SIMPLE SUTURE AND ANCHOR IN RABBIT HIPS

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ABSTRACT

Objective: Using biomechanical studies, this research aims to compare hip capsulorrhaphy in rabbits, carried out with two different techniques: capsulorrhaphy with simple sutures and with anchors. Method: Thirteen New Zealand Albino (Oryctolaguscuniculus) male rabbits, twenty-six hip joints, were used. First, a pilot project was performed with three rabbits (six hip joints). This experiment consisted of ten rabbits divided into two groups: group 1 underwent capsulorrhaphy on both right and left hips with simple suture using polyglycolic acid absorbable thread, and group 2 underwent capsulorrhaphy with titanium anchors. After a four-week postoperative period, the animals were euthanized and the hip joints were frozen. On the same day of the biomechanical studies, after the hip joints were previously unfrozen, the following parameters were evaluated: rigidity, maximum force, maximum deformity and energy. Results: There was no relevant statistical difference in rigidity, maximum force, maximum deformity and energy between the simple suture and anchor groups. Conclusion: Through biomechanical analyses, using parameters of rigidity, maximum force, maximum deformity and energy, it has been shown that capsulorrhaphy with simple suture and with anchors has similar results in rabbit hip joints. ***Level of Evidence II, Prospective Comparative Study.***

Keywords: Experimental animal models. Hip/surgery. Suture Anchor. Biomechanics. New Zealand rabbits.

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INTRODUCTION

Developmental dysplasia of the hip (DDH) is a complex disease that affects the hips of children and can lead to severe sequelae when it is not correctly diagnosed and treated. The complexity of the three-dimensional anatomy of the hip and the alterations present in DDH make treatment difficult, especially when open reduction is necessary.[1]

The surgical treatment of DDH in children "after walking age" is uncommon at the more developed centers; however, in developing countries this situation continues to occur.[1]

The goals with surgical treatment in children "after walking age" are similar to those of treatments in newborn patients. Thus we wish to obtain a well reduced and stable coxofemoral joint, to correct acetabular dysplasia and to avoid possible complications, including redislocations.[2-5]

Hip redislocation after open reduction has several etiologies. The possibilities include failure to obtain concentric reduction, technical failure in correcting the obstacles that prevent reduction, insufficient acetabular coverage, poor positioning of the proximal femur and capsular laxity.[6-8]

In the research concerning the different forms of surgical treatment of DDH, we found several studies on bone interventions. As regards capsulorrhaphy, we observed that this topic is not yet widely discussed among researchers.

In the open reduction technique, capsulorrhaphy of the hip is an important factor for maintenance of stability and of concentric reduction. In the attempt to refine this technique and to avoid the consequent laxity of the capsule, we considered using surgical anchors positioned on the acetabular margin. The use of anchors could facilitate the capsulorrhaphy and induce better results in the treatment.[9-11]

MATERIAL AND METHOD

This study was conducted after approval by the Institutional Review Bureau and fulfilled the criteria of the Law of Procedures for the Scientific Use of Animals, no. 11,794 of October 8, 2008. Thirteen male New Zealand (*Oryctolagus cuniculus*) albino rabbits weighing from 1.8 to 2.8 kilograms (Kg) and aged approximately two months were used. All the animals were kept and accommodated in metal cages designed for rabbits. They were operated at the surgical center for experimental surgery by the same surgeon.

All the authors declare that there is no potential conflict of interest referring to this article.

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The studied animals were arranged in two groups: Group 1(G1) - Suture and Group 2(G2)- Anchor.
The pilot group consisted of six hips (three rabbits).
The suture group (G1) was made up of five rabbits (10 hips), all submitted to capsulorrhaphy using simple suture with (Vycril®) 2-0 absorbable thread made of polyglycolic acid.
The anchor group (G2) was made up of five rabbits (10 hips), all submitted to capsulorrhaphy using IKARIOS®-Ortocir titanium anchors, measuring 2mm in diameter.

Surgical Procedure

As regards preoperative precautions, all the animals were operated by a single surgeon, kept fasting for six hours and made use of antimicrobial prophylaxis with intramuscular administration of enrofloxacin 15mg/kg, 30min before the incision in the skin and maintained for three days after the surgery, administered via intramuscular route with enrofloxacin in the daily dose of 5mg/kg.[12]
All the rabbits were submitted to anesthesia according to the pre-established protocol.[13] Each animal received 0.2 mg/kg of weight of atropine sulfate, 0.2 mg/kg of weight of benzodiazepine and 3.0 mg/kg ketamine via intramuscular route. The anesthetic procedure was supplemented by local injection of 2.0% lidocaine without vasoconstrictor, applied at the incision site and, when necessary, internally in the surgical wound, in the muscular planes.

