variation seen in the expression of hip DJD. That is, some dogs with tight-appearing hips on the hip-extended radiograph may develop DJD, and conversely, not all dogs with loose hips on the hip-extended radiograph will necessarily develop DJD. Similarly, dogs with excessive passive hip laxity as determined from the distraction radiograph have variable expression of DJD but in contrast to the shortcoming of the hip-extended view, dogs with tight hips on the distraction radiographic view rarely, if ever, express radiographic signs of hip DJD. That is, there are almost no false-negative diagnoses. Such dogs are distinctly not susceptible to DJD.[6,39,40]

Although not well studied, the results of hip palpation have not proven to be accurate in predicting hip DJD. A report by Puerto and colleagues[23] found that hip laxity evaluated by the Ortolani method of palpation was moderately correlated with hip laxity on distraction radiography; no similar correlation was found in dogs with radiographic evidence of DJD. Interestingly, 33% of dogs graded as OFA "good" had a positive Ortolani sign.[23] The methods of Bardens,[22] Barlow,[21] and Slocum and coworkers[41] (angles of luxation/reduction) have not been adequately investigated to draw evidence-based conclusions.[42]

To better understand the relationship between hip laxity and hip DJD, Smith and colleagues[6,43] divided hip laxity conceptually into two types: passive and functional. **Passive hip laxity** is the laxity appreciated or

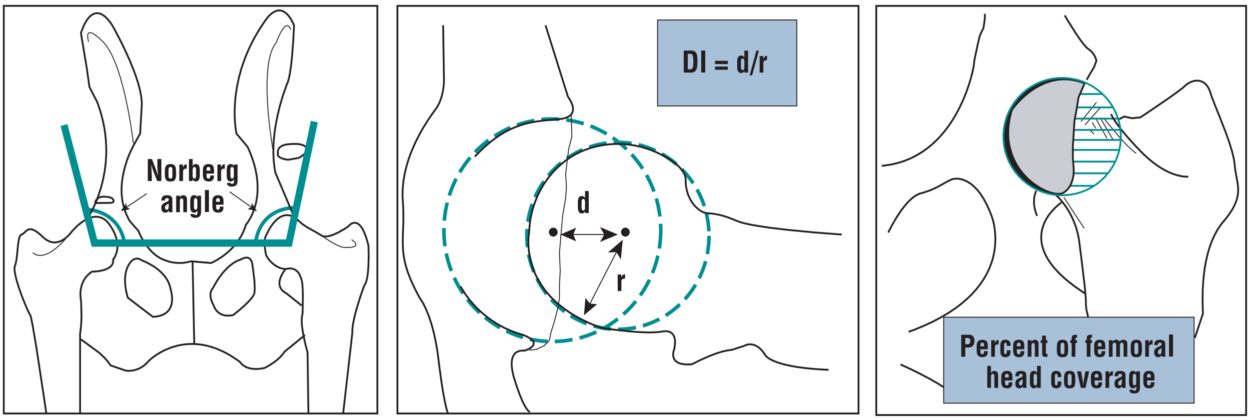

Figure 1—Laxity measurement methods. The Norberg angle, DI, and percent of femoral head coverage are three popular methods to quantitate hip laxity in dogs. The DI is less affected by malpositioning of the pelvis and conformational differences among breeds. *d* = magnitude of separation distance between the acetabular and femoral head centers under distraction; *r* = radius of the femoral head.

measured on a hip radiograph (or by palpation) of a nonambulating dog under heavy sedation or anesthesia. This form of laxity is relatively easy to measure in a clinical setting. **Functional hip laxity**, in contrast, is the pathologic form of laxity that occurs when the dog is weight-bearing. Unfortunately, functional hip laxity is not measurable; only passive hip laxity can be quantified. Studies[6,43] suggest that a dog cannot have functional hip laxity without first having passive hip laxity as a precursor. It is unknown when or why passive hip laxity converts to functional hip laxity, but environmental stressors can play a role and when the conversion occurs, the femoral head translates laterally under weight-bearing forces. In this case, the muscle forces needed to balance the rotational moments about the hip increase and at the same time the contact area of the joint cartilage markedly decreases.[43] The sum of these destructive events is high joint contact stresses producing injury and ultimately loss of delicate articular cartilage. Once the degenerative process begins, cartilage damage initiates the cascade of release of cytokines and inflammatory mediators, ultimately and inexorably leading to DJD.

