**Canine Total Hip Replacement using a cementless threaded cup and stem: A Review of 55 Cases**

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**Summary**

**Objectives:** To determine the long-term results and complications associated with the Helica® cementless hip endoprosthesis system using two generations of femoral stem.

**Methods:** A retrospective study was made of 55 consecutive Helica® total hip replacements performed between January 2010 and February 2015.

**Results:** A total of 55 total hip replacements were performed in 50 dogs; 45 dogs had unilateral hip replacements and five had staged bilateral replacements. Twenty-three first-generation short femoral stems were implanted in 22 dogs, of which nine cases (39%) experienced complications and 19 dogs (86%) made satisfactory recoveries when revisions were included. Thirty-one second-generation femoral stems (the modified Three-Part Stem (TPS)), were implanted in 28 dogs, of which 10 cases (32%) experienced complications and 26 dogs (93%) made satisfactory recoveries including revisions. Pre- and post-operative LOAD scores were available in 36 cases, with the reduction in scores being significant (P<0.001). Complications were seen in 19 cases in total (34.5%; 95%CI 22-47.1%) with aseptic loosening of the femoral stem being the commonest and occurring in 11 cases (20%; 95%CI 9.4-30.6%). Following multivariate analysis, no risk factors were identified for overall complications, but there was a significant association of implant type (first-generation short stem) with loosening (odds ratio 4.9, 95%CI: 1.1-22.1, *P*=0.034).

**Clinical significance:** We have found the Helica® Hip Endoprosthesis system to bean effective method of treating hip dysplasia and osteoarthritis in dogs. Aseptic loosening of the femoral stem remains the most common complication but appears to have been significantly reduced with the introduction of the second-generation TPS stem.

**Keywords**

Canine, Orthopaedic-General

**Introduction**

Initial experience with a newly-developed total hip replacement system(Helica® Hip Endoprosthesis (HHE); Innoplant Veterinary, Hannover, Germany) was described by Hach & Delfs (2009). The HHE is a cementless system with threaded acetabular cup and femoral stem components. The results of HHE implantation in a series of 39 dogs have been reported (Hach & Delfs 2009). Complications occurred in five cases (13%). Surgical revisions following implant loosening were carried out in all five cases; three were successfully revised and two resulted in explantation. Two case reports of successful revisions of loose Helica® first-generation short femoral stems with Kyon (Zurich® Cementless Total Hip Replacement; Kyon AG, Zurich, Switzerland) and BioMedtrix (BFX®; BioMedtrix, Whippany, New Jersey, USA) femoral implants have also been published (Andreoni et al. 2010, Roe et al. 2015).

The Helica® implants have positive profile threads which screw into the acetabulum and into the neck and proximal metaphysis of the femur, providing early stabilisation of the implants prior to bone ongrowth (Kim et al. 2012). However aseptic loosening of the femoral stem is not uncommon and in a recent series of 16 dogs, six (38%) had loosening of the femoral prosthesis within one year post-implantation (Agnello et al. 2015). All the patients in this series received first-generation femoral stems, and no significant risk factors could be identified as to the causes of stem loosening. The first generation of femoral stems are relatively short and are located entirely within the proximal femur. These stems have subsequently been modified and the second-generation Helica® TPS femoral stem has been introduced in an attempt to reduce the incidence of aseptic loosening. To date, there has been no reporting of the long term clinical results and complications associated with the Helica® system, or comparison of the two generations of femoral stem published.

**Materials and methods**

*Inclusion criteria*

Dogs that underwent total hip replacement (THR) using the Helica® system at an orthopaedic referral centre between January 2010 and February 2015 with complete practice medical records, and that were registered on the British Veterinary Orthopaedic Association (BVOA)-University of Liverpool (UoL) Canine Hip Registry were included in this case series. All dogs had clinically significant hip pain related to joint dysplasia and/or osteoarthritis which was intractable to medical management. There was no upper limit regarding severity of joint disease with respect to surgical selection, and the only anatomic restriction to Helica® THR placement was suitable skeletal size for stable implant placement. Minimum and maximum patient size were determined by femoral neck diameter and acetabular bone stock. The smallest and largest patients in this series were 19 kg and 49 kg respectively, but the limits may be somewhat wider than this depending upon body condition score and skeletal conformation. Inclusion criteria were identical for both generations of femoral stem. All cases were consecutive from the outset of our use of the system, and no other THR system was used during this period.

