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Radiographic anatomy of the soft tissue attachments of the equine stifle

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Summary

Reasons for performing study: **Radiography is a very important aspect of equine stifle imaging. The precise radiographic anatomy of the soft tissue structures of the equine stifle has not been described previously.**

Objective: **To describe the anatomical relationship between sites of attachment of soft tissue structures of the equine stifle and their locations on standard radiographic views.**

Methods: **The sites of bony attachments of the tendons, ligaments and fibrous portion of the joint capsules of equine stifles were determined by gross dissection. These sites of attachment were transposed onto one set of bones deprived of soft tissue and mapped using radiopaque markers. This specimen was then radiographed in the standard radiographic projections (lateromedial, caudocranial and caudal 60° lateral-craniomedial oblique) to determine the position of the attachment sites on the radiographs.**

Results: **Two radiographic maps were drawn per radiographic projection, one for the attachment sites of the ligaments and tendons and one for the attachment sites of the joint capsules.**

Conclusions and potential relevance: **The radiographic maps of the precise position of the soft tissue attachments of the tendons, ligaments and joint capsules of the equine stifle should assist interpretation of equine stifle radiographs.**

Introduction

The stifle is the largest and most complex joint in the horse (Sullins 2002) and its anatomy has been described in detail (Ellenberger and Baum 1914; Montane *et al.* 1937; Koch 1960; Sisson 1975; Rankin and Diesem 1976; Vaden 1977; Updike and Diesem 1980; Nickel *et al.* 1986; Reeves *et al.* 1991; Vacek *et al.* 1992; Dyce *et al.* 1996). Gross radiographic features of the stifle joint have also been described (O'Brien 1973; Quick and Rendano 1978; Jeffcott and Kold 1982a; Nickels and Sande 1982; Jeffcott 1984, 1986; Scheibitz and Wilkens 1986; O'Brien *et al.* 1987; Harrison and Edwards 1995; Butler *et al.* 2000; Dyson 2003a). However, the detailed correlation between bony features identified radiographically and the sites of attachment of soft tissue structures has not been comprehensively documented in the literature.

Injury to the stifle is an important cause of hindlimb lameness in the horse (Stick and Nickels 1999; Sullins 2002; Denoix 2004). Soft tissue and ligament injuries to the stifle represent a diagnostic challenge to equine clinicians. The prevalence of soft tissue injuries to the stifle is uncertain because accurate diagnosis is often difficult (Holcombe *et al.* 1995; Flynn and Whitcomb 2002), but they have been commonly reported in the literature (O'Brien 1973; Quick and Rendano 1978; Jeffcott and Kold 1982b; Jeffcott 1986; Baker *et al.* 1987; Lewis 1987; O'Brien *et al.* 1987; Bukowiecki *et al.* 1988; Sanders-Shamis *et al.* 1988; Lindsay *et al.* 1989; Prades *et al.* 1989; Desjardins and Hurting 1991; Bertone and Holcombe 1992; Blikslager and Bristol 1994; Dyson 1994, 2003b; Holcombe and Bertone 1994; Mueller *et al.* 1994; Dik 1995; Dyson and Dik 1995; Walmsley 1995, 2003; Wright 1995; Edwards and Nixon 1996; Stick and Nickels 1999; Butler *et al.* 2000; Dik and Gunsser 2002; Dyson 2002; Flynn and Whitcomb 2002; Peroni and Stick 2002; Sullins 2002; Arnold *et al.* 2003; Denoix 2004).

Radiography is usually the first imaging modality to be employed once the site of lameness has been localised to the stifle (Flynn and Whitcomb 2002; Walmsley 2003). Connective tissue pathology is often associated with bony changes that might be detected radiographically. The aim of this study was to construct precise radiographic maps of the soft tissue attachments from the tendons, ligaments and joint capsules of the equine stifle. Such maps should assist in the interpretation of equine stifle radiographs.