METHODS OF HIP DYSPLASIA DIAGNOSIS AND SCORING

Hip-Extended Radiographic Method

The first effort to establish uniform radiographic diagnostic criteria for CHD was organized by the American Veterinary Medical Association in 1961.[44] The product of this effort evolved to become the conventional radiographic technique used worldwide. The technique is performed with the dog (preferably sedated) in dorsal recumbency, its legs fully extended, and its stifles internally rotated. This radiographic positioning technique is termed the *hip-extended method* throughout this article. Although the hip-extended positioning of the dog has become the convention, the method of hip scoring and the age at which dogs are evaluated vary considerably.

In 1966, the OFA was founded (at the University of Pennsylvania), and it introduced a 7-point subjective scoring system to be applied to dogs at 2 years of age or older. In Great Britain, however, a 106-point subjective scoring system (53 points for each hip) is used to score hips on the hip-extended radiograph in dogs at 1 year of age.[45] The Federation Cynologique Internationale, on the other hand, adopted a 5-point scoring system similar to that of the OFA but having only one grade for normal hips.[46] Some hip-scoring methods are purely subjective, whereas others incorporate objective measures of joint laxity such as the Norberg angle, percent of femoral head coverage, or distraction index (DI; Figure 1).

In subjective hip scoring systems, a diagnosis of CHD is typically made if there is radiographic evidence of hip subluxation (joint laxity), DJD, or both. Radiographic evidence of DJD includes one or more of the following[47]:

- Femoral periarticular osteophyte formation
- Subchondral sclerosis of the craniodorsal acetabulum
- Osteophytes on the cranial or caudal acetabular margin
- Joint remodeling from chronic wear

It is generally understood that subtle arthritic changes of the hip defy detection by conventional radiographic methods and (as mentioned previously) that not all dogs genotypically predisposed to DJD necessarily express the characteristic phenotype by 2 years of age or over their lifetime, for that matter. Both circumstances negatively impact accurate CHD diagnosis using conventional hip-extended radiography. In the previously cited lifelong study of Labrador retrievers, 55% of the dogs graded normal by OFA-type scoring became dysplastic by the end of life.[15] This high rate of false-negative diagnosis helps to explain the slow progress in reducing the frequency and severity of CHD by selective breeding. There is no requirement for dogs that are OFA certified at 2 years of age to undergo repeat evaluations to validate the 2-year score. This new data would warrant such a recommendation.[15]

PennHIP® Radiographic Method

The stress-radiographic method that has come to be called PennHIP® was developed partly because of recognized variations among radiologists in regard to subjective hip scores assigned to radiographs.[4] Likewise, it was understood that the prevalence of CHD among many dog breeds was disturbingly high, despite efforts to lower prevalence using a subjective hip score as a selection criterion.[3] Accordingly in 1983, research was initiated at the University of Pennsylvania to explore the hitherto empirical relationship between passive hip laxity and the ultimate development of DJD. The PennHIP® method of hip evaluation was the product, and the method was made commercially available in 1994. This method requires that dogs be sedated or anesthetized and positioned in dorsal recumbency.[5] A standard, ventrodorsal, hip-extended radiographic projection is the first of three radiographs to be made. Two additional radiographs are obtained with the hip joints in the neutral position: A compression view with the femoral heads fully seated in the acetabula and a distraction view with the femoral heads displaced laterally by use of a custom-designed device. This device is placed between the legs and acts as a fulcrum on the femur at the level of the ventral aspect of the pelvis. The so-called "neutral" hip position was chosen after mechanical testing of cadaver hips identified it as the position in which the hip reveals its maximum passive laxity.[12]