*Data collection*

Data retrieved from the medical records included patient age, breed, bodyweight, pre-and post-operative Liverpool Osteoarthritis in Dogs (LOAD) scores (Hercock et al. 2009, Walton et al. 2013) indication for THR, first or second THR or revision, Helica® femoral stem length and diameter, Helica® acetabular cup diameter, Helica® head size (neck length) and diameter, complications and actions taken. Owners were also requested to complete a follow-up practice questionnaire (Supplementary material 1) and pre- and post-operative LOAD questionnaires (Walton et al. 2013).

Post-operative LOAD scores were obtained by the BVOA-UoL Canine Total Hip Registry every 12 months from 2014 onwards.

*Description of the Helica® Hip Endoprosthesis system*

The Helica® acetabular cup and femoral stem are made of bio-compatible, osteoconductive titanium alloy Ti6AL4V (European standard IS0 5832-3 / US standard ASTM F136). The surface is rough blasted (RA=40 µm). The first-generation femoral stem is available in five sizes ranging from 8 to 12 mm in diameter and from 26 to 32 mm in length, with self-tapping threads. These femoral stems are ‘short’ and are implanted entirely within the femoral neck and proximal metaphysis, without engaging the lateral cortex.

Development of the second-generation TPS stem resulted from experience revising loose first-generation stems using a technique involving further resection of the femoral neck and placement of a larger stem in order to penetrate the lateral cortex. The TPS stem is a longer stem which engages an increased area of cortical bone for load dispersal. The femoral neck is preserved and the screw threads purchase in both the neck and in the lateral cortex of the femur, resulting in improved stability and increased resistance to loosening. The three components of the TPS stem are illustrated in Figure 1. Interchangeable stem and flange sizes permit the second-generation stem to be customised more accurately to the individual patient. Standard heads are 18 mm in diameter and are made of titanium alloy with a titanium nitride coating. The head attaches to the femoral stem with a Morse taper and can be used in Hybrid THR configurations as they will also fit onto femoral stems from other manufacturers (Kyon AG, BioMedtrix and Veterinary Instrumentation, Sheffield, UK). A smaller head of 15 mm diameter is available specifically to fit the smallest HHE acetabular cup.

Acetabular cup diameter ranges from 22 to 32 mm. The cups are rough blasted titanium with self-tapping threads. The acetabular liner is manufactured from ultra-high molecular weight polyethylene. The liners are available as self-retentive or unconstrained, except for the smallest diameter which is only available as unconstrained.

*Surgical technique*

Dogs were premedicated with methadone (Comfortan; Dechra Veterinary Products Ltd) 0.3mg/kg and acepromazine (ACP; Novartis Animal Health) 0.03mg/kg by intramuscular injection. General anaesthesia was induced with propofol (PropoFlo Plus; Abbott Laboratories Ltd), and maintained with isoflurane (IsoFlo; Abbott Laboratories Ltd) in oxygen and nitrous oxide via a rebreathing circuit (Humphrey ADE-circle; Anaequip Vet UK). Additional perioperative analgesia was provided with carprofen (Rimadyl; Zoetis UK Ltd) 4mg/kg or meloxicam (Metacam; Boehringer Ingelheim Ltd) 0.1-0.2mg/kg given intravenously at induction, or firocoxib (Previcox; Merial Animal Health Ltd) 5-10mg/kg administered orally two hours prior to induction, depending upon the preoperative protocol provided by the referring veterinary surgeon. Post-operative analgesia consisted of methadone (0.2mg/kg q4h) as judged clinically necessary until the dog was discharged (typically 24-36 hours postoperatively), tramadol (Tramadol Hydrochloride; Summit Veterinary Pharmaceuticals Ltd) 2-3mg/kg orally every eight hours for seven days, and either carprofen (4mg/kg), meloxicam (0.1mg/kg) or firocoxib (5-10mg/kg) orally once every 24 hours for 10 days or as judged necessary by the referring veterinary surgeon. Peri-operative antibiotic prophylaxis was provided with cefuroxime (Zinacef; GlaxoSmithKline) 22mg/kg intravenously at induction and repeated every 90 minutes during the period of general anaesthesia. Postoperatively cephalexin (Rilexine; Virbac Ltd) 15-20mg/kg was administered orally every 12 hours for five days.