Materials and methods

Twenty-two stifles from horses aged >2 years, of medium size (height 1.50–1.65 m at the withers) and subjected to euthanasia for reasons unrelated to stifle lameness, were collected. Ten stifles were used to study tendons and ligaments, 10 to study joint capsules and 2 were boiled to remove all soft tissue; these served to collect data and obtain radiographs. The stifles were chilled immediately and dissected within 36 h post euthanasia. The major soft tissue structures were included provided that their fibres could clearly be seen inserting onto bone. The following structures were therefore included: 1) ligaments: cranial tibial of the medial and lateral menisci, caudal tibial of the medial and lateral menisci, femoral of the lateral meniscus, lateral and

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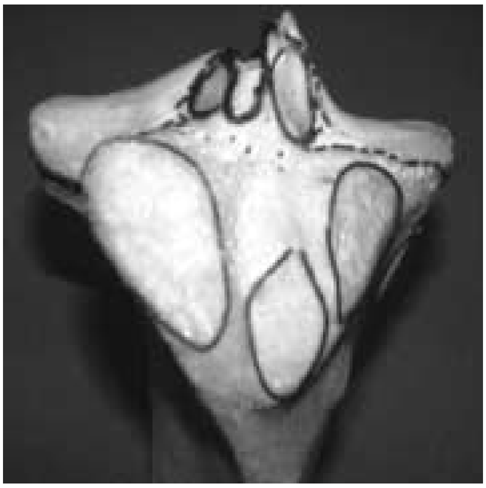

Fig 1: Stifle A*, proximal tibia; cranial view. The wires are glued in place.*

medial collateral, cranial and caudal cruciate, lateral and medial femoropatellar, and medial, intermediate and lateral patellar; 2) tendons of origins of the long digital extensor, *peroneus tertius* and *popliteus* muscle; and 3) femorotibial and femoropatellar joint capsules. The surface areas of attachments onto bone were referred to as areas of interest (AOIs).

After collection and dissection, the 10 stifles used to study the ligaments and tendons were stored in a refrigerated room for 36–48 h, allowing them to dry. This drying process allowed the loose connective tissue surrounding the sites of interest to become transparent, while the tendons and ligaments remained clearly visible and were therefore better defined. Data obtained from the 10 stifles used for the joint capsules were collected immediately upon dissection (i.e. no drying period).

One of the boiled stifles was that on which all the data obtained from the 20 dissected stifles were collectively mapped. For clarity, this stifle was referred to as *Stifle A*. The second boiled stifle was used to obtain the plain radiographs that served as basis for drawing the final radiographic maps of the soft tissue attachments and was referred to as *Stifle B*.

After the final dissection of a stifle, each AOI was mapped with a pencil onto *Stifle A* using many anatomical landmarks (including bony ridges, margins and roughened surfaces). This process was repeated for every stifle dissected, and each AOI was drawn onto *Stifle A* at the place observed. Once all the data from all the stifles were mapped onto *Stifles A*, a line representing the visualised average of the 10 AOIs was identified and used as the final (representative) area. Each representative AOI was marked by gluing radiopaque wires along their margins onto *Stifle A* (Fig 1).

Different patterns and sizes of wire were used in order to differentiate attachment sites from each other, since they would be superimposed on the radiographs (Fig 2). *Stifles A* and *B* were maintained in the correct anatomical alignment for radiography with radiolucent supports. Radiographs of *Stifles A* and *B* were obtained in lateromedial, caudocranial and caudal 60° lateral-craniomedial oblique projections.

Radiographs from *Stifle A* were placed on a radiographic viewer next to the corresponding projection of the plain radiograph (of *Stifle B*). The transfer of the data from *Stifle A* onto the corresponding plain radiograph (of *Stifle B*) was performed via transparent sheets. The maps for the ligaments and tendons were performed separately from those for the joint capsules, for the purpose of clarity.

Results

The results of the present study depicted the average size and location of the AOIs. The locations on radiographs of the attachments of connective tissue structures are illustrated in Figures 3–8. The key for all figures is given in Table 1.

The 2-dimensional appearance of the attachment sites varies depending on the projection plane of the x-ray beam and the shape of the structure on which it inserts. Superimposition of structures on opposite sides of the bones occurred to some degree. The insertion of the lateral collateral ligament followed the outer (lateral) contour of the head of the fibula, and was situated deep to the lateral digital extensor muscle which arises on that ligament and the fibula (Figs 3, 5 and 7). The intercondylar part of the attachment of the medial sac of the femorotibial joint on the tibia followed the proximal

a)

b)