The distraction radiograph quantifies the relative degree of femoral head displacement from the acetabulum by calculating a DI. The DI ranges from 0 to >1, with 0 representing full congruency of the hip joint and 1 representing complete luxation. The standard, ventrodorsal, hip-extended radiographic projection is included as part of the PennHIP® analysis because this

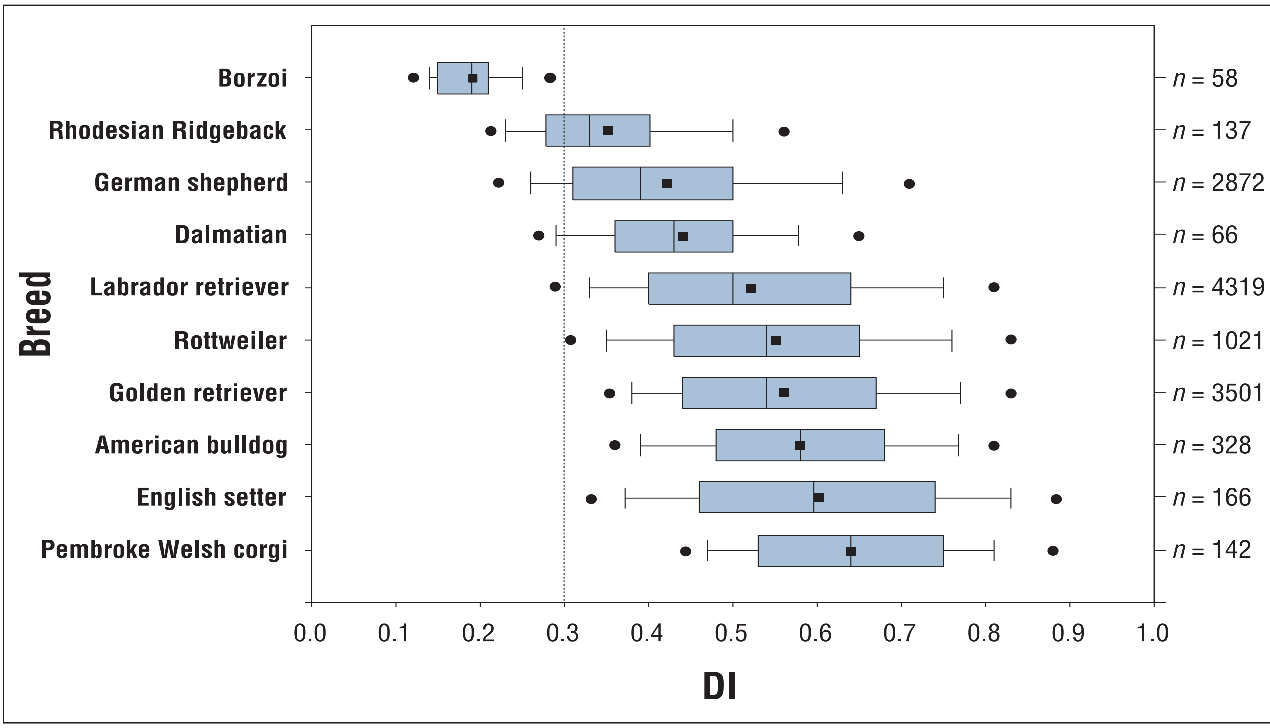

Figure 2—Box plots of passive hip laxity by breed. Unpublished data are drawn from the PennHIP® database (August 1998) and show breed-specific passive hip laxity. Note that the borzoi breed has no members with hip laxity greater than a DI of 0.3. Note also that the golden retriever breed has few, if any, members with hip laxity less than a DI of 0.3. The obvious objective of selective breeding is to move the laxity profiles of the looser CHD-prone breeds, such as golden retrievers, into the hip-laxity range approximating that of the borzoi breed, which has an extremely low incidence of CHD.

