FACULTY OF VETERINARY MEDICINE
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RIDGESTOP® FOR PATELLAR LUXATION IN THE DOG : SURGICAL TECHNIQUE AND SHORT TERM RESULTS

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PREFACE

I would like to thank everybody who assisted me in the realization of this master's thesis. First of all I would like to thank my supervisor Prof. dr. Geert Verhoeven, to who I could always go for the necessary support and advice. I would also like to thank my co-supervisor dr. Yves Samoy for the support and good tips for completing my Master's thesis.

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SUMMERY

Patellar luxation is one of the most common orthopaedic disorders found in dogs, in which the patella can be dislocated medially or laterally. A grading system for patellar luxation has been described and divides the patellar luxation in four different grades in order of severity. Various surgical techniques to stabilize the femoropatellar joint of the stifle have been described. The surgical techniques include medial/lateral imbrication, transposition of the tuberosity tibiae, trochleoplasty, desmotomy, tibial and/or femoral corrective osteotomy, trochlear- or patellar groove replacement. Recently a new technique has been introduced, which has not yet been described: RidgeStop®. The RidgeStop® is an implant consisting of high molecular weight polyethylene, that protrudes above the ridge of the trochlea. The RidgeStop® can be used as a "stand - alone" procedure, or is alternatively employed as an adjunct procedure when re-alignment operations, such as distal femoral osteotomy or transposition of the tibial tuberosity tibiae (TTT), have been performed.

In this thesis, the clinical files of 43 dogs and oral information of the owners were obtained to evaluate the short term results. In total 24 different breeds were included. Twenty out of 43 patients had a "stand - alone" procedure with the RidgeStop® implant. In other patients, the RidgeStop® was used as an adjunct procedure. In 13 % of cases, complications occurred, 4,64 % of all cases had an infection of surgical site. Revision surgery was required in 2,32 % of all the cases, due to reluxation of the patella. After 6 months of revalidation, in 88,37 % of the cases, there was no limping and no pain. In the remaining 11,63% a mild lameness associated with a mild pain were still present. There is a success rate of 100 % in reducing the patellar luxation and 88,37 % in solving the clinical signs. More studies for conclusive results are required.

DUTCH SUMMERY

Patella luxatie is een van de meest voorkomende orthopedische aandoeningen bij honden, hierbij kan de patella mediaal of lateraal verplaatst zijn. Een beoordelingssysteem voor patellaluxatie is beschreven en verdeelt het in vier verschillende gradaties in volgorde van ernst. Verschillende chirurgische technieken om het femoropatellaire gewricht van de knie te stabiliseren zijn reeds beschreven. De chirurgische technieken omvatten mediale / laterale imbricatie, transpositie van de tuberositas tibiae, trochleoplastie, desmotomie, tibiale en / of femorale osteotomie, trochlear- of patellaire groefvervanging. Onlangs werd een volledige nieuwe techniek geïntroduceerd, die nog nooit eerder beschreven werd: RidgeStop®. De RidgeStop® is een implantaat dat bestaat uit hoogmoleculair polyethyleen, en dat geplaatst wordt op de trochlea en deze als het ware verhoogt. De RidgeStop® kan als een alleenstaande procedure gebruikt worden of wordt alternatief gebruikt als een aanvullende procedure wanneer andere chirurgische technieken worden gebruikt.

In het kader van deze masterproef werden de kliniekgegevens van 43 honden verkregen, alsook mondelinge informatie van de eigenaars, om de resultaten op korte termijn te evalueren. In totaal werden 24 verschillende rassen opgenomen. In 20 van de 43 patiënten was het plaatse nvan RidgeStop® implantaat de enige chirurgische techniek. Bij de andere patiënten werd de RidgeStop® gebruikt als een aanvullende procedure. In 13% van de gevallen traden complicaties op, in 4,6% van alle patiënten die chirurgie ondergingen, ging dit om een infectie van de operatieplaats. Revisiechirurgie was vereist in 2,3%, wegens reluxatie van de patella. Na 6 maanden revalidatie was er in 88,4% van de honden geen sprake meer van klinische symptomen. In de andere 11,6% was er nog aanwezigheid van minimale kreupelheid geassocieerd met lichte pijn. Er kan gesproken worden

van een slaagpercentage van 100% in het reduceren van de patella luxatie en van een 88,4% slaagpercentage in het oplossen van de klinische symptomen. Er zijn echter nog meerdere verdere studies noodzakelijk voor voldoende representatieve en concluderende resultaten.

1. INTRODUCTORY LITERATURE STUDY

1.1 Anatomy of the stifle joint

The stifle joint can be situated between the femoral bone and the tibial bone. The distal epiphysis of the femoral bone exist of two condyles with on each side an epicondyle on top. The two condyles are separated by the fossa intercondylaris. The trochlear groove is created between the trochlear ridges at the cranial aspect of the femur, in which the patella acts as a pulley. The patella is an ossification (sesamoid bone) in the insertion of the quadriceps femoris muscle tendon and improves the efficiency of the extensor mechanism (Tobias, 2013). The part of the tendon between the patella and its insertion on the tibial tuberosity can be named as the patellar ligament, as seen in figure 1. In the caudal aspect of the stifle, there are further two sesamoid bones. These are often called fabellae, and are situated in the end of the gastrocnemius muscle (Evans and De Lahunta., 2013).

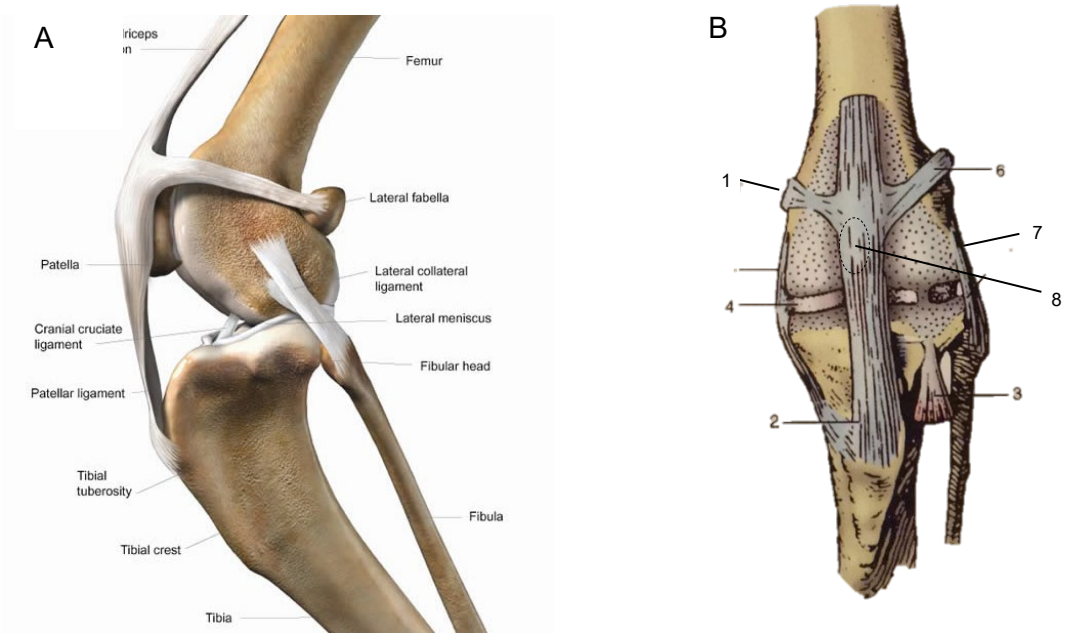


Figure 1, A, lateral three dimensional view of the stifle. (from Svetoslav, 2015). B, cranial view of the stifle, 1, medial femoropatellar ligament. 2, patellar ligament. 3, tendon of the long digital extensor passing through the extensor groove. 4, medial meniscus. 5, medial collateral ligament. 6, lateral femoropatellar ligament. 7, lateral collateral ligament. 8, patella (from Saunders veterinary anatomy flash cards, 2010)

1.2 Patellar luxation

Patellar luxation is one of the most common orthopaedic disorders found in dogs (Ness et al., 1996; Morgan, 2013). The patella can be dislocated medially or laterally (Alam et al., 2007). Medial patellar luxation is much more common than lateral patellar luxation in the dog. Lateral patellar luxation is seen more in large breed dogs than in small breed dogs. Bilateral patellar luxation occurs in about 50 - 68% of patients (Morgan, 2013).

An improper alignment of the quadriceps femoris muscle tendon at young age can result in patellar luxation (Verhoeven and Dallago, 2016; Morgan, 2013). Possible consequences are angular, torsional and other skeletal deformations with associated lameness (Morgan, 2013). The significant clinical signs of a patellar luxation are dependent on the grade of luxation and may include pain,

intermittent or consistent hind limb lameness and genu varum/valgum (Roush et al., 1993). Roush et al. (1993) described a grading system for patellar luxation that can be used to determine the severity of the luxation:

- Grade 1: the patella can be manually manoeuvred in and out the patellar trochlear groove without any problem. When releasing the patella, after manually luxating it, it returns back to normal position (Roush et al., 1993).
- Grade 2: the patella remains luxated, after manually or spontaneously luxating the patella, until replacing the patella back in the groove by moving the leg or manual replacement (Roush et al., 1993)
- Grade 3: the patella is constantly luxated, but can still be replaced manually. After replacement, the patella shoots back from its normal position (Roush et al., 1993)
- Grade 4: In grade four, the patella cannot be replaced in the right position (Roush et al., 1993).

