A study of debilitating orthopaedic conditions of working New Zealand Police German shepherd dogs.

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Abstract

This thesis explored the causes of retirement or loss from service of German shepherd Police dogs working in New Zealand. Abnormal development of the hip joint with subsequent development of osteoarthritis (hip dysplasia), and degeneration of the lumbosacral junction, were identified as the leading causes of early retirement of Police dogs due to an inability to meet the physical requirements of Police work.

Hip dysplasia is a multifactorial disease with moderate heritability and improvements in the phenotypic selection of dogs for breeding should improve subsequent longevity in future generations of Police dogs. Selection of dogs for breeding based on traditional phenotypic scoring, using radiographs of the hips in extension, was shown to be producing minimal improvement in hip status. When compared with distraction radiography, correlation between the two methods was low and they were not equivalent in terms of ranking dogs for susceptibility to hip dysplasia.

In the second part of the thesis, degeneration of the lumbosacral joint was reviewed and the role of surgical management of this condition was examined. A new method of computed tomographic volumetric analysis of the L7-S1 lateral intervertebral neurovascular foramen was described, which can be performed on anaesthetised dogs. This method was then tested on German shepherds, both normal and affected by lumbosacral degeneration. The dogs were imaged in extended, neutral and flexed positions of the lumbosacral junction. Extension results in marked narrowing of the L7-S1 foramina. Dogs affected by degenerative disease of the lumbosacral junction had smaller foraminal volumes than unaffected dogs, indicating that dynamic narrowing likely contributes to clinical signs. An ex-vivo experiment demonstrated that surgical resection of the dorsal annulus and partial L7-S1 discectomy (as commonly performed during dorsal decompressive surgery) may lead to further narrowing of the lateral intervertebral lumbosacral neurovascular canal. A prospective evaluation of a recently developed surgical procedure, dorsolateral foraminotomy, confirmed effective enlargement of the L7-S1 foraminal volume, but showed that by one year there was bone regrowth partially attenuating the effect. Finally, a novel method of dorsal stabilisation, which maintained the foraminal volume by fixation of the lumbosacral junction in a favourable position, was developed through a series of pilot studies, providing the basis for further development.

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Abbreviations

ANOVA = Analysis of variance

BVA = British Veterinary Association

CHD = Canine hip dysplasia

CT = Computed tomography

DI = distraction index (PennHIP)

DLS = dorsolateral subluxation score

DLSS = degenerative lumbosacral stenosis

FCI = Federation Cytologique Internationale

GSD = German shepherd dog

KC = Kennel Club (UK)

L = lumbar (nerve or vertebrae)

LS = Lumbosacral

MRI = Magnetic Resonance Imaging

NA = Norberg angle (measured on VD radiographs of the coxofemoral joint)

NZ PDS = New Zealand Police Dog Section

NZVA = New Zealand Veterinary Association

OFA = Orthopedic Foundation for Animals (USA)

PennHIP = The University of Pennsylvania Hip Improvement Program

PL = pelvic limb

VD = ventrodorsal (radiographic beam direction or positioning for surgery)

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The New Zealand Police force, like many law enforcement agencies around the world, uses the German shepherd dog (GSD) for patrol duties, tracking criminals, apprehension of criminals and armed offender operations. The GSD is known for its intelligence and willingness to work, having been initially bred as a dog for herding cattle.

The GSD is a relatively modern breed of dog. Herding dogs were used throughout Europe in the 18th century with widespread phenotypic variation in their physical and behavioural characteristics. In each local farming community, shepherds selected and bred dogs that they believed possessed desirable characteristics for herding of domestic livestock. The Phylax Society was formed in Germany in 1791 with the intention of creating standardized dog breeds (Strickland *et al.* 1988). However, it was disbanded after only three years due to conflicts amongst members regarding the traits of dogs that the society should promote.

The standardization of a German shepherding dog began in 1899 by Captain Max von Stephanitz (http://www.suite101.com/content/origin-of-the-german-shepherd-dog). Having purchased a part-wolf herding dog (which he renamed Horand von Grafrath), he went on to establish a new breed through inbreeding the progeny of that founder sire. Von Stephanitz founded a breed society and named the breed *Deutscher Schäferhund*, literally translating to "German shepherd dog" (Strickland *et al.* 1988).

The direct translation of the name was adopted for use in the official breed registry. However, at the conclusion of World War I (WWI), it was believed that the inclusion of the word "German" would harm the breed's popularity. The breed was officially renamed by the Kennel Club in the United Kingdom as the "Alsatian Wolf Dog" which was also adopted by many other international kennel clubs (Strickland *et al.* 1988). Eventually, the appendage "wolf dog" was dropped. The name Alsatian remained in use for five decades, until 1977, when successful campaigns by dog enthusiasts pressured the British kennel clubs to allow the breed to be registered again as the German Shepherd Dog. The word "Alsatian" still appeared in parentheses as part of the formal breed name and was finally removed in 2010 (Strickland *et al.* 1988).