radiographic view provides pertinent information as to the presence and severity of DJD. This subjective DJD grade is combined with the quantitative DI to determine on a population basis (from a growing database) the breed-specific relationship between passive hip laxity and DJD.[6,7,13,16] The PennHIP® method then has the advantage of yielding all the information contained on the hip-extended radiograph, plus the added benefit of quantified passive hip laxity. Reports issued to dog owners include the DI of each hip, a subjective assessment of the presence and severity of DJD, and the laxity ranking of the specific dog (based on the looser of the two hips) relative to other members of its breed. It is not a pass/fail system, although dogs showing definitive radiographic signs of DJD are given a designation of "confirmed hip dysplasia."

Other Radiographic Methods

Scientific proof of hip laxity as an important risk factor for hip DJD has led to the introduction of other methods of radiographic evaluation to improve diagnostically on both the conventional OFA method and distraction radiography as used in the PennHIP® method. The most notable of these are techniques by Belkoff and coworkers,[48] Fluckiger and coworkers,[49] Farese and coworkers,[25] and Slocum and Devine.[41] Although claims have been made as to potential advantages, few techniques have been shown to have correlation with subjective scoring and DI. More importantly, none of the methods has been directly correlated—either contemporaneously or longitudinally—with the radiographic evidence of hip DJD. Claims have been made by Farese and coworkers[25] that the dorsolateral hip subluxation (DLS) method measures functional rather than passive hip laxity and, therefore, ostensibly is a better predictor of DJD than the PennHIP® method. A recent study, however, could not corroborate these claims. This study found that 23% of the dogs that had been categorized by the DLS method to have passive hip laxity and, therefore, to be unsusceptible to DJD, in fact did have functional hip laxity as evidenced by the radiographic expression of hip DJD.[50] These data also refute more recent reports by Lust and colleagues[51] that claim higher diagnostic sensitivity of the DLS method. In short, the DLS method has not been shown to have advantages over the PennHIP® method.[51–53]

Emerging Diagnostic Methods

Other noninvasive methods to image or determine the disease status of the hip have been investigated. These include computed tomography,[24,25] ultrasonography,[28,31,54,55] force plate,[27,56,57] kinematics,[26] and molecular tests.[29,30] None of the methods to date has been studied adequately to warrant clinical use for CHD diagnosis. Certainly, continued investigation into new diagnostic methodology is encouraged.

Relationships (Correlations) Between Diagnostic Methods

Considering the many methods to evaluate hip integrity, including palpation, radiography, ultrasonography, computed tomography, and molecular tests, a logical question is, which method has the greatest scientific evidence to support its utility for the genetic control of CHD? A related question would be, which of these methods, if any, can be used to identify the dogs that may be candidates for putative preventive surgeries?

To answer the first question, among the comparative analyses performed at multiple centers thus far, all have indicated that distraction radiography and the DI are the most informative diagnostically and genetically.[5–9,12,13,25,39,40,48,49,58] It should be emphasized, however, that no method is diagnostically perfect, and studies need to be conducted on all methods to identify the limits of applicability and relative advantages, if any.

The PennHIP® method has a solid foundation in scientific investigation. Biomechanical testing of cadaver canine hips at the University of Pennsylvania revealed the nature of passive hip laxity as a function of hip position. It was shown that with the hip in the standard hip-extended, internally rotated position, passive laxity was minimized due to the winding up of the joint capsule.[5,8,12] On the other hand, passive hip laxity was maximized when the hip was positioned in a neutral orientation (approximate weight bearing).[12] Finally, the load/displacement behavior of the hip in neutral position was found to be sigmoidal. This mechanical result predicted high repeatability among examiners performing distraction radiography with the hip in the neutral position, even with the expected examiner-to-examiner variability in applied loads.[8] Subsequent clinical investigations proved the high clinical repeatability of DI as predicted from the mechanical data.[9]