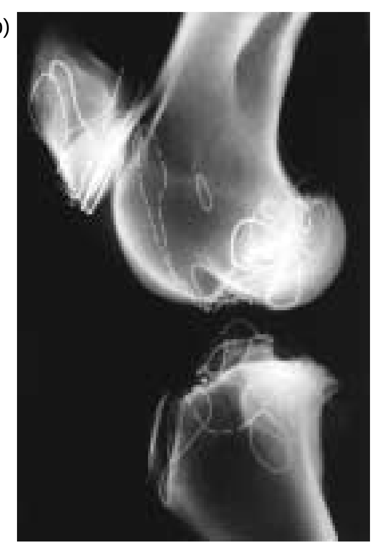

Fig 2: Lateromedial projection of Stifle A*. The femur was separated from the tibia (b) to facilitate visualisation of the wires within the intercondylar area. These data were then transferred onto the plain radiographs of* Stifle B *in order to produce the radiographic maps.*

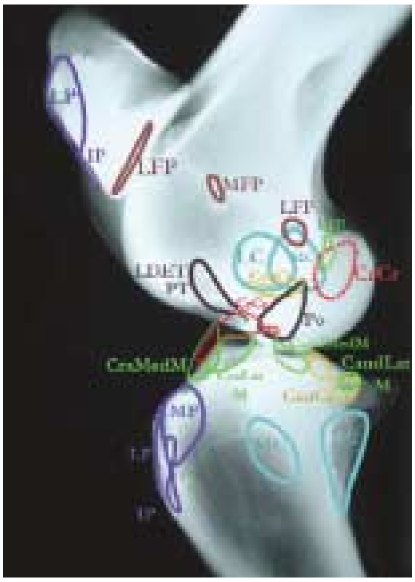

Fig 3: Lateromedial radiographic map of ligament and tendon attachments to the stifle. Structures attaching within the intercondylar area of the tibia and the femur are indicated with dotted lines.

TABLE 1: Key for the connective tissue structures with attachment sites illustrated in Figures 3–8

Abbreviation	Structure
LP	Lateral patellar ligament
IP	Intermediate patellar ligament
MP	Medial patellar ligament
LFP	Lateral femoropatellar ligament
MFP	Medial femoropatellar ligament
LC	Lateral collateral ligament of the femorotibial joint
MC	Medial collateral ligament of the femorotibial joint
CraLatM	Cranial tibial ligament of the lateral meniscus
CraMedM	Cranial tibial ligament of the medial meniscus
CauLatM	Caudal tibial ligament of the lateral meniscus
CauMedM	Caudal tibial ligament of the medial meniscus
MF	Meniscofemoral ligament of the lateral meniscus
CrCr	Cranial cruciate ligament
CauCr	Caudal cruciate ligament
Po	Tendon of origin of the *popliteus* muscle
PT	Tendon of origin of the *peroneus tertius*
LDET	Tendon of origin of the long digital extensor muscle
FP	Femoropatellar joint capsule
LatFT	Lateral sac of the femorotibial joint capsule
MedFT	Medial sac of the femorotibial joint capsule

axial contour of the medial tibial intercondylar eminence (Figs 4, 6 and 8), as did part of the insertion of the cranial cruciate ligament (Figs 3, 5 and 7). The medial sac of the femorotibial joint extended distally on the medial aspect of the tibia as it formed a diverticulum deep to the medial collateral ligament (Figs 4, 6 and 8). The attachment of the lateral sac of the femorotibial joint capsule extended distally at the cranial aspect of the tibia within the extensor groove (Figs 4, 6 and 8). The pouch itself, however, extended a few centimetres further distally.

Discussion

The radiographic maps were constructed in order to describe precisely the anatomical relationship between the sites of attachments of the soft tissue structures of the equine stifle and their locations on standard radiographic projections.

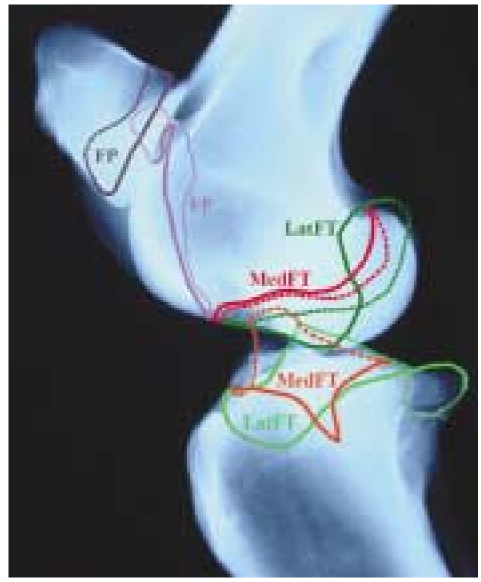

Fig 4: Lateromedial radiographic map of joint capsule attachments to the stifle. Areas of femoropatellar joint capsule attaching onto the medial half of the bones and of the femorotibial joint capsule attaching in the intercondylar area are indicated with dotted lines.