Surgical implantation of the first-generation prosthesis was performed as previously described (Hach & Delfs 2009). The only exceptions were five cases which developed loosening of a first-generation stem and were revised using a larger-sized first-generation stem in order to intentionally penetrate the lateral cortex. The modified technique for second-generation TPS stem implantation is described in the surgery manual produced by the implant manufacturer and is available online (Innoplant Veterinary 2012). Femoral stem and acetabular cup size were selected based upon pre-operative radiographic templating. Calibrated ventrodorsal views of the pelvis with hips extended and flexed were taken in order to template femoral stem length and diameter respectively, and acetabular cup diameter can be measured from either view. Flange size and neck length (head-size) were determined intra-operatively using trial components to assess best fit. Post-operative radiographic assessment of implant placement consisted of the same two ventrodorsal views as described above, and in addition a lateral view of the pelvis. Follow-up postoperative radiographs using the same views were taken under general anaesthesia at approximately 12 weeks (6 cases), during assessment for contralateral THR (5 cases), or in the event of lameness recurring (19 cases). Craniocaudal horizontal beam radiographs of the femoral neck were not taken due to radiation protection restrictions. Follow-up postoperative radiographs were not taken in 20 dogs which made good recoveries and had no clinical evidence of complications, due to owner wishes and the requirement for general anaesthesia.

Radiographic evidence of loosening was taken as a halo of lucent bone around the implant, typically surrounded by an area of sclerosis and periosteal new bone formation around the tip of the stem in patients with loose TPS implants (Figure 3). Stem subsidence was not a noted feature of loosening.

*Statistical analysis*

Statistical analyses were performed using computerised statistical analysis software (SPSS 22.0 for Windows, SPSS Inc., Chicago, Illinois, USA) and the MLwiN statistical software package (MLwiN Version 2.20, Centre for Multilevel Modelling, University of Bristol). Independent variables were derived from the signalment data, surgical procedure details and patient follow-up. Variables assessed included those related to the dog (bodyweight, age, breed) and surgical procedure (implant type, implant size). Descriptive statistics were calculated for variables as appropriate; continuous data were expressed as median values with interquartile ranges, and categorical data were expressed as frequencies with 95% confidence intervals (95% CI). Categorical variables with many categories and/or categories containing only small numbers were simplified by aggregation of categories. For continuous variables the functional form of the variable with respect to the outcome was assessed using generalised additive models (GAM) fitted using cubic spline smoothers in the R software package (R version 3.2.0, The R Foundation for Statistical Computing). A test for departure from linear trend was applied to determine if analysis could be undertaken with an assumption of linear association. Normality of distribution for continuous variables was also assessed through graphical analysis and with the Kolmogorov-Smirnov test.

Dog hip joints were considered the unit of interest; the binary outcome for each hip was the presence or absence of a complication following THR surgery. Implant loosening was considered as an addition separate outcome. As some cases represented dogs undergoing bilateral procedures, the two resultant outcomes are not independent, with dog hips (level one units) clustered within dogs (level two units). To allow for this, factors affecting the occurrence of complications were examined using multilevel logistic regression models and within-dog clustering of hips was accounted for as a random intercept term. Initial univariable and final multivariable calculations were performed using penalised quasi-likelihood estimates (2nd order PQL). All variables showing some association with complications on initial exploratory univariable analysis (a *P*-value <0.25) were considered for incorporation into final multivariable models. The model was constructed by a manual backwards stepwise procedure where variables with Wald and likelihood ratio test *P* < 0.05 were retained in the model. Potential confounding factors were assessed by examining parameter estimates for substantial changes following their removal.

The data relating to long-term outcome were not clustered, as dogs were the unit of interest. Continuous variables were compared between dogs with and without complications using the Mann-Whitney U-test and categorical variables with the Chi-squared or Fisher’s exact tests. For all analyses significance was set at *P*<0.05.

**Results**

*Signalment*

A total of 55 total hip replacements were performed in 50 dogs; 45 dogs had unilateral hip replacements and five had staged bilateral replacements. There were 20 Labrador Retrievers, 7 Border Collies, 5 cross-breeds, 4 German Shepherd Dogs, 3 lurchers, 2 Golden Retrievers, 2 Springer Spaniels and 7 breeds represented by a single dog each. The median age of the dogs was 36 months (interquartile range [IQR] 12-84 months, minimum age 9 months, maximum age 12 years) and the median bodyweight was 30 kg (IQR 26-35 kg, minimum weight 19 kg, maximum weight 49 kg). The indications for THR were hip dysplasia and/or osteoarthritis which were intractable to medical management. Full patient details with surgical indications are listed in Tables 1 and 2. Approximately 90 dogs were assessed for hip replacement over the same five-year period. Of these approximately 30 were considered to be suitable for conservative management and three were treated by femoral head and neck ostectomy.