In other studies, the mean and range of DI were shown to vary by breed of dog (Figure 2), but within an individual dog, hip laxity as measured by the DI remained constant (within limits of scientific acceptability and clinical applicability) from 16 weeks of age.[6]

Passive laxity measured on the distraction radiograph was on average 2.5 to 11 times greater than that measured from the standard, hip-extended radiograph.[5,59] Performance borzois and greyhounds, breeds recognized to have an extremely low prevalence of CHD, had uniformly tight hips (DI <0.3), and mean DI (hip laxity) for canine breeds known to have a high prevalence of CHD had significantly greater mean DI than borzois and greyhounds.[5] Importantly, the tight-hipped dogs (DI <0.3) within disease-prone breeds of dogs had a similarly low (near 0) risk of developing DJD. Although tight hips conferred resistance to CHD in all canine breeds studied, not all dogs with loose hips (DI >0.3) developed DJD by 3 years of age. Early DI was shown to be the most important risk factor for development of hip DJD among all phenotypes tested thus far.[6,7,13] Therefore, although some dogs with hip laxity (DI >0.3) do not develop DJD, the higher the hip laxity, the greater the risk for DJD. Additionally, this susceptibility to the development of DJD was shown to be breed specific. For example, given equivalent hip laxity as measured by DI, German shepherds were five times more at risk for developing DJD than were rottweilers, Labrador retrievers, and golden retrievers, even despite the obvious weight differences among the breeds (Figure 3).[13,16]

A direct comparison of the official OFA score with DI in a pool of 260 large-breed dogs showed that a large proportion of dogs that had officially passed as excellent, good, or fair had DI scores in excess of 0.3 in the DJD susceptible range. Specifically, 53% of the hips in dogs considered OFA “excellents” were looser than 0.3 (with the loosest DI being 0.61), 77% of OFA “goods” were looser than 0.3 (the loosest was DI = 0.77), and 93% of the OFA “fairs” were looser than DI = 0.3 (the loosest was 0.91).[60] The study confirmed that the OFA radiograph does not reveal this “occult” passive hip laxity, indicating that the OFA screening method unwittingly passes dogs for breeding that have considerable susceptibility for hip DJD.

Evidence for this can be gleaned from a recent OFA report that was unable to show a statistically significant decrease in CHD incidence in the breeds included over the 20 years of the study. An increase in the percent of excellent diagnosis from 7.8% to 10.6% was the only statistically significant improvement reported.[61] Further evidence to question the effectiveness of selection using the subjective scoring of the hip-extended radiograph comes from the report of Leppanen and colleagues.[62] In Finland, no reduction in the frequency of CHD in German shepherds could be demonstrated in response to using a subjective hip score from 1985 to 1997 as a selection criterion.[62] Perhaps most telling is the evidence, previously cited, showing the false-negative rate of CHD diagnosis to be 55% comparing 2-year OFA scores with end-of-life hip scores.

Of great importance in determining relative superiority of diagnostic methods is an understanding of the trait’s hereditability coefficient. Estimates of DI heritability have been shown to be substantially higher than those of the subjective hip score.[63] To our knowledge, heritabilities have not been calculated for other methods of hip evaluation. This finding suggests that selection pressure based on DI should result in faster genetic change than selection pressure based on subjective hip scores. Finally, distraction radiography has not been found to be deleterious to the hip. As of this writing, more than 32,000 dogs have undergone the procedure, some of which were evaluated multiple times, and the method is no more harmful than the standard hip-extended radiographic