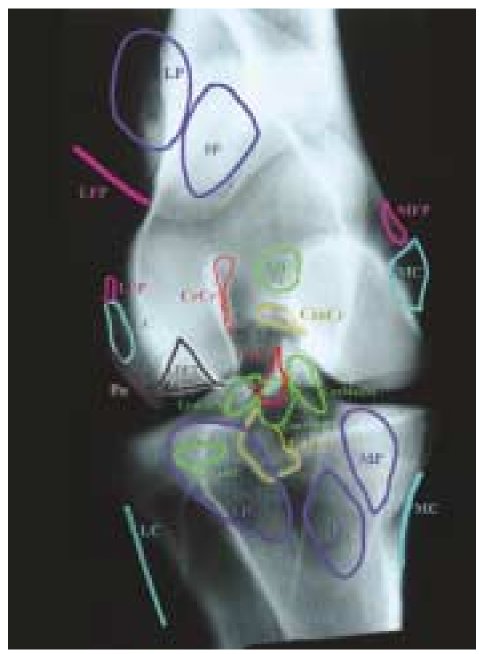

Fig 5: Caudocranial radiographic map of ligament and tendon attachments to the stifle. Structures associated with the caudal half of the femur or tibia are indicated with dotted lines.

Some mild variation was noted in both the size and precise location of the AOIs between the stifles dissected. The only important variation was recorded for the medial femoropatellar ligament, a very weak ligament that was difficult to identify clearly in some specimens. Although those mild variations may have been associated with breed, sex, age, conformation and other factors, these sources of variations were not addressed in this study.

Attachment sites for structures via other soft tissue structures, such as the *biceps femoris* muscle inserting onto the lateral patellar ligament, were not included in the current radiographic maps. The

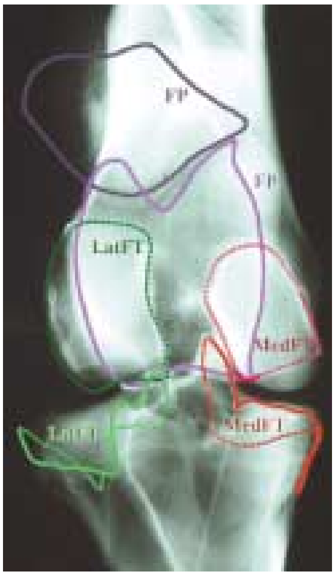

Fig 6: Caudocranial radiographic map of joint capsule attachments to the stifle. Structures situated on the caudal half of the femur or tibia are indicated with dotted lines.

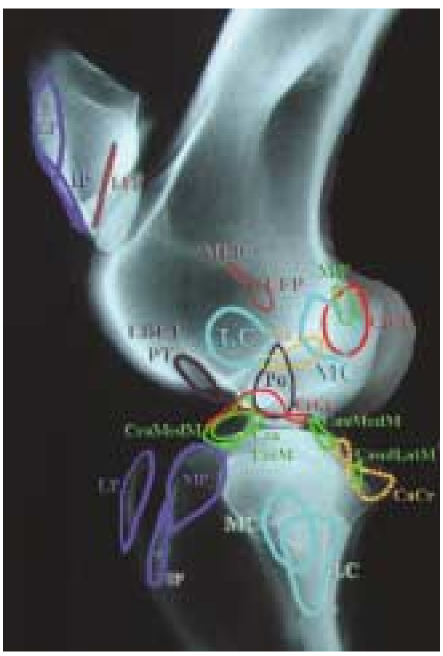

Fig 7: Caudal 60° lateral-craniomedial oblique map of ligament and tendon attachments to the stifle. Areas of interest situated in the intercondylar area of the tibia and femur are indicated with dotted lines.

parapatellar fibrocartilage and the soft tissue attachments attaching on it (i.e. the origin of the medial patellar ligament and medial femoropatellar ligament) were not included in the study because no fibres could be clearly seen attaching onto bone.