German shepherd dogs were valuable as military dogs during WWI. They served as messengers, sentries, and guards as well as locating wounded soldiers for the Red Cross. Military working dogs were deployed in World War II, Vietnam and the Middle

East conflicts, and have been valuable in police work, drug detection and search and rescue as well as being excellent guide dogs for the blind and assistants to disabled persons (http://en.wikipedia.org/wiki/German_Shepherd_Dog). German shepherd and Belgian Malinois dogs are specifically chosen for this type of work due to their characteristics (size and high level of drive) and reputation for endurance, speed, strength, courage, intelligence and adaptability to almost any climate (Strickland *et al.* 1988).

The modern German Shepherd dog has been criticized for traits and an appearance different from von Stephanitz's original vision for the breed: that German Shepherd dogs should be bred primarily as working dogs, and that breeding should be strictly controlled to quickly eliminate undesirable traits. Some critics of the breed have commented that careless breeding has promoted inherited disease conditions and anatomical defects.

The history of the New Zealand Police Dog Section (NZPDS) began in 1956 when the then Prime Minister Sir Sidney Holland recruited a police sergeant and his dogs from the English Constabulary of Surrey. A dog training centre was set up in Trentham in conjunction with the Police Training School. Whilst the Police Training School was relocated to Porirua in 1981, the dog training centre has remained at its original site (http://www.police.govt.nz/service/dogs/history.html). From those early beginnings the dog section became established and training of dogs for specialist police work began. The first drug-detection training course was held in 1976, which was closely followed by the introduction of explosive detection courses in 1977. More recent developments have seen the introduction of other specialised courses including the Armed Offenders Squad dog course (1992), Accelerated Detection (1997), and Search and Rescue (1998) courses. Currently there are 115 Police Dog Handlers with 90-95 operational dogs and 10-15 in training at any one time (Inspector Brendon Gibson NZPDS pers. comm. 2015)

The operational life of a NZ Police GSD is considered to be approximately eight or nine years (Sergeant Mark Sandford, Breeding Unit Manager, NZPDS pers. comm. 2010) but precise reasons for withdrawal of dogs from service in NZ have not been collated. Each Police dog represents a large financial investment (*circa* $25,000 NZD) and time commitment for breeding and initial training. An operational team of one dog and one handler requires an annual expenditure of $120,000 including salary, vehicles, equipment and training (Inspector Brendon Gibson, NZPDS pers. comm. 2012). In order to maximise a Police dog’s active working life it is important to identify the major causes of loss and to target strategies to reduce their impact. This is the subject of chapter one. Degenerative orthopaedic disease has been identified as a major cause of early retirement of working dogs from the United States Military (Moore *et al.* 2001). Specifically, appendicular degenerative joint disease and spinal cord disease were the two conditions most likely to lead to elective euthanasia of military GSDs in that study. Canine hip dysplasia (CHD) and secondary osteoarthritis of the coxo-femoral joints have been reported to be the primary reason for rejection of working dogs during procurement and the most common reason for death/euthanasia in Military working dogs (Olson 1971; Dutton and Moore 1987). As military dogs share many training practices and have similar working conditions to Police dogs, it is likely that any disease incidence will be similar in these two populations. However there is little worldwide data and no specific data from New Zealand on the causes of loss/retirement from work of civilian Police working dogs. Sensibly the NZPDS has employed breeding policies for many years based on international practice, intended to reduce the incidence of CHD.

Hip Dysplasia is a multifactorial developmental disorder with a polygenic mode of inheritance (Cook, Tomlinson et al. 1996) [reviewed in chapter two]. Multiple quantitative trait loci associated with CHD have been identified (Lust and Farrell 1977, Mäki *et al.* 2002, Janutta *et al.* 2006). An experimental SNP array, which enables interrogation of genetic variation, is now available but is not yet suitable for the purposes of breeding selection (CanineHD BeadChip, Illumina Inc., San Diego, California, US). Therefore selection of breeding animals in an attempt to reduce the incidence of CHD is currently based on the radiological hip phenotype. There are several schemes based on radiological phenotype in use internationally. Each is based on detection of radiological features of hip dysplasia such as subluxation and degenerative joint disease. The British Veterinary Association Hip Dysplasia Scoring system was introduced in the UK in 1984 and subsequently adopted by the New Zealand Veterinary Association (NZVA). The NZVA has maintained a national computerised database since 1989. Since 1990 the NZPDS has utilised the NZVA hip dysplasia scheme to determine the most suitable dogs to select for breeding. This scheme is based on assessment of a single hip-extended radiograph, using semi-objective scoring criteria (Gibbs 1997). Studies in the UK and the US show a lack of, or only minor, improvement in hip phenotype of successive generations when the standard hip-extended radiograph is used as a selection tool (Corley and Hogan 1985, Willis 1997, Hou *et al.* 2010). Analysis and objective interpretation of the NZVA hip scoring data is required to assess whether the current hip dysplasia screening methods as used by the NZ Police are effective for selecting dogs with a superior phenotype. This question will be addressed in chapter three.