Alam et al. (2007) reported that medial patellar luxation increases stress on the cranial cruciate ligament predisposing to degeneration and rupture.

The pathogenesis of patellar luxation is currently not completely known, despite thorough research (Alam et al., 2007). Patellar luxation is a developmental disorder, most likely associated with the improper alignment of the quadriceps femoris muscle. With patellar luxation, a hypoplasia of the trochlear ridge, caused by the quadriceps femoris muscle working mechanism, can often be found. According to Koichi Fuji et al. (2012) the ridge can be non-existing, especially in cases where the luxation is already present for a longer time. Traumatic patellar luxation can occur. Patellar luxation is considered a hereditary condition; therefore, breeding protocols are recommended (Morgan, 2013).

When a dog is presented with a suspicion of patellar luxation, clinical orthopaedic examination is important. During the manipulation of the stifle, it is possible to define instability, location of the patella, range of motion, pain and the ability or inability to reduce the patella in the trochlear groove. Sometimes sedation is needed to detect instability of the patella (Di Dona et al., 2018). The second step in the diagnosis is a radiographic survey to confirm or reject the patellar luxation. Lateral projection of the stifle allows identification of a patella alta or baja. A craniocaudally or caudocranial projection of the stifle allows the identification of the lateral or medial movement of the patella. An additional CT scan can be used to make a surgical correctional plan (Di Dona et al., 2018).

Figure 2 : A, B, C, a lateromedial, craniocaudal and tangential radiographic projection of a canine stifle with lateral patellar luxation respectively. (from Di Dona et al., 2018)

1.3 Treatment

1.3.1 Conservative treatment

A conservative treatment can be instituted in cases of grade one patellar luxation if the lameness is not severe and infrequent, with a mild osteoarthritis. Medical treatment exists consists in administration of nonsteroidal anti-inflammatory drugs with, in some cases, additional analgetic drugs such as tramadol (Di Dona et al., 2018; Morgan, 2013). Rest is an important component of conservative treatment (Morgan, 2013). Weight control is also essential to avoid additional stress on the stifle joint (Di Dona et al., 2018).

1.3.2 Surgical treatment: techniques

Surgery is only indicated for dogs with significant clinical signs that are not responsive to medical treatment. In asymptomatic adult dogs, despite the risk of degenerative joint disease and rupture of the cranial cruciate ligament, there is no evidence that prophylactical surgery is beneficial. (Harason, 2006). Except in two situations of asymptomatic patellar luxation, surgery is required to reduce the luxation, as described by Evans and De Lahunta (2013). The first situation occurs in puppies that suffer from patellar ectopia; in this case the surgery is performed at the age of three or four months to avoid irreparable damage to the femoropatellar joint. The second situation occurs in large breeds in order to avoid erosion of the trochlea. Once these changes have occurred, the surgical techniques are limited due to these erosions (Evans and Lahunta, 2013).

Conventional surgery aims to anatomically realign the patellar mechanism, releasing any constraining tissue and prevent reluxation (Perry, 2017). Various surgical techniques to stabilize the femoropatellar joint have been described.

The surgical techniques include medial/lateral imbrication, transposition of the tuberosity tibiae, trochleoplasty, desmotomy, tibial and/or femoral corrective osteotomy, trochlear- or patellar groove replacement. Recently, a new technique has been introduced, which has not been described: RidgeStop®.

1.3.2.1 Medial/lateral imbrication

Medial or lateral imbrication is a technique where lateral or medial sutures are placed in the joint capsule under tension, leaving the patella with less movement. In most, if not all cases, soft tissue techniques are not sufficient to overcome the forces responsible for patellar luxation because stretching arises after initial tightening (Verhoeven and Dallago, 2016).

1.3.2.2 Transposition of the tuberositas tibiae (TTT)

Transposition of the tibial tuberosity tibiae (TTT) is a technique that re-aligns the working mechanisms of the quadriceps muscle. An osteotomy is made in the tibial crest where the most distal part remains connected to the periost. The bone piece is gently moved laterally or medially in case of medial and lateral patellar luxation, respectively (Verhoeven and Dallago, 2016). Ample bone stock is necessary to ensure proper pin fixation and to avoid crest fractures.

The best method described to fixate the bone piece is to use two pins, placed beneath or next to each other. Using three pins gives no significant better fixation results (Cashmore et al., 2014). The first placed pin is introduced at the level of, or just distally of the attachment of the patellar ligament. The best result is obtained with a pin placed caudoproximal, in this position there is three to six times more resistance against tensile forces then a caudal or distal positioned pin. To avoid caudal migration of the pins, the protruding part of the pins at the cranial side, can be bent (Verhoeven and Dallago, 2016).

1.3.2.3 Trochleoplasty

The goal of trochleoplasty is to deepen the trochlear groove in order to seat the patella better in its groove (Johnson et al., 2001). There are two techniques to perform a trochleoplasty, the V-sulcoplasty and the block-sulcoplasty. When a trochleoplasty is performed, first a piece of hyaline cartilage and subchondral bone is temporarily removed, secondly a bone piece is resected from the trochlear groove and finally the hyaline cartilage is placed back in the groove (Talcott et al., 2000). The ultimate goal is to have the patella at least 50 % of its thickness deeper in the groove (Fossum et al., 2007). Figure 3 illustrates the two types of trochleoplasty.

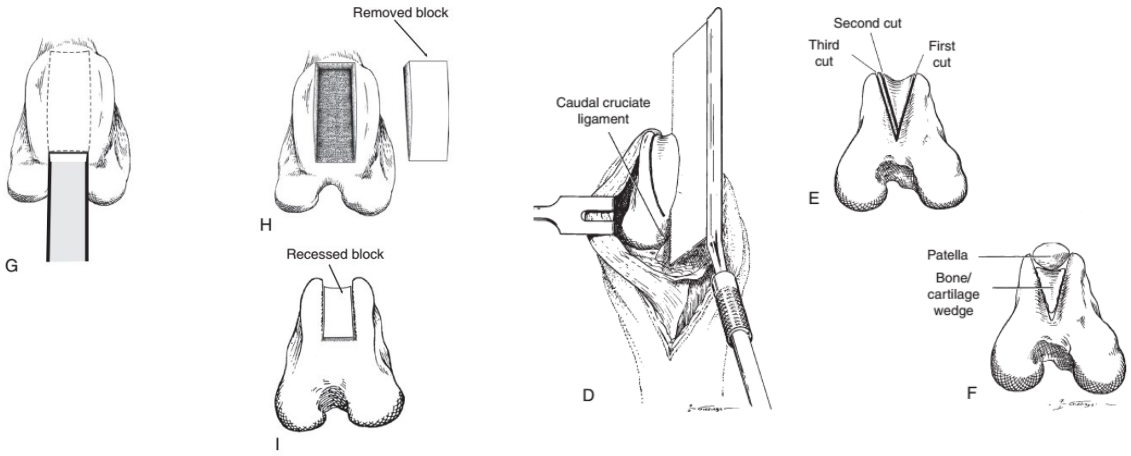


Figure 3: G to I, Trochlear block recession. G, Using a thin-blade power saw or an osteotome the trochlear block is outlined and removed. H, After removing the block, the trochlear groove is deepened more. I, The recessed block is placed back without fixation. D, A V-shaped wedge is cutted from the trochlea. E, the best indicated order of cuts. F, The sulcus is made deeper and the wedge is replaced. (Decamp et al., 2016)

1.3.2.4 Medial/lateral desmotomy

Medial or lateral desmotomy is performed when the patella is still experiencing too much medial/lateral traction after transposition of the tuberositas tibiae and trochleoplasty. In case of medial patellar luxation, the medial retinaculum is incised, partially or completely trough the synovium (Verhoeven and Dallago, 2016). Performing a medial desmotomy gives a small risk at complications due to instability of the quadriceps.

1.3.2.5 Tibial and/or femoral corrective osteotomy

Corrective osteotomy is a surgical technique that can be useful in case of severe deformation of the bones, most common in stage four of patellar luxation. Performing a corrective osteotomy has the purpose of realigning the improper alignment of the bones (Verhoeven and Dallago, 2016).

1.3.2.6 Trochlear or patellar groove replacement

A trochlear groove replacement is indicated when osteophytes and cartilage erosion have damaged the trochlear groove, due to chronic instability and erosion of the femoropatellar joint. Additionally, in other cases of severe deformation of the femoropatellar joint, a standard trochleoplasty will not suffice as a surgical treatment in this case of patellar luxation. The technique of trochlear groove replacement is based on a two-component titanium-ceramic prosthesis, consisting of a base plate and a trochlear implant. Choosing the right size of implant is a crucial step to achieve the best possible result (Perry, 2017).