Surgical Technique

After the preoperative precautions, the animals were placed on the operating table specifically designed for small animals in pronation, trichotomized and submitted to antisepsis, followed by the positioning of the sterile drapes.
The surgical procedures were carried out through a single anterolateral approach in the skin measuring 6-8cm. The surgeon performed the opening of the retinaculum and of the superficial aponeurosis of the anterolateral musculature of the hips. After identifying the hip joint, the surgeon went on to perform the opening of the musculature with its aponeurosis and the articular capsule from 2 to 4cm (varying according to hip size), thus exposing the femoral head and acetabulum.
A degree of capsular fragility was observed in the pilot group surgeries, which would prevent the capsule from being sutured. This was resolved by modifying the capsular reinforcement with the use of the aponeurosis juxtaposed to this capsule. This favored its reinforcement and decreased the fragility of the articular capsule of the rabbit hip.
In the suture group the capsulorrhaphy was performed after identification of the femoral head and of the acetabular region. The suturing was performed using the block suture whipstitch technique (involving the articular capsule and the aponeurosis), with absorbable polyglycolic acid thread (Vycril® 2-0).
In the anchor group the capsulorrhaphy was also performed with identification of the femoral head and of the acetabular region. Only one titanium anchor (IKARIOS®-Ortocir) was inserted in the upper cortex of the acetabular margin. (Figure 1) The capsular suturing was then performed using the whipstitch technique, using braided polyester silicone suture thread with the diameter of 2-0 contained in the anchor.
We illustrated the opening of the articular capsule in letter A. In letter B, we illustrated the insertion of the anchor in the acetabular margin, and in letter C, the articular capsulorrhaphy of the hip with the use of the thread contained in the anchor. (Figure 2) In the two groups, the suturing was performed on a single plane, using the musculature and the aponeurosis as a block juxtaposed to the hip joint, together with the articular capsule. The skin was closed with 3-0 mononylon suture thread, covering the surgical wound with a sterile gauze dressing. The pelvic limbs were not immobilized.

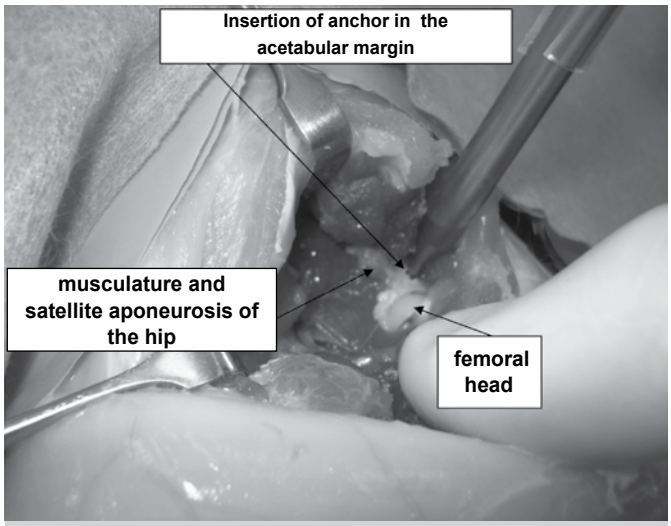

Figure 1. *Capsulorrhaphy with IKARIOS®-Ortocir titanium anchor in a diameter of 2mm.*

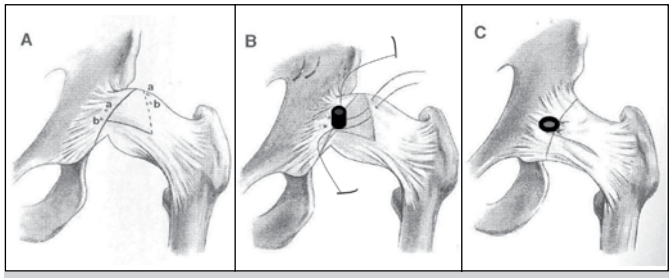

Figure 2. *(A) opening of the articular capsule in the letter; (B) insertion of the anchor in the acetabular rim; (C) articular capsulorrhaphy of the hip using the thread contained in the anchor.*

All the rabbits from Groups 1 and 2 were maintained at rest, under the conditions previously reported in this study, over a thirty-day period. They were confined in suitable accommodations for the breed in the vivarium.
Euthanasia occurred after the tissue healing period of approximately 30 days, involving all the rabbits (G1 and G2). This process was performed using an intravenous injection of thionembutal (100mg/kg of body mass) in association with the intracardiac injection of 5ml of 10% potassium chloride.

Biomechanical Analysis

For the performance of the biomechanical analysis the operated hemipelves and femurs were removed in a single block, identified and submitted to freezing until the day of the analysis. The remains of the animals were disposed of in the central laboratory incinerator. The pieces were submitted to ascending

mechanical tensions in the KRATOS model 5002 universal testing machine, with load cell of 100Kgf, adjusted on the scale of 20kgf and with test speed of 20mm/min. For the biomechanical test the pieces were arranged as follows: the hemipelvis was placed in the upper mobile part of the testing machine, inserted between the two wide holes so that the iliac crest, ischium and pubis would rest on each hole of the plate. This mobile part was attached to the dynamometer of the machine using a universal joint. With the ascension of this mobile part, the hemipelvis moved away from the femoral head and consequently, the capsule and round ligament underwent traction. To fix the femur to the base of the machine, we used a tubular clamp that allowed the diaphyseal region to be fixed using four radial screws tightened with a Metalac® model MTE-100 digital torque meter, up to 3N/m. To make sure that the femur would not flex and would maintain its alignment during the test, the adjustment was made visually, using a point on the