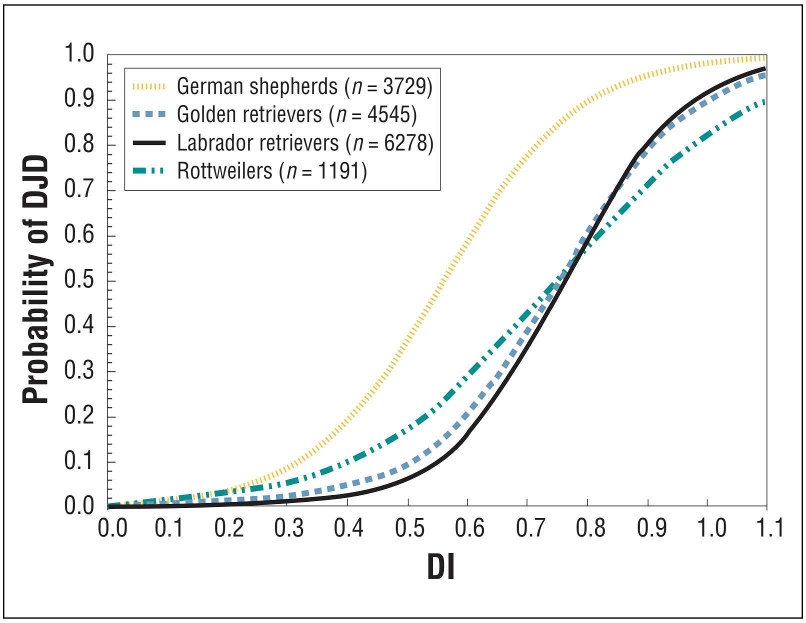

Figure 3—Probability of radiographic evidence of DJD as a function of DI for dogs ≥24 months of age in four common breeds. Note the spatial shift to the left for German shepherds, indicating an increased probability of DJD for any given DI compared with the three other breeds. (From Smith GK, Mayhew PD, Kapatkin AS, et al: Evaluation of risk factors for degenerative joint disease associated wth hip dysplasia in German shepherd dogs, golden retrievers, and rottweilers. *JAVMA* 219:1721, 2001; with permission.)

method or palpation performed as part of a routine orthopedic examination.[11]

Screening to Indicate Preventive Treatment

It is more difficult to determine whether there are diagnostic tests capable of providing indication for putative preventive surgeries. A few surgical techniques have been advanced as methods to prevent hip DJD in dogs having overt hip laxity. Such methods are recommended prior to the development of DJD. These include triple pelvic osteotomy, femoral neck lengthening procedure, and more recently, juvenile pubic symphysiodesis. Determining the prophylactic potential of a given surgical method, however, presupposes that 1) the diagnostic test can identify dogs that are at risk for hip DJD; 2) the DJD is associated with sufficient pain or disability to warrant the procedure; and 3) the treatment prevents the DJD or lessens its severity relative to age, breed, weight, and sex-matched control dogs not having surgical treatment. Unfortunately, much of this information is currently not available.

Control epidemiologic data, however, are contained in the PennHIP® database so that the prevalence of DJD in age, breed, weight, gender, and DI-matched dogs is known. For example, an analysis of DJD frequency as a function of hip laxity (DI) for four popular breeds of dogs was recently reported (Figure 3).[16] This study was a follow-up to an earlier study that was criticized by some for small sample size (approximately 183 dogs).[13] In the more recent study, a sampling of 15,742 popular purebred dogs confirmed the earlier highly statistically significant relationship between DI and DJD susceptibility and again it was shown that this relationship was breed specific.[16] For example, DJD probability for German shepherds (mean age 39 months) with demonstrated hip laxity (DI = 0.7) was approximately 0.82, but for Labrador retrievers, golden retrievers, and rottweilers with the same hip laxity, the probability for DJD was roughly half that (probability = 0.39; Figure 3). To show efficacy, then, a procedure claiming to prevent DJD would have to lower significantly the observed frequency of DJD below the expected frequency of DJD in breed, age, weight, sex, and DI-matched dogs.