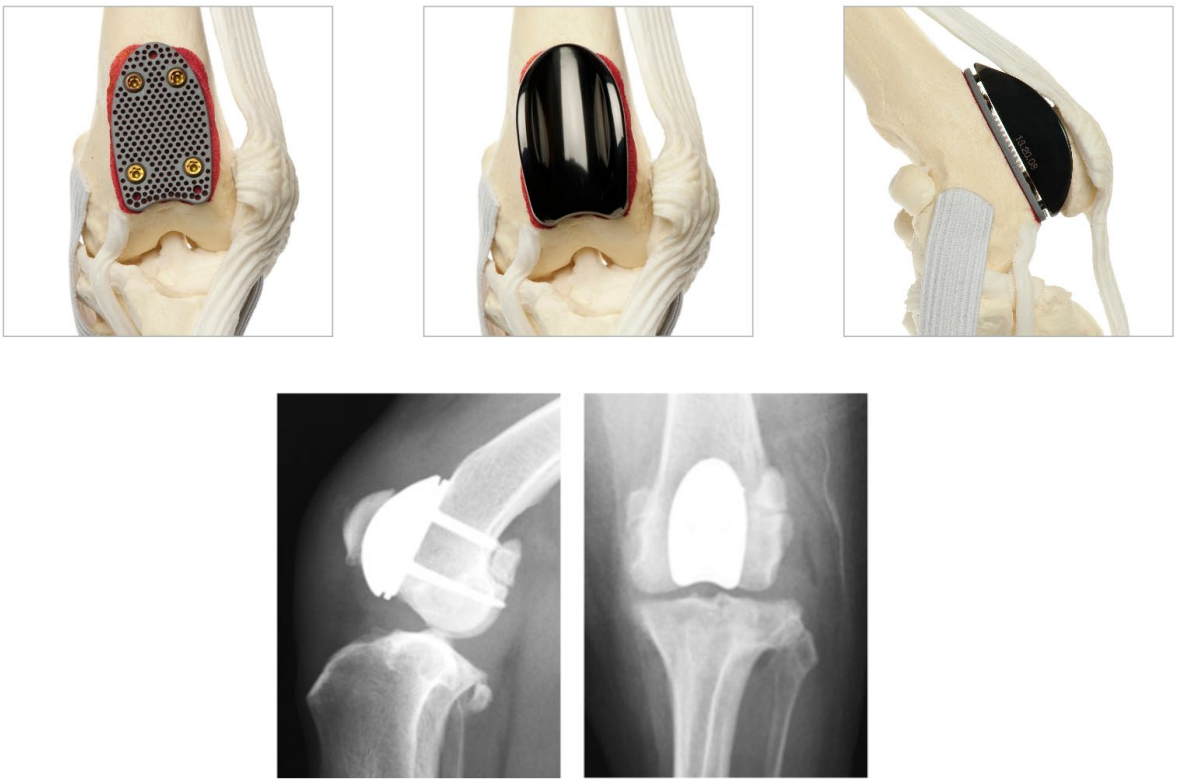


Figure 4: A - B, cranial view of the baseplate and trochlear implant of the “patellar groove replacement” implant. C, lateromedial view of the “patellar groove replacement” implant. C, Lateromedial radiograph with two pins and the “patellar groove replacement” implant. D, Dorsoplantar view of the patellar joint with the “patellar groove replacement” (KYON, PGRR brochure)

1.3.2.7 RidgeStop®

The RidgeStop® can be used as a "stand - alone" procedure for less severe cases of patellar luxation – grades 1 or 2. Alternatively, RidgeStop® is employed as an adjunct procedure when re-alignment operations, such as distal femoral osteotomy or transposition of the tuberositas tibiae, have been performed. In those cases, RidgeStop® acts effectively as an alternative to sulcoplasty procedures[1]. The RidgeStop® is a complex three - dimensional implant consisting out of high molecular weight polyethylene, that protrudes above the ridge of the trochlea and can be held in place with 2,4 and 2,7 mm standard cortical screws. The implant is available in the following sizes: 1,5 cm, 2 cm, 2,5 cm, 3 cm and 3,5 cm. Left and right implants are available. The required size can be determined from the length of the ridge measured on a standard mediolateral radiograph of the stifle. The RidgeStop® implant itself is radiolucent on radiographs, only the cortical screws that fixate the implant can be noticed.

Before placing the implant, a drill guide can be placed in the correct position, resembling the final position of the implant itself. First, the most distal hole is drilled using a 2 mm drill bit, secondly a temporary fixation peg is placed in the drill hole. The next step is to drill the most proximal hole, also using a 2 mm drill bit, followed by placing a temporary fixation peg. Then the remaining hole can be drilled in the same manner. The most distal screw is unicortical; the other two screws are bicortical. At this stage the most distal fixation peg is removed, and the drill guide can be gently removed from the surgical site. After removing the drill guide, the RidgeStop® is placed in the same position formally occupied by the drill guide. Screws with the right length are now used to fix the implant, placing them in the order as the holes were drilled. It is important not to overtighten the screws to avoid deformation of the RidgeStop®[1] . For the 1,5 cm implant, two sizes are available: normal and low-profile (difference in height) and it allows for placement a 2,4 cortical screw distally and proximally, so only two screws are employed.

One of the benefits is that surgical time is reduced significantly in comparison to the other conventional techniques, and if necessary, the surgeon can still resort to the classical techniques. Avoidance of making bone cuts results in shorter time of recovery, making this technique less traumatic then classical techniques[1].

Figure 5: A: Guide for RidgeStop® in place. B, C: RidgeStop® implant in place (orthomed, surgical userguide)

[1] Ridgestop for patellar luxation, surgical userguide, orthomed (www.orthomed.co.uk), last consultated on 24 of April, 18u41

2. LIMITED RESEARCH

2.1 Issues and Purpose

RidgeStop® is a new implant, which is currently not often used for treatment of patellar luxation. There are very few studies that evaluate the results after surgical intervention. Based on this retrospective study, an evaluation of the short-term results of the use of a RidgeStop® implant in case of medial patellar luxation in dogs is performed. This will be executed based on a survey which contains standardized questions about the post-op evolution of dogs after RidgeStop® placement. Every client owning a dog that has been treated with a RidgeStop® in Belgium will be contacted personally by telephone, in an attempt to evaluate the greatest amount of dogs. Some questions cannot be answered by the owner, so contact with the treating veterinarian is required in order to solve this problem. In the clinical files, we can acquire more objective results in connection with lameness pre – and post – surgery and after a short time of recuperation.

2.2 Material and method

With the help of a survey based on standardized questions, all dogs with a patellar luxation treated in the period between the 28th of March 2017 and the 30th of October 2018 with a RidgeStop® implant in Belgium were evaluated. The RidgeStop® technique is quite often used in two of the largest animal clinics and is becoming a standard procedure. To analyse all the data as correctly as possible, the date will be put in an online survey program (www.enquetemaken.be), making it easier to get straightforward results and comparisons. These online surveys are completed with the help of personal contact with the owners of treated dogs and the clinical files. With the help of the data in the clinical files, filled in by veterinarians, more objective results can be obtained to compare with each other. After completing all the online surveys, the results were put together in an excel file to create various diagrams and tables, and to analyse the data in an efficient and comprehensive manner.

2.3 Research results

2.3.1 Population

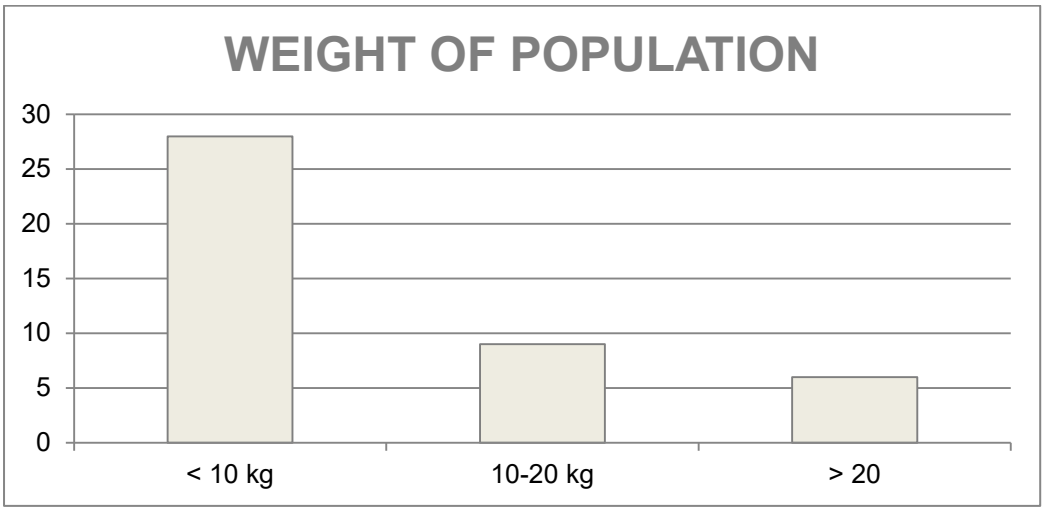
In total 43 out of 46 owners were willing to participate. The other three patients were not included in the study. In total 24 different breeds were included. Cavalier King Charles, Yorkshire terriers and French bulldogs were the most common breeds, with five (11,6%), four (9,3%) and four (9,3%) dogs respectively.

Table 2: In this table, the 24 different breeds included in the study are listed, in total 43 dogs participated.