Gross *post mortem* dissections demonstrated the meniscal ligaments to be in general accordance with reports in the literature (Nickel *et al.* 1986; Holcombe *et al.* 1995; Wright 1995; Cauvin *et al.* 1996), with the exception of the intermeniscal ligament joining both cranial tibial ligaments of the meniscus at their cranial borders, described by Vaden (1977), which was not observed in our specimens.

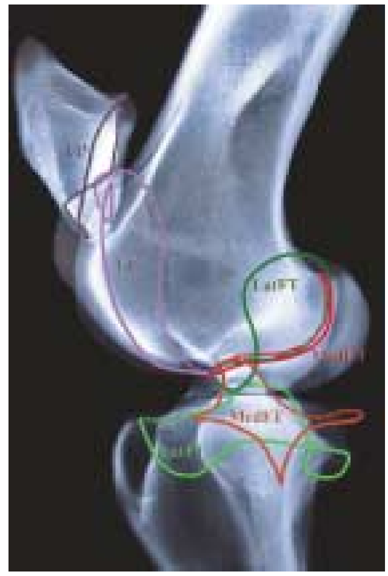

Fig 8: Caudal 60° lateral-craniomedial oblique map of joint capsule attachments to the stifle. Areas of attachment of the femoropatellar joint capsule situated on the medial half of the patella and the femur, and areas of attachment of the femorotibial joint capsule situated in the intercondylar areas of the tibia and the femur are indicated as dotted lines.

Similarly, data obtained for the attachments of the collateral ligaments of the femorotibial joint corroborate those reported previously (O'Brien 1973; Sisson 1975; Nickel *et al.* 1986; Holcombe *et al.* 1995; Wright 1995; Dyce *et al.* 1996), except that insertion of the lateral collateral ligament on the lateral condyle of the tibia (Nickel *et al.* 1986) was not observed in our study.

The anatomical findings regarding the cruciate ligaments were largely similar to those reported previously (O'Brien 1973; Sisson 1975; Nickel *et al.* 1986; Baker *et al.* 1987; Holcombe *et al.* 1995; Wright 1995; Cauvin *et al.* 1996), with some exceptions. Some authors described the cranial cruciate ligament as inserting axially in the cranial intercondyloid area of the tibia, cranial to the intercondylar eminences (O'Brien *et al.* 1987), as well as partially together with the cranial ligament of the menisci (Cauvin *et al.* 1996; Butler *et al.* 2000). The current study found that the cranial cruciate ligament inserted in the central intercondyloid area of the tibia (rather than cranial); although part of its insertion was situated craniolateral to the medial intercondylar eminence of the tibia, a large proportion of its insertion was situated just lateral (axial) to this eminence. In addition, in the current study, the insertions of the cranial cruciate ligament and the cranial ligament of the menisci were found to be contiguous but distinct. Several authors have described the caudal cruciate ligament as arising from the intercondylar surface of the medial condyle of the femur (Sisson 1975; Holcombe *et al.* 1995; Cauvin *et al.* 1996), at the cranial inlet of the intercondylar fossa (Baker *et al.* 1987). The present study indicated that this ligament arose in the central intercondyloid fossa (rather than cranial) and, although it was in contact with, and arose partly on, the medial condyle, the main part of the origin was axial to that condyle. Baker *et al.* (1987) reported that the caudal cruciate ligament inserted about 1 cm distal to the articular surface of the medial tibial condyle. This study found that it inserted at about the same level as the articular aspect of the medial tibial condyle for its main part, and slightly distal to it for a small portion.

The insertions of the *biceps femoris* muscle situated around the stifle joint were found to be largely in accordance with previous reports in the literature (Sisson 1975; Nickel *et al.* 1986; Dyce *et al.* 1996). However, the insertion on the cranial patella (Sisson 1975; Dyce *et al.* 1996) was found only through the intermediary of the lateral patellar ligament and its origin, rather than a direct insertion on the cranial patella.