*Surgical description*

All surgical procedures were performed by the same two surgeons. Twenty-three first-generation short stems were implanted in 22 dogs (one symmetrical bilateral case) and 31 second-generation TPS stems were implanted in 28 dogs (3 symmetrical bilateral cases). One dog received both first- and second-generation stems, and one dog received a hybrid THR using a Helica® acetabular cup and head combined with a cemented stem (Long cemented femoral stem; Veterinary Instrumentation) due to failure of a first-generation Helica® stem to purchase in poor bone stock at the time of original surgery.

The first-generation short stem diameter and length combinations were 8 x 26 mm (n=17), 10 x 28 mm (n=4) and 12 x 32 mm (n=2). The second-generation TPS stem diameter and length combinations were 8 x 31 mm (n=23), 10 x 35 mm (n=2) and 11 x 37 mm (n=6). The acetabular cup outer diameters were 22 mm (n=3), 24 mm (n=22), 26 mm (n=21), 28 mm (n=6), and 32 mm (n=3). The head diameter was 18 mm in 52 hips and 15 mm in three. Head sizes were short (n=19), medium (n=24), long (n=11) and extra-long (n=1). In four of the five dogs which had bilateral hip replacements, implant size on the second side was the same as for the first THR. The one exception is shown in Figure 2; this dog received an 8 x 26 mm first-generation short stem for the first THR and an 8 x 31 mm second-generation TPS stem for the contralateral THR.

*Post-operative radiographic assessment*

Follow-up postoperative radiographs using the views indicated in the methods section were taken under general anaesthesia at approximately 12 weeks (6 cases), during assessment for contralateral THR (5 cases), or in the event of lameness recurring (19 cases). Follow-up postoperative radiographs were not taken in 20 dogs which made good recoveries and had no clinical evidence of complications, due to owner wishes and the requirement for general anaesthesia.

*Questionnaire data*

Forty owners (80%) completed follow-up practice questionnaires, and thirty-three (66%) completed follow-up LOAD questionnaires.

Pre-operative LOAD or estimated LOAD scores were available in 53 cases (28 of these were estimated by one of the authors through retrospective telephone calls to owners as LOAD scoring was only introduced as part of the BVOA–UoL Canine Total Hip Registry in 2014) with a median of 21.0 (IQR 20.0-28.0). Post-operative LOAD scores were available in 37 cases with a median of 11.0 (IQR 5.5-15.0). Pre-operative LOAD questionnaires were completed by owners at the time of surgery from 2014 onwards and follow-up questionnaires were obtained by the BVOA–UoL Canine Total Hip Registry every 12 months postoperatively. Dogs undergoing staged contralateral THR had a second pre-operative LOAD score assessed at that time. There were 36 cases for which both pre- and post-operative LOAD scores were available and the change in scores for these cases was significant (*P*<0.001).

*Follow-up*

Follow-up periods ranged from 12 to 63 months with an average of 30.5 months (Tables 1 & 2). The only exceptions to this were two dogs that were euthanased due to unrelated neoplasia, one dog was lost to follow-up after seven months, and one dog developed loosening of the femoral stem eight months postoperatively. Revision surgery was recommended at that time but the owners requested euthanasia at the referring practice.

Owner-assessed full or acceptable postoperative function (Cook et al. 2010) was reported in 45 patients (90%). Recovery time was reported to range from 3 weeks to 24 weeks, with an average time of 10.7 weeks. Six dogs (12%) were reported to show lameness at the time of follow-up which was reported to be slight in five and moderate in one, and being intermittent in four and constant in two. Nine dogs (18%) were reported to have a degree of transient stiffness after rest.

Of the 22 dogs receiving first-generation short Helica® femoral stems, 19 (86%) of these (including five revision cases and three explantation cases) made satisfactory recoveries as assessed by owner follow-up questionnaires. Of the 28 dogs receiving second-generation TPS stems, 26 (93%) of these (including four revisions and three explantations), made satisfactory recoveries following assessment as detailed above (for full details see Tables 1 and 2).