Breed	Numbers	Breed	Numbers
American Stafford	1	*French Bulldog*	4
Argentinian Dog	1	*Jack Russel Terrier*	1
Boston Terrier	1	*Labrador Retriever*	1
Bouvier	1	*Lhaso Apso*	1
Boxer	1	*Maltese*	2
Cavalier King Charles	5	*Pinscher*	1
Chihuahua	1	*Poodle*	1
Chowchow	1	*Pomerian*	1
Canis Vulgaris	3	*Pug*	1
Dachshund	3	*Shiba Inu*	3
Miniature Dog	3	*West highland white terrier*	1
English Bulldog	3	*Yorkshire terrier*	4

Small breeds were considered when weighing less than 10 kilograms; mediate breeds when weighing between 10 and 20 kilograms and big breeds when weighing over 20 kilograms. The distribution of patients in the weight categories described previously can be seen in the table below. All patients were weighed at the day of surgical intervention. The majority of the breeds were small breeds under 10 kilograms, with a percentage of 65% (n = 28). Less than a quarter (14%) of population weighed over 20 kilograms (n = 6).

Table 3: Weight categories of the population participating in this study at time of surgery



In the survey the included population was divided into eight different categories of age. As seen in figure 6, the RidgeStop® was mostly used in dogs between the age of 12 months and 48 months (62 %). This group is almost identically distributed into the three different age categories, namely 23% is between 12 and 24 months old, 23% is between 24 and 36 months old, and 16% is between 36 and 48 months old. Only a small number of dogs, who underwent the surgery, were

older than 84 months. The average age of the dogs that underwent surgery for patellar luxation was 39,1 months, which can be placed in the largest age category.

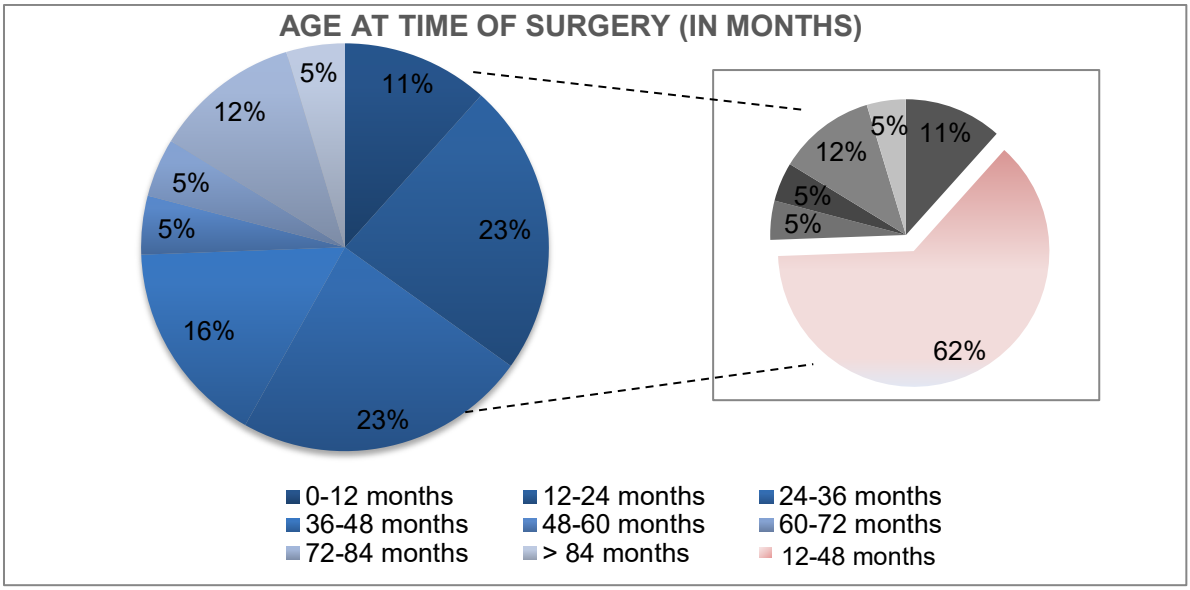


Figure 6 : the population of dogs participating in this study divided into different age categories.

In this retrospective study the sex of almost half of population is female castrated. 62,8% (n = 27) of population is female, in contrast to 37,2% (n = 16) of male dogs in this study (figure 7). The majority of all dogs were castrated (67,4%).

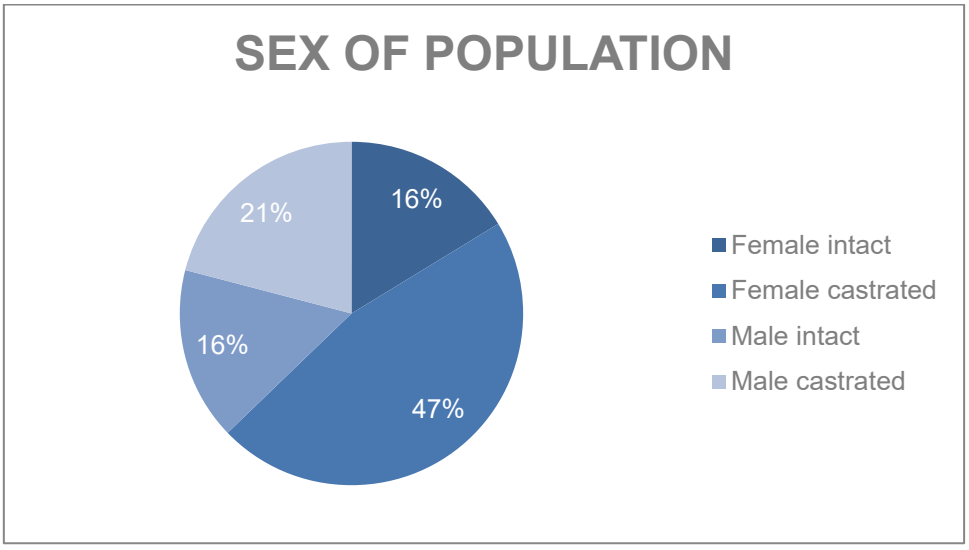


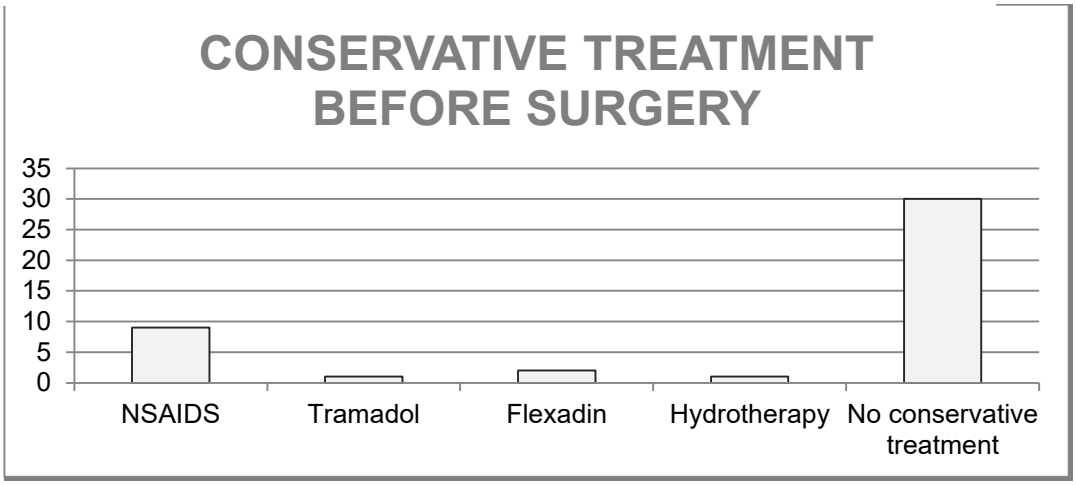
Figure 7: the population of dogs participating in this study divided into the different sex categories

2.3.1 Conservative treatment before surgery

Before deciding to go further with surgical correction for the patellar luxation, 30,2% (n = 13) of the dogs in this study had a conservative treatment with non - steroidal anti - inflammatory drugs, during a period variating between two and four weeks. The non - steroidal anti - inflammatory drugs

of choice are meloxicam, robenacoxib and carprofen. Additionally, some dogs received some sessions of hydrotherapy on an underwater treadmill. When no non - steroidal anti - inflammatory drugs were administered (history of gastro – intestinal problems), tramadol was an alternative option Dietary supplements were given in some cases: flexadin advanced (Vetoquinol, Belgium). Flexadin advanced (Vetoquinol, Belgium) contains anti-inflammatory omega-3 fatty acids, vitamin E, which is an antioxidant that reduces the breakdown of cartilage, and non-denatured collagen type II, which provides increased mobility of the joints.