The locations of the AOIs were correlated with the radiographic features of the equine stifle with radiopaque wire. The radiographs obtained from *Stifle A* could not be used directly as radiographic maps because the data on them were too dense, due to the numerous superimpositions of wires (Fig 2). Therefore, maps were created by transferring data present on the radiographs from *Stifle A* onto the plain radiographs (*Stifle B*) via transparent sheets. The technique used in this study differs from that previously performed in a similar study of the radiographic anatomy of the soft tissue attachments in the metacarpophalangeal joint (Weaver *et al.* 1992), where the attachment sites were copied from a photograph (of the set of bones deprived of soft tissue containing the marked sites) directly onto the radiographs. The technique used in the study by Weaver *et al.* (1992) would not have been appropriate for the stifle joint because many important structures were 'hidden' in the intercondylar region. Furthermore, it was noted during the course of the study that the shape of some of the wires on the radiographs of *Stifle A* was unanticipated. For example, the shape of the insertion of the caudal cruciate ligament took the form of an '8', due to the irregular shape of the tubercle onto which it inserts. This technique was therefore considered more accurate than the drawing method. In effect, it produced a more direct relationship between specimens and radiographs. Another aspect of the technique reported in this study was that a general view of all AOIs could be obtained on one radiograph. Some structures, therefore, appear partly superimposed in the maps. However, the different colours and marking patterns used allows differentiation and localisation of AOIs around the stifle joint. Therefore, any bony pathology viewed on clinical radiographs can be compared directly with the corresponding radiographic map containing all the ligaments or all the joint capsules. Maps have been constructed for the most commonly used radiographic projections in order to allow the clinician to differentiate which structure(s) is (are) involved in the pathological process in regions of superimposition of AOIs.

The radiographic maps of the origins and insertions of the soft tissue structures of the equine stifle illustrate the accurate position of those structures on equine stifle radiographs. Since entheseophytes and bone modelling have been identified in clinical cases involving pathology of numerous soft tissues structures of the stifle, these radiographic maps should be an invaluable tool for the clinician to correlate radiographic abnormalities with the sites of attachment of the soft tissue structures of the equine stifle, allowing determination of which of those structures are involved in pathological processes.

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EQUINE VETERINARY JOURNAL'S *Literary Awards...*

The **EVJ Open Award** is available annually for a paper of outstanding merit published in *Equine Veterinary Journal.*

The award is a monetary prize of £500 provided by BEVA Trust.

For the year 2004 (Volume 36), the award was made to: J. Van Biervliet, P.V. Scrivan, T.J. Divers, H.N. Erb, A. de Lahunta and A. Nixon for their paper '*Evaluation of decision criteria for detection of spinal cord compression based on cervical myelography in horse: 38 cases (1981-2001)*' in the January 2004 issue.

The **Richard Hartley Clinical Prize** was established in memory of Richard, a Past President of BEVA, who was in practice at Liphook in Hampshire in the 1960s.

The prize is presented annually to the senior author of a paper containing original material published in *Equine Veterinary Journal* or *Equine Veterinary Education* and considered to possess outstanding merit as contributing to clinical science.

The award is in the form of a grant, funded by BEVA, of £1000 to be used specifically towards overseas travelling expenses in the case of a veterinary surgeon normally resident in the UK and for travelling to the UK for those resident overseas. A trophy to be held for 1 year is also presented.

In 2004, the prize was awarded to T.D.H. Parkin, P.D. Clegg, N.P. French, C.J. Proudman, C.M. Riggs, E.R. Singer, P.M. Webbon and K.L. Morgan, for their paper '*Horse-level risk factors for fatal distal limb fracture in racing Thoroughbreds in the UK*' published in the November 2004 issue of *EVJ.*

The **Home of Rest for Horses Clinical Evidence Award** is presented to the senior author of a paper published in the category of Clinical Evidence (EBM) during each year, which is judged to be of outstanding merit. The paper should describe a study based on a naturally occurring condition, and provide strong clinical evidence to define outcomes relating to specific therapeutic or diagnostic interventions, refine prognostic indicators and/or provide an aid to informed clinical decision-making regarding specific problems encountered in contemporary equine practice.

The award consists of £1000 and a bronze to be retained in perpetuity.

This year the award was given to M.A. Smith, J.P. Walmsley, T.J. Phillips, G.L. Pinchbeck, T.M. Booth, T.R.C. Greet, D.W. Richardson, M.W. Ross, M.C. Schramme, E.R. Singer, R.K. Smith and P.D. Clegg, for their paper '*Effect of age at presentation on outcome following arthroscopic debridement of subchondral cystic lesions of the medial femoral condyle: 85 horses (1993-2003)*' in the March 2005 issue of *EVJ.*