*Complications*

Complications of all types were seen in 19 cases (34.5%; 95%CI 22-47.1%) from 19 dogs (38%; 95%CI 24.5-51.5%), with aseptic loosening of the femoral stem occurring in 11 cases (20%; 95%CI 9.4-30.6%) from 11 dogs (22%; 95%CI 10.5-33.5%) (Tables 1 and 2). No dogs had more than one complication. Using the classification system proposed by Cook et al. (2010), eight out of 23 cases (35%) involving first-generation femoral stems suffered major complications. Of these, one was short-term (3-6 months postoperatively), two were mid-term (6-12 months postoperatively), and five were long-term (greater than 12 months postoperatively). There was one (4%) significant minor complication, and no catastrophic complications. Nine out of 31 cases (29%) involving second-generation TPS stems suffered major complications. Of these five were perioperative (up to 3 months postoperatively), one was short-term and three were long-term. By definition there was one (3%) catastrophic complication, when an owner requested euthanasia rather than the recommended option of revision surgery for treatment of femoral stem loosening. Details of all cases are listed in Tables 1 and 2.

In the 11 cases which developed aseptic loosening of the femoral stem (as assessed radiographically and clinically), eight were first-generation short stems and three were second-generation TPS stems. Four of the loose short stems were successfully revised by removing the original 8 x 26 mm stems and replacing them with 12 x 32 mm first-generation stems so that they penetrated the lateral femoral cortex. One of the loose TPS stems was also successfully replaced with a larger-diameter stem. In three cases the head and stem were explanted leaving the acetabular cup *in situ*, and complete explantation was performed in two cases. One TPS stem fractured 35 months post-operatively, possibly associated with slight radiographic loss of bone support around the neck combined with solid integration of the tip within the lateral cortex. The head and proximal portion of the stem were explanted and the dog was reported to have good function at 10 months follow-up.

Dorsal luxation of the hip prosthesis occurred in three cases within two weeks of surgery. Constrained liners had been used in each of these patients, and revision surgery to reposition the acetabular cup resulted in a successful outcome in all three cases.

Loosening of the acetabular cup occurred in two cases. In one of these cases the cup displaced acutely six months after THR, thought to be due to inadequate seating of the cup at the time of the original surgery. The 26 mm cup was replaced with a 28 mm cup, and the patient subsequently made a full recovery. The other case, which had undergone staged bilateral THR, presented with loosening of the second acetabular cup due to a coagulase negative staphylococcal infection five months after the second surgery. Cephalexin was given for three weeks and the loose 26 mm cup was removed. Culture of the cup and acetabular bed was negative and a 28 mm cup was re-implanted. Two months later the second cup loosened again and complete explantation was performed. Although initial recovery following explantation appeared satisfactory, a moderate degree of lameness persisted and the dog was taken to another referral clinic for further surgery and was lost to follow-up. One patient developed septic loosening of both acetabular cup and femoral stem two months after THR. Complete explantation was performed and the dog regained good function.

The final complication encountered was in a 12-year-old dog which suffered an acetabular fracture following THR. This complication was not apparent at the time of surgery and was not present on the postoperative radiographs but was unexpectedly evident on 2-month follow-up radiographs. Limb function and comfort level were good at that stage and remained so without further treatment for eight months when the dog was euthanased because of an oral sarcoma. The cause of the fracture was unknown as no adverse events occurred during the surgical procedure. The medial cortex was penetrated only by the drill hole used to estimate medial acetabular bone thickness and no postoperative trauma was observed by the owner. Acetabular bone was noted to be especially hard whilst reaming and implanting the cup and it is possible that this may have contributed to the fracture occurring due to the high torque required to screw the cup into position.

None of the continuous variables demonstrated a significantly non-linear relationship with the outcome considered and so all were incorporated into the subsequent logistic regression analyses. Of all the variables considered, only implant type showed some association with implant loosening, and bodyweight some association with all types of complication on initial univariable analysis. Following construction of the final multivariable models no risk factors were identified for overall complications, but there was a significant association of implant type with implant loosening, with first-generation short stem implants showing increased risk of loosening (odds ratio 4.9, 95%CI: 1.1-22.1, *P*=0.034).

**Discussion**

Fifty-five consecutive Helica® cementless total hip replacements were carried out in 50 dogs over a five-year period (2010-2015). Forty-five dogs had unilateral hip replacements and five had bilateral replacements. Complications of all types occurred in 19/55 (34.5%) cases of which 12/19 (63%) cases were revised successfully. The most common complication was aseptic loosening of the femoral stem which occurred in 11 cases (eight first-generation short stems and three second-generation TPS stems).