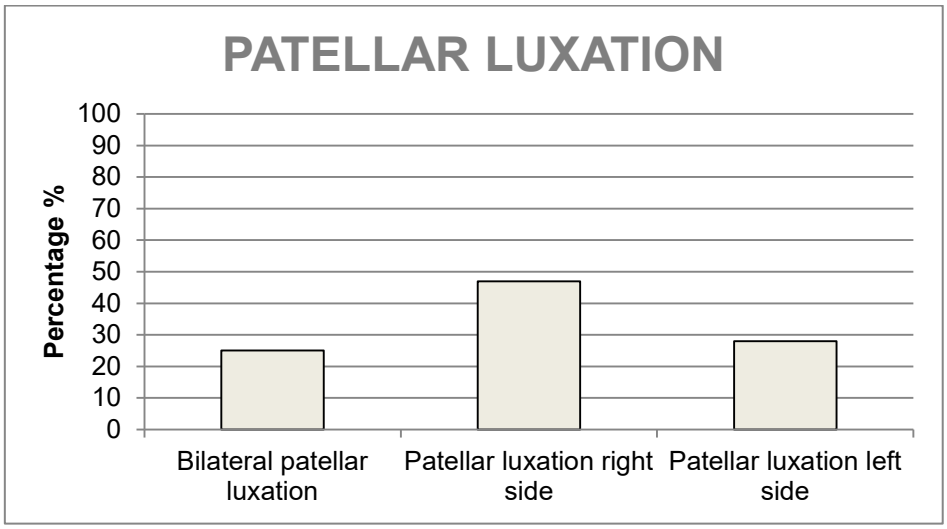
Table 4: Conservative treatment that was administered before deciding to go further with surgery



2.3.2 Patellar luxation

Table 5 illustrates that 25% (n = 11) of the dogs had a bilateral luxation, 12% (n = 5) of them underwent surgery at the left side and 13% (n = 6) on the right side, corresponding to the most severe patellar luxation. In cases with unilateral luxation, most patellar luxations were present at the right stifle joint with an incidence of 47% (n = 20). On the left side, 28% of patients had a patellar luxation (n = 12).

Table 5: distribution of the side of patellar luxation before surgery in the population of dogs participating in this study



Another imperative part of this study was the grade of luxation before a surgical intervention was planned. As seen in figure 8, 40% of cases (n = 17) had a patellar luxation grade three, 30% (n = 13) a grade two. Much less common luxation grades are one or four (30%).

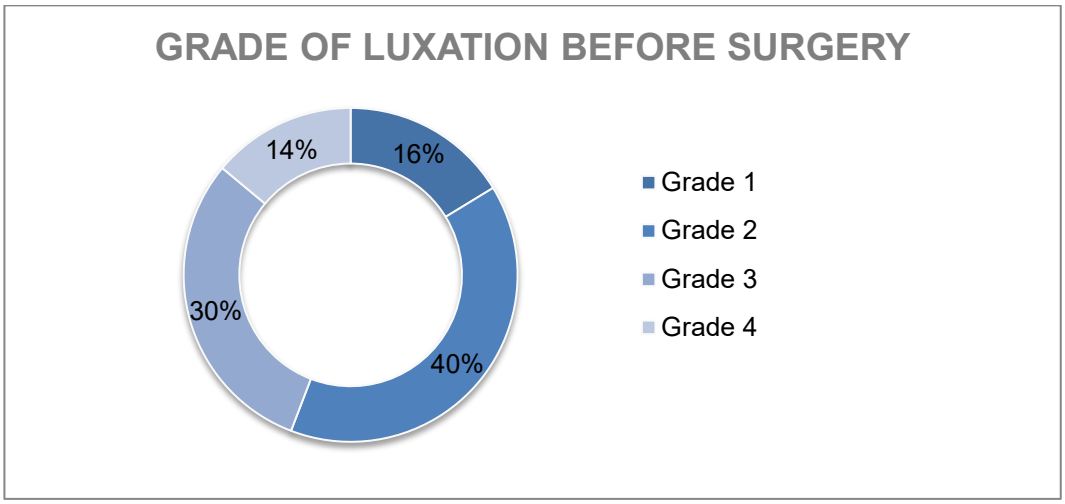


Figure 8: grade of luxation that was diagnosed before surgery

In table 6 the grades of luxation are compared with the score of lameness. Patients with a grade one patellar luxation have a less severe lameness than patients with a higher grade of patellar luxation, there is an obvious correlation between the grade of lameness and the grade of patellar luxation. In 7% of patients an intermittent lameness was observed, these three patients had a grade three patellar luxation.

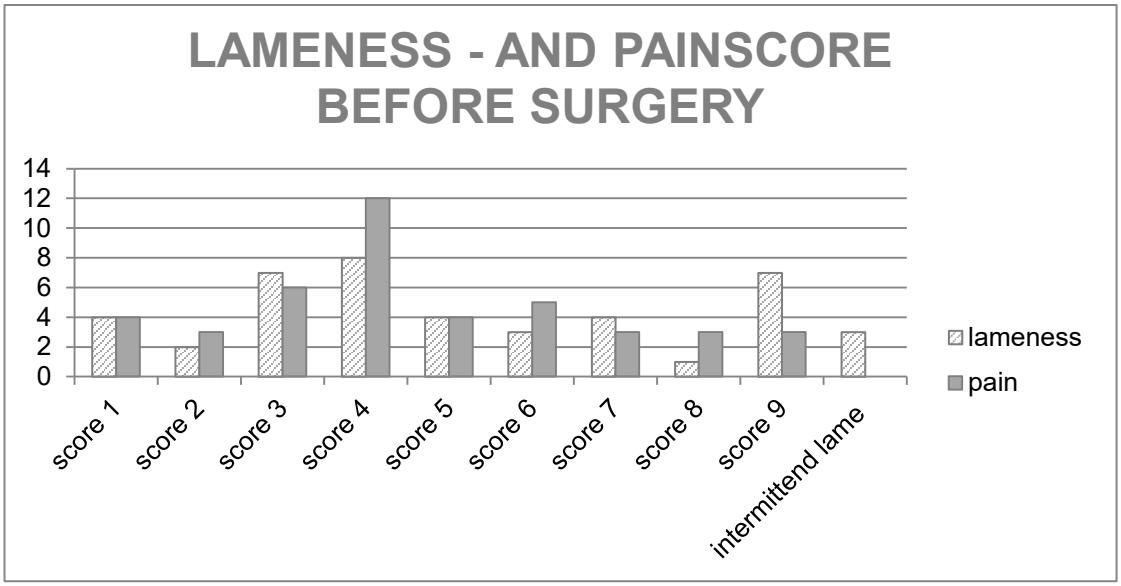
Table 6: grade of luxation in comparison with score of lameness

	Lameness score before surgical intervention									
Grade of luxation	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9	Intermittent lameness
Grade 1	1		1	4						
Grade 2	2	2	2	2	3		4		2	
Grade 3			2	2	1	2			3	3
Grade 4			2			1		1	2	

2.3.3 Pain – and Lameness score

Comparing the pain scores before surgery from all the included patients, it can be seen that 44,2% of them had a mild to moderate pain score (score 4 – 5 - 6). These scores were determined by the owners, and this cannot be considered as 100 % objective parameters. Lameness scores are also included in the following table. The pain – and lameness scores are distributed almost equally.

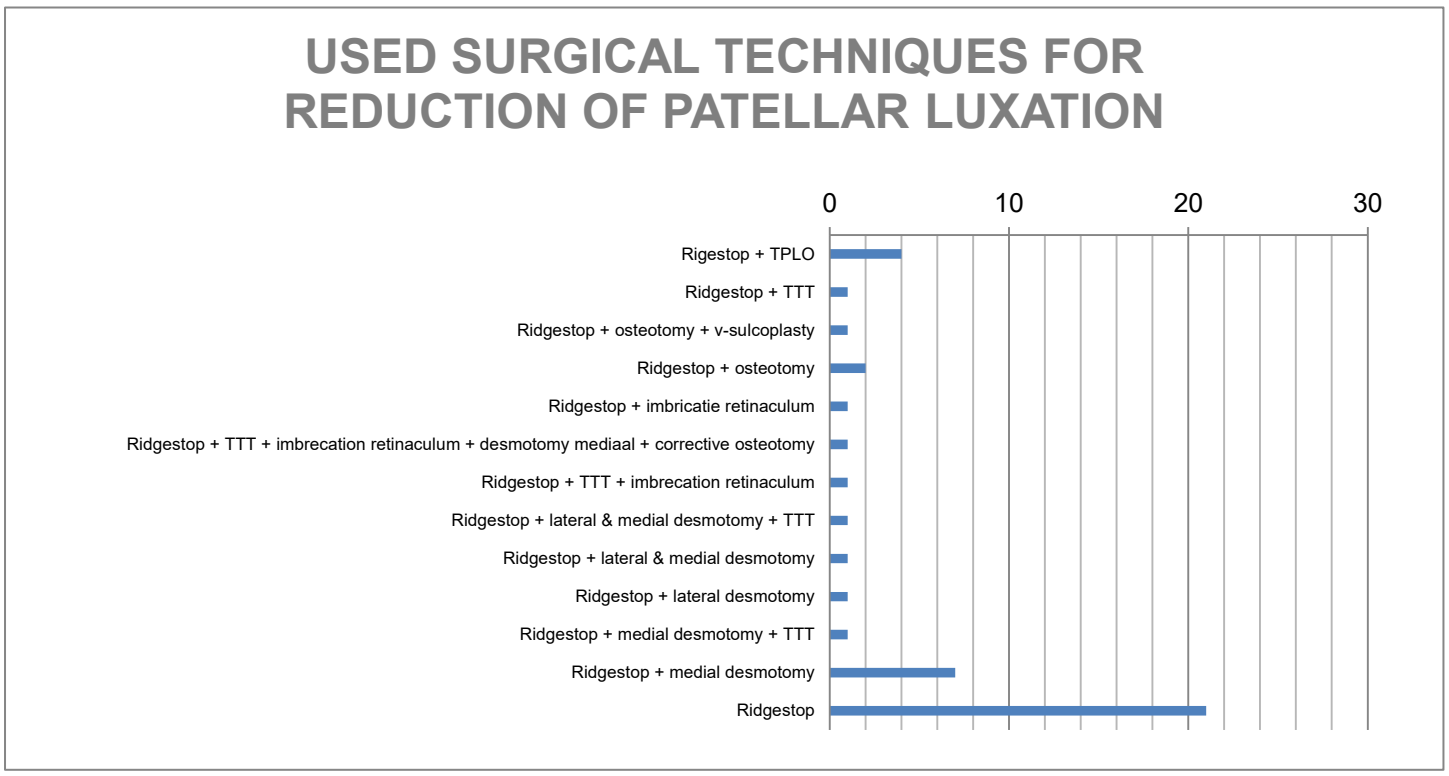
Table 7: Lameness – and painscore before surgery



2.3.4 Used techniques

All the surgeries in this study were performed by experienced orthopaedic surgeons and / or their residents. In 46,5% (n = 20) of the surgeries performed, the RidgeStop® technique was the only technique used to reduce the patellar luxation. In the other surgeries (53,5%) some different standard patellar luxation techniques were used to stabilize the patella.