A new paradigm in the understanding of hip dysplasia has been established with the recognition that coxo-femoral joint laxity is predictive of later osteoarthritis (Smith *et al.* 1990, 1995). A new screening test, utilising distraction radiography (PennHIP), has been developed and the degree of passive laxity has been estimated to have a heritability higher than the radiological score from the hip extended phenotype (Smith *et al.* 1990, 1995, Kapatkin 2002, Janutta and Distl 2006). Despite adoption by the Seeing Eye and other working dog organisations, the PennHIP method had not been adopted as a national scoring scheme anywhere in the world*, and in Europe the Federation Cytologique Internationale (FCI) does not recognise the PennHIP method as a means of CHD assessment. Changes to the reporting of the NZVA scheme from 2003, with a subtotal score in addition to the total score, were proposed to be more useful in determining a dog's hip status (Burbidge 2003). The subtotal score incorporates those radiological criteria present on the hip-extended view associated with coxo-femoral laxity and therefore should be at least partially representative of passive hip laxity. Thus a comparison needed to be performed to determine if the NZVA hip-extended subtotal score identifies the same population of affected dogs as the PennHIP distraction method (chapter four).

In the study by Moore *et al* (2001), "spinal cord disease" ranked second as a cause of death or euthanasia of GSDs in the US Military program. The general term 'spinal cord disease' used in that study includes degenerative intervertebral disc disease, degenerative lumbosacral stenosis (DLSS) and degenerative (GSD) myelopathy. Experience gained at the Massey University Veterinary Teaching Hospital indicates that of these, DLSS is the most prevalent within the NZPDS working dog population. DLSS is characterised by degenerative disc disease and changes to the articulation of the L7-S1 spinal unit with resultant compression of the *cauda equina* (Meij and Bergknut 2010) [reviewed in chapter five]. It has been proposed that working GSDs are predisposed to DLSS due to abnormal anatomical characteristics and/or the particular work they are required to undertake. Subsequent failure of the supportive structures of the lumbosacral (LS) junction is thought to lead to narrowing of the L7-S1 lateral intervertebral neurovascular foramen and LS vertebral canal, with subsequent nerve root and *cauda equina* compression, and clinical signs of pain and neurological dysfunction.

* Until 2014 when it was recommended by the NZVA on the recommendation of the author.

Breeding of GSDs with a lowered propensity to develop DLSS could potentially reduce rates of retirement due to this condition. Whilst transitional vertebral anomalies have been shown to predispose a dog to DLSS (Morgan *et al*. 1993), it is not clear what, if any, more subtle anatomical variations may be contributory to the syndrome. If such predisposing anatomical variations are found and proven to be heritable then breeding selection could be changed to promote better LS conformation. A better understanding of the LS articulation, both anatomically and dynamically, would aid development of new treatment interventions.

Several surgical procedures are promoted as a means of resolving pain and disability in dogs with DLSS but the long-term efficacy of surgery in working dogs with DLSS has been questioned (Linn *et al.* 2003). There is no consensus as to the best strategy for surgical management, whether to perform decompression of the *cauda equina* or stabilisation/fusion of the LS articulation. In order to establish some reference data for future research the long-term clinical success rate of surgical intervention for DLSS in working dogs was investigated using measures of performance in a handler survey, as outlined chapter six.

The effect of angle of the LS junction on the three-dimensional volume of the L7-S1 lateral intervertebral neurovascular foramina will be investigated in chapter seven. Dynamic narrowing of the foramen is considered to be a cause of L7 nerve root compression that contributes to the clinical signs of DLSS. The effect of surgical annulectomy (removal of a section of the dorsal annulus of the L7-S1 intervertebral disc) will be investigated in chapter eight.

A new surgical procedure, lateral foraminotomy, which decompresses the L7-S1 lateral intervertebral neurovascular foramen (Godde and Steffen 2007) offers promise as an effective treatment for DLSS but has not been evaluated long-term. A cohort of dogs were followed to determine if foraminal enlargement is long lasting (chapter nine). Finally, dorsal stabilisation with screws transfixing the adjacent articular processes is widely used to treat DLSS in pet dogs (Slocum and Devine 1986). However, anecdotally, there is a high incidence of implant failure in working dogs. A refinement of trans-fixation of the articular processes, by the addition of pedicle screws, would be considered a novel approach and the success or otherwise of such a procedure should be evaluated. Biomechanical testing could also be used to show the potential strength and failure resistance of the new construct prior to its clinical application. A novel method of dorsal stabilisation is then proposed which uses computer aided design and rapid prototyping technologies to overcome some of the deficiencies of the existing surgical strategies, (chapter ten).

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The New Zealand Veterinary Association granted access to their Hip Dysplasia database. From 2008 I have been the Convenor for the NZVA Hip and Elbow Dysplasia panel, an appointee of the Companion Animal Society. On the basis of research described in chapters three and four, and subsequent projects funded by Massey University and the Companion Animal Health Fund (Soo *et al. in press 2014*), the NZVA discontinued traditional hip scoring in favour of recommending PennHIP from 2014.

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