The potential for early osteointegration permits the Helica® Hip Endoprosthesis to be implanted in dogs from nine months of age onwards, and 17 of the 50 dogs recorded here were between 9 and 14 months old at the time of surgery. Aseptic loosening of the femoral stem occurred in six young dogs between 22 and 33 months after implantation. Of these six, three (50%) had successful revisions using larger diameter first-generation stems which intentionally penetrated the lateral cortex. The other 11 young dogs (65%) in this group made satisfactory recoveries with no evidence of implant loosening. This included five patients with follow-up periods of between 38-48 months, in which first-generation 26 x 8 mm femoral stems were used.

Aseptic loosening of the original Helica® short femoral stem is not uncommon and in a recently published series of 16 dogs, six (38%) developed loosening of the first-generation femoral prosthesis within one year post-implantation (Agnello et al. 2015). No significant risk factors could be identified in this group. In our series aseptic loosening of the femoral stem occurred in 11 hips (20%) in total, with eight (73%) of these being first-generation stems. However, only four of these 11 cases occurred within one year of implantation. These were all mature dogs, aged 7 years (n=3) and 10 years (n=1). Loosening occurred later in the other seven dogs, diagnosed between 12 months and 33 months postoperatively, with an average time of 24 months. The majority (71%) of these were younger dogs, aged 12 months (n=4) and 9 months (n=1) at the time of the original surgery. The other two cases were in dogs aged 4 years and 7 years. Theoretically the potential for osteointegration is greater when a HHE is implanted in a young dog, and the late onset of aseptic loosening identified up to 33 months after implantation is of concern. However long-term radiographic follow-up (up to 63 months postoperatively) on some cases in the series reported here showed no loosening and little or no bone remodelling (Figure 2), suggesting that the stem implant may mimic the loading pattern in the normal proximal femur as has been previously suggested.

The incidence of hip luxation following Helica® THR was relatively low (5.5%), and when it did occur it was suspected to be due to seating the acetabular cup with insufficient retroversion and / or an excessive angle of lateral opening. In all three cases luxation of the hip occurred within two weeks of surgery. Repositioning of the acetabular cup resulted in a successful outcome in all of these cases.

Seven cases (13%) required implant removal. Complete explantation of the acetabular cup and femoral stem was carried out in two cases with septic loosening and in two cases with aseptic loosening of both components. Partial explantation with removal of the femoral stem but retention of the acetabular cup was performed in three cases with aseptic loosening of the femoral stem alone. In this series recovery with partial explantation and conversion to hemi-arthroplasty was faster compared with complete explantation and conversion to excision arthroplasty. Both groups regained satisfactory function within three months of surgery.

In interpreting these results it should be considered that the complication rate reported may in part reflect the learning curve associated with early cases, as has been reported with similar systems (Hayes et al. 2011), as well as the modification of the stem during this period. The cases in this series were consecutive from the outset of our use of the system and neither surgeon had previous experience of cementless systems. However one surgeon has 30 years previous experience of cemented THR and the other surgeon has 8 years previous experience of assisting cemented THR.

The change in the pre- and post-operative LOAD scores was significant (P<0.001). Reduction in LOAD score is a validated measurement for assessing improved mobility and function in canine osteoarthritis patients (De Sousa *et al* 2016, Hercock *et al* 2009, Walton *et al* 2013), and has been used by the BVOA-UoL Canine Hip Replacement Registry to assess postoperative outcomes (Forster et al. 2012). These findings agree with our owner-reported follow-up data and the follow-up of previous hip replacement systems (Forster *et al* 2012).

The cohort of dogs in this series which received (current) second-generation TPS stems had a higher postoperative complication rate than several published reviews of THR outcomes using other systems (Forster *et al* 2012, Henderson *et al* 2017, Hummel *et al* 2010). However, the overall rate of satisfactory recovery was similar (Henderson *et al* 2017) or better (Forster *et al* 2012), possibly partly associated with the relative ease of revision when complications did occur.

In our experience the HHE has proved to be a relatively simple method of treating hip dysplasia and osteoarthritis in dogs. The screw design of the implants allows changes in implant placement to be made during surgery without loss of stability, and also facilitates revision surgery when necessary. In our series the incidence of aseptic loosening of the femoral stem appears to have been greatly reduced with the introduction of the TPS stem, but still remains the most common complication. As some cases of loosening occurred several years postoperatively, further follow up is needed to monitor whether this remains a true reflection of the success rate associated with the second-generation stem.

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