For dogs with extreme hip laxity (>0.9), the probability for hip DJD is high. Therefore, treating all such dogs with preventive surgery may be considered reasonable if it could be shown that the incidence of DJD was reduced significantly in the treated group. However, problems arise when considering certain breeds of dogs with less extreme hip laxity. For example, for Labrador retrievers with a DI of 0.5, the probability for DJD is only 6%; therefore, showing a significant decrease in DJD prevalence below this level would require an extremely large sample size. Even if a candidate procedure could be shown to be preventive, this low prevalence would require performing surgery on 100 dogs in the hopes that 6 dogs will be spared developing DJD. Considering the relative low morbidity of mild and moderate forms of hip DJD, such broad application of a preventive procedure may not be warranted. It is understood that a simple, inexpensive, low-morbidity surgery to prevent the development of the DJD of hip dysplasia would represent a welcomed breakthrough; however, the epidemiology and biologic behavior of hip dysplasia must be factored into the analysis of clinical efficacy. This is a professional prerequisite. The history of veterinary orthopedics and radiology has been checkered with empiricism often being accepted in lieu of evidence-based medicine.

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ARTICLE #2 CE TEST

The article you have read qualifies for 1.5 contact hours of Continuing Education Credit from the Auburn University College of Veterinary Medicine. *Choose the best answer* to each of the following questions; then mark your answers on the postage-paid envelope inserted in *Compendium*.

1. In dogs, a quantitative trait
   a. does not reflect the frequency of bad genes in the phenotype.
   b. can be adequately judged by a pass/fail scoring system.
   c. expresses itself on a continuous scale from normal to severely abnormal.
   d. is unaffected by a dog's environment.

2. The accepted convention for the diagnosis of CHD is
   a. clinical signs.
   b. radiography.
   c. palpation of hip laxity.
   d. subluxation/reduction methods.

3. Which of these statements about CCO (Morgan's line) is false?
   a. Dogs with CCO should be bred because this radiographic sign is not significant.
   b. A CCO means there is an increased risk of a dog developing DJD.
   c. Board-certified radiologists vary in their opinion in what CCO means as a sign of DJD when other factors look normal.
   d. CCO is a radiographic sign of an osteophyte on the caudal margin of the femoral neck.

4. Maximum passive hip laxity
   a. must be determined in a weight-bearing dog.

b. does not lead to functional hip laxity.
c. can be performed in an awake dog without any specific tools.
d. is best demonstrated by distraction radiography using the PennHIP® method.

5. The PennHIP® radiographic method can be conducted by multiple examiners and still yield consistent results because
a. all the examiners learn to put exactly 30 Newtons force on the limbs.
b. the apparatus measures the force on the hips so the examiner can regulate it.
c. the measurement technique can compensate for changes in the forces placed on the hips.
d. load/displacement behavior of the hip is sigmoidal so that moderate changes in the forces on the hip do not affect the measured hip laxity.

6. Radiographic evidence of DJD of the hip can include all except
a. femoral periarticular osteophyte formation.
b. osteopenia of subchondral trabecular bone.
c. joint remodeling from chronic wear.
d. osteophytes on the cranial or caudal acetabular margins.

7. PennHIP® reports issued to dog owners do not include
a. a DI of each hip.
b. a pass/fail ranking.
c. subjective assessment of the presence and severity of DJD.
d. laxity ranking of that specific dog relative to other members of the breed.

8. The magnitude of passive hip laxity is determined mostly by
a. hip position.
b. force applied to the hindlimbs.
c. muscular strength.
d. bone length.

9. DJD
a. occurs equally in all breeds of dogs.
b. always develops in 3-year-old dogs with loose hips.
c. risk increases as hip laxity increases.
d. is seen in all cases of hip laxity.

10. Distraction radiography
a. is not deleterious to the hip.
b. is more harmful than standard hip-extended radiography.
c. cannot be performed multiple times.
d. is more harmful than a routine orthopedic examination.