Table 8: Numbers of used of different surgical techniques in combination with the Ridgestop® in case of patellar luxation in dogs



Medial/lateral desmotomy is with an incidence of 27,9% one of the most used techniques in combination with the RidgeStop®. In case of severe deformation of the bones, an osteotomy is a

commonly used technique to correct the position of the bones and to stabilize the patella. In addition to these techniques, transposition of the tuberositas tibia (TTT), imbrication, corrective osteotomy and sulcoplasty were used in some of these specific cases. When a cruciate ligament rupture was present in addition to the patellar luxation, a tibial plateau levelling osteotomy (TPLO) was required, which was the case in four patients.

Table 9: Numbers of use of different surgical techniques used in case of the four different grades of patellar luxation in dogs

	Surgical Technique													
Grade of luxation before surgery	RidgeStop® + TPLO	RidgeStop® + TTT	RidgeStop® + osteotomy + V - sulcoplasty	RidgeStop® + osteotomy	RidgeStop® + imbrication retinaculum	RidgeStop® + TTT + imbrication retinaculum + medial desmotomy + corrective osteotomy	RidgeStop® + TTT + imbrication retinaculum	RidgeStop® + lateral & medial desmotomy + TTT	RidgeStop® + lateral & medial desmotomy	RidgeStop® + lateral desmotomy	RidgeStop® + medial desmotomy + TTT	RidgeStop® + medial desmotomy	RidgeStop®
Grade 1			1	1							1		4
Grade 2	2				1	1						7	6
Grade 3	2						1		1				9
Grade 4	1	1	1	1						1			1

RidgeStop® is used as a single procedure in 57,1% (n = 4) of cases with a patellar luxation grade one, in 35,3% (n = 6) of cases with a patellar luxation grade two, in 69,2% (n = 9) of cases with a patellar luxation grade three and at in 16,7% (n = 1) of cases with a patellar luxation of grade four.

Throughout the surgeries performed in this study, no complications could be reported. In the period shortly after surgery, in 13% (n = 6) of cases complications occurred, of which two required revision surgery. In 4,6% of the cases, infection of surgical site was present as complication. In one of these cases, it was necessary to remove the RidgeStop® due to this. The patient in which this infection was present, was a female castrated boxer of four years old, with severe lameness (grade of luxation = 2) and pain before surgery and with a bilateral medial patellar luxation. Besides the RidgeStop® technique that was used in this case, an imbrication was performed. After the revision surgery to remove the implant, all problems of this dog were solved. The other infections that occurred after the surgeries were easily resolved after antibiotic therapy. The most common complication seen in the post - op evolution of these patients was the development of a seroma, and occurred in 7% of the patients. Further treatment was necessary, after removing the fluids and placing a pressure bandage on the stifle joint, these complications were resolved.

In two of twenty cases, where the RidgeStop® was the only technique used, complications occurred in the period shortly after surgery, which is the same as 10 % of “stand – alone” procedures or 4,6% (n = 2) of all cases evaluated. Revision surgery was required in 2,3% (n = 1) of all the cases in this study, due to reoccurrence of luxation of the patella. This revision surgery was performed on a male castrated Labrador retriever of ten years old, with initially a patellar luxation grade three.

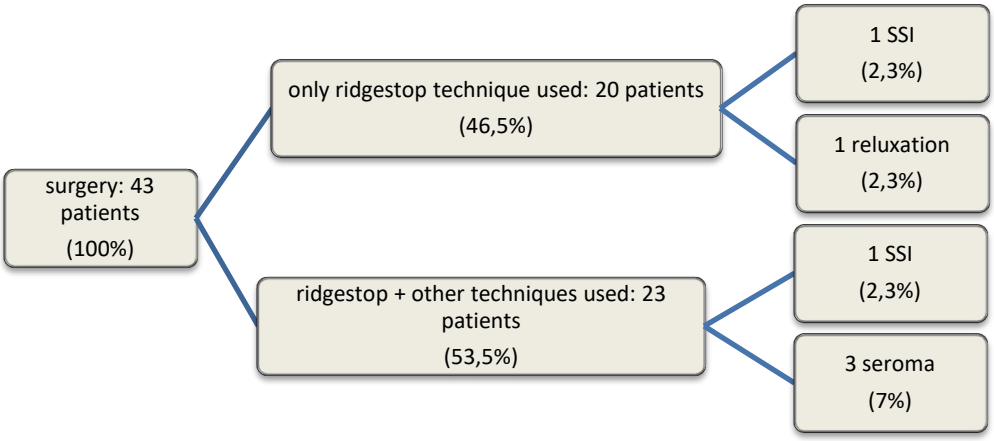


Figure 9: used surgical techniques combined with the complication rate after surgery

Complications, as described above, were present in two French bulldogs, one English bulldog, one pug, one boxer, one Labrador retriever and one Yorkshire terrier. In 66,7% a grade 2 luxation was present, 16,7% of luxations were grade one and 16,7% of luxations were grade three. In table 9, the patients with complications were listed and half of them is female, half of them male. Complications that occurred are not equally divided between male and female dogs and were 11,1% in female dogs and 18,8% in male dogs.

Table 10: the six different patients with complications after surgical intervention for patellar luxation, with breed, age, sex, grade of luxation, lameness score, pain score, surgerical technique and treatment after the surgery included

	Age	sex	Grade of luxation	Lame-ness score	Pain score	Surgical technique	Treatment after surgery	Compli-cations	Revision surgery
French bulldog	4	Female castrated	1	4	3	RidgeStop®	3 weeks non - steroidal anti - inflammatory drugs, 5 days of antibiotics	Infection	no
French bulldog	3	Male	2	9	9	RidgeStop® + desmotomy	14 days non - steroidal anti - inflammatory drugs, 5 days of antibiotics	Seroma	no
Pug	2	Female	2	2	6	RidgeStop® + Medial desmotomy	One month of non – steroidal anti – inflammatory drugs, 5 days of antibiotics	Seroma	no
Boxer	4	Female castrated	2	7	3	RidgeStop® + imbrication	3 weeks non - steroidal anti - inflammatory drugs, antibiotics, flexadin advanced	Infection	yes
Labrador Retriever	10 years	Male castrated	3	4	1	RidgeStop®	3 weeks non - steroidal anti - inflammatory drugs, antibiotics, flexadin advanced	Reluxation	yes
English bulldog	2 years	male	2	7	8	TTT, imbrication, corrective osteotomy, lateral desmotomy	3 weeks non - steroidal anti - inflammatory drugs, antibiotics, kynosil	Seroma with acute lameness	no

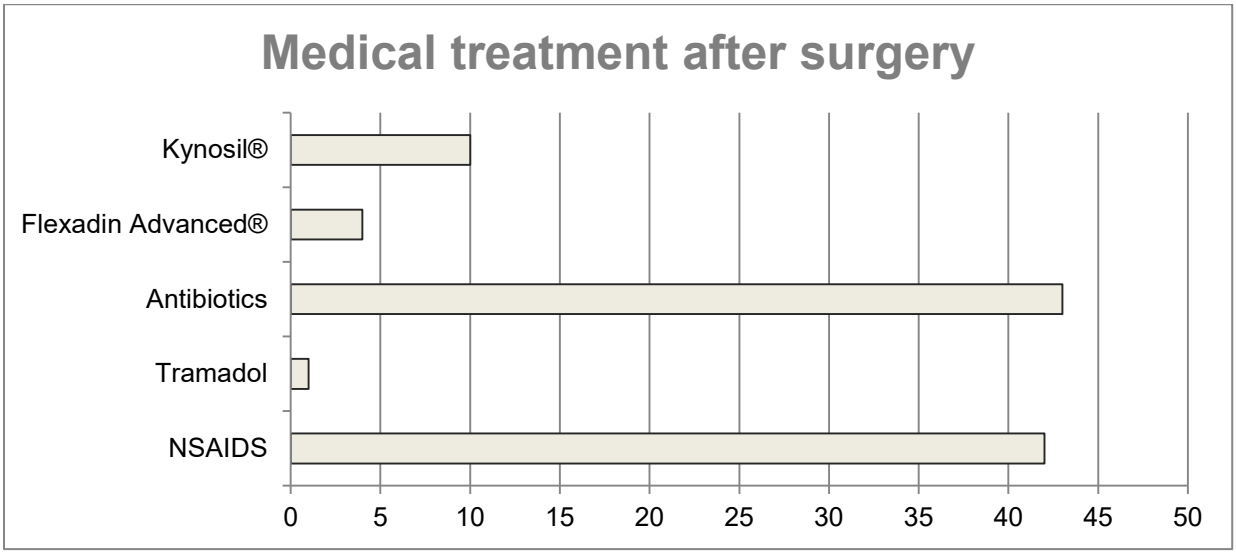
The success rate in terms of not having any complications during and shortly after surgery can be set at 86% in total. When only evaluating the single use of RidgeStop® there was a success rate of 90%. Evaluating the success rate of cases with use of RidgeStop® on top of traditional techniques is 82,6%.

2.3.5 Post-op period

After surgery, every patient was treated with medication, generally combining analgesics with antibiotics. In 100% of patients antibiotics were given, the most administered antibiotic is amoxicillin clavulanic acid with a maximal treating period of seven days. The non - steroidal anti - inflammatory drugs were given in 97,7% (n = 42) of the times for a period varying between one and three weeks. In the 2,3% (n = 1) of other situations, tramadol was administered.

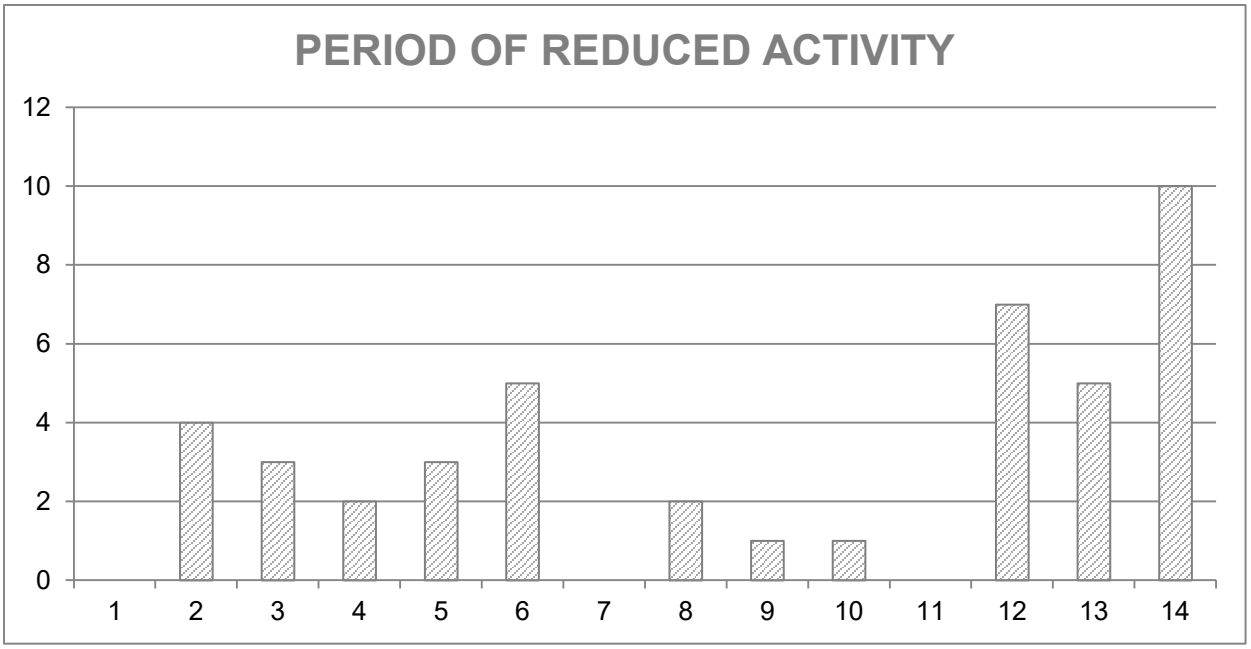
As described in the conservative treatment, flexadin advanced® (Vetoquinol, Belgium) was continued as an additional dietary treatment when the patient was supplemented with it before surgery. It was also recommended several times to the other owners. Another treatment dietary supplement used after surgery is kynosil® (B+ Pharma, Belgium).

Table 11: used medical treatment after surgery



The time of reduced activity was quite different for each dog. Reduced activity consists of shorter walks, less frequent walking and certainly not walking without a leash. The personal preferences and thoughts of the owner must also be taken into consideration when evaluating these factors.

Table 12: time of revalidation with a reduced activity after surgical treatment

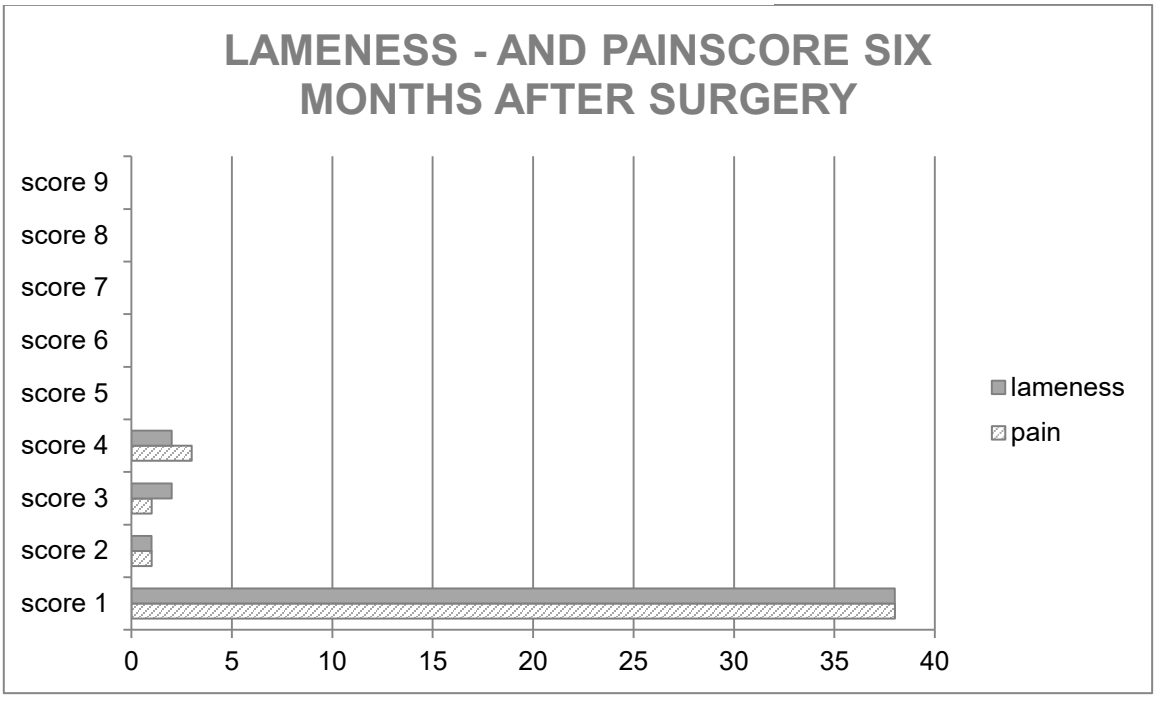


Control visits were planned six weeks after the surgery, therefore it was imperative to try and keep the dogs as quite as possible, however with some restricted activity until the control. 30,2% of dogs recovered that quickly that only zero to two weeks of strict rest with restricted activity was necessary to have no more clinical signs at all. More than half (= 53,9%) of these 30,2% of patients that recovered that quickly were patients where the RidgeStop® was a "stand – alone" procedure.

2.3.6 Results after 6 months

After 6 months of revalidation, in 88,4% of the cases, there was no longer any limping or pain. In the remaining 11,6% a mild lameness associated with a mild pain were still present.

Table 13: lameness – and painscore six months after surgery



In all the participating dogs, there was no patellar luxation present after six months. In one of the patients revision surgery was necessary to achieve this. Therefore, it can be concluded that there was a success rate of 97,7% in reducing the patellar luxation shortly after the surgical intervention. After six months there was consequently a succes rate of 100% in reduction of the patellar luxation. In one of the dogs, one and a half year following the surgery, one of the distal screws that fixates the RidgeStop® was broken after trauma and was replaced afterwards. This was due to the application of a too small diameter screw (2,0 mm instead of 2,7 mm). Success rate of solving any clinical sign could be set at 88,4%.

2.4 Discussion

In total, only a small amount of dogs was evaluated in this study (n=43), compared with the great amount of 559 dogs included in the study of Bosio et al. (2017), in which 52% was female and 48% male and with 166 dogs participating in the study of Arthurs and Langley-Hobbs (2006), in which 43% was female and 57% male. 62,8% of female and 37,2% of male patients is comparable with the results of the study of Bosio et al. (2017), however not with the study of Arthurs and Langley-Hobbs (2006), in which more males than females were included in the study. In the studies above, only conventional surgical techniques for patellar luxation were administered. 17 dogs were evaluated in the study of HarGittai T. et al. (2014), in which patients, treated with a RidgeStop® implant only were evaluated. This study is comparable with the number of patients reached in this study, who underwent the RidgeStop® as a "stand-alone" procedure (n = 20). In the study of Arthurs & Langley-Hobbs (2006) 37% of dogs weighed under ten kilograms, 25% between 10 and 20 kilograms and 38% over 20 kilograms, with in total a population of 96 dogs with medial patellar luxation. The different weight categories are almost the same as in the study of Bosio et al., 47% of dogs weighed under 9 kilograms, 22 % between 9 and 18 kilograms, and 31% over 18 kilograms. Most of dogs (65% of population) of this study weighed under 10 kilograms, which is a greater amount than in the previous studies. However in these studies, the greatest part of dogs can be found in the smallest weightcategorie (under ten kilograms). When evaluating the age of patients in the study of Bosio et al., there can be concluded that 43% of dogs is less than 12 months old, 30 % between 12 months and 36 months and 27% is over 36 months old. When comparing these numbers with this retrospective study, relative older dogs than in the study of Bosio et al. (2017) were included, with in the same age categories as in that study 11%, 46% and 43%, respectively. Medial patellar luxation occurred in 5% of Cavalier king Charles spaniels (Arthurs and Langley-Hobbs, 2006), which is comparable with 7% in the study of Bosio et al. (2017). The most common breeds according to Bosio et al. (2017) are Cavalier King Charles Spaniels, Chihuahuas, Pinschers, Poodles, English Bulldogs, Yorkshire Terriers, Labrador Retrievers, crossbreeds and German Shepards, which is in majority comparable with most affected breeds included in this study, 11,6% of the population were Cavalier Kings Charles. 25% of patellar luxations were bilateral, in contrast to the 42,8% in the study of Bosio et al. (2017). According to Gibbons et al. (2006), 50% of luxations were bilateral, which is also not comparable with our number (25% bilateral luxations). In most cases, patellar luxations are unilateral, 75% in this study, 57,2% in the study of Bosio et al. (2017) and 50% in the study of Gibbons et al. (2006).

Conservative treatment was set up in 7,2% of cases, but no records were available if these dogs did receive surgical corrective treatment afterwards (Bosio et al., 2017), 30,2% of dogs received conservative treatment before surgery in this study. Corrective surgical techniques for patellar luxation were femoral trochlear sulcoplasty, tibial tuberosity transposition (TTT), capsular/retinacular release, capsular/retinacular imbrication, and anti-rotational suture placement (fabello-patella or

fabello-tibial) (Arthurs and Langley-Hobbs, 2006). Imbrication was performed in 93% of cases with medial patellar luxation (Arthurs and Langley-Hobbs, 2006), which is not corresponding at all with 4,6% in this study.

In 51,2% of patients, an obvious correlation between pain score and lameness score before surgery was found. 16,3% of all patients had a same score on a scale of nine for lameness and pain. In the remaining 34,9 %, the difference in scores for lameness and pain had a maximal difference of one. In 48,8 % of cases there was no correlation found between pain and lameness, which was assumed when there was a greater difference than one in the value of score for pain and lameness. In comparison to the lameness score, which was divided into the same scale, there can be concluded that the pain – and lameness score are almost divided equally. A straight forward correlation between the grade of luxation and the pain and lameness score could not be found, this could be due to the owners subjectivity of pain scoring.

When using traditional surgical techniques for patellar luxation a complication rate of 29% of dogs surgically treated was found: 10% major and 19% minor complications. In the major complications implant failures were included and in the minor complications, surgical site infection, wound dehisention, seroma formation and infection of the wound were reported (Gibbons et al., 2006). In another study the frequency of postoperative complications was 18%, with 13% major and 5% minor complications (Arthurs & Langley-Hobbs, 2006). In 86% of major complication revision surgery due to reluxation was required (Arthurs & Langley-Hobbs, 2006). 86% of the 13% of major complication corresponds to 8% of all cases. According to Bosio et al. (2017), major complications occurred in 16% of cases, of which 35% consisted out of recurrence of luxation. In a study of Cashmore et al. (2014) 18% of dogs developed a major complication after surgery. In the study done in this review, 13% complications occurred in the period after surgery, 11,6% were minor complications, such as seromas and surgical site infections. Major complications occurred in 2,3% of cases (n = 1). Evaluating the dogs that received a RidgeStop®, combined with traditional techniques, 17,4% developed complications, which is lower than in one of the studies described above. Comparing with the study of Arthurs and Langley-Hobbs (2006) and Cashmore et al. (2014), no major complications occurred with use of the RidgeStop® implant when combined with traditional techniques. However, minor complications occurred more often: 17,4%. RidgeStop® combined with other surgical techniques, generates less major complications. Reluxation occurred in only 2,3% of all cases, or in 4,4% of cases with only a RidgeStop® implant, which is half of the reluxations in the study of Arthurs and Langley-Hobbs (2006) using traditional techniques. 82,4% of cases were fully solved with only a RidgeStop® implant (Hargittai et al., 2014). In the other 17,6% of cases, in which complication occurred, it was necessary to remove the RidgeStop® implant, which was only the case in 5% in this study. Comparing the study of Hargittai et al (2014) with the 90% success rate in this study, when only evaluating the single use of the RidgeStop, there can be concluded that the RidgeStop® is an effective implant. In total, the success rate of not having any complication in this study, evaluating all the 43 patients, can be set at 86%.

Patients should receive bench rest for approximately two to four weeks (Ferguson, 1997), however today this is not the case anymore as seen in this study. Short leash exercises are permitted; also hydrotherapy (28% in this study) can be an exercise to strengthen the joint without weight bearing. The patients evaluated in this study, were advised to have strict rest for at least six weeks, after which a post-op control visit was advised, during these six weeks, restricted revalidation is advised. Non-steroidal anti-inflammatory drugs, such as meloxicam deliver effective post-op analgesia (Deneuche et al., 2014; Kazakos et al., 2006; Luna et al., 2006). They are commonly used for pain management after surgical interventions (KuKanich, 2012; Luna et al., 2006). Non-steroidal anti-inflammatory drugs inhibit COX-2 (cyclo-oxygenase 2 enzyme), which produces prostaglandins from

arachidonic acid. Prostaglandins cause vasodilation and sensitization of sensory receptors, which explains the anti-inflammatory and analgesic effects of non-steroidal anti-inflammatory drugs (Kukanich et al., 2012; Lascelles et al., 2015). The side effect of non-steroidal anti-inflammatory drugs are gastrointestinal problems, such as vomiting, diarrhea and ulcers due to inhibition of the COX-1 enzyme and consequently, physiologically important prostaglandins that protect the gastro-intestinal tract and renal function (PGI2). Tramadol is an opioid that works on the μ-receptors and inhibits re-uptake of noradrenaline and serotonin inhibitors (Kukanich et al., 2004). When only using tramadol, pain scores after surgical intervention are higher than when using non-steroidal anti-inflammatory drugs. Combination of both gives no significant differences in comparison with only non-steroidal anti-inflammatory drugs. (Davila et al., 2013). However, tramadol is a worthy alternative when a history of side effects of the non-steroidal anti -inflammatory drugs is known; tramadol was used once in a patient with the clinical signs of side effects of Non-steroidal anti-inflammatory drugs. A many dietary supplements are available on the market to support the joint function when an orthopedic problem is present. The continuation of the administration of the dietary supplement Kynosil® (Bioradix, Belgium) was advised. Kynosil® is a supporting supplement for the joints and mobility of dogs and is consisting out of methylsulfonylmethane (MSM), glucosamine and organic silicium[2]. Flexadin advanced is a dietary supplement consisting of omega -3 fatty acids, vitamin E and Boswellia. Glucosamine and chondroitin are essential parts of cartilage[3]. Vitamin E and Omega-3 fatty acids have an anti-inflammatory working mechanism (Johnston et al., 2008).

2.5 Conclusion

The RidgeStop®, a high molecular weight polyethylene implant, acts as trochlear ridge prosthesis. Despite the technical challenges, there are many beneficials as a "stand-alone" procedure, such as less invasivity and shorter surgical time. When applied with other conventional surgical techniques for reduction of patellar luxation, the complication rate can be reduced. In this study, a succes rate of 97,7% in reducing the patellar luxation shortly after the surgery is achieved. After revision surgery of one of the patients due to reluxation a 100% succes rate was reached. In terms of clinical signs it was possible to obtain a succes rate of 88,4% after six months. In 13% of cases complications occurred in the period shortly after surgical intervention. Overal, this is a better result compared to conventional surgical technique. However, more studies are required to give a conclusive result about the short- and long term results of the RidgeStop® Implant.

Even though there are some conclusive results about the success rate in this review, more investigation is needed to gain more information about the long-term results of the implant. Only 20 patients were surgically treated with the RidgeStop® implant alone, and except for the study of Hargittai et al, no other studies are available to compare the results with.

[2] http://www.bpluspharma.be/nl/b2c/brand/kynosil (last consulted on 24th of April 2019 at 20h50)
[3] https://www.vetoquinol.be/nl/producten/diersoort (last visited on 24th of April 2019 at 21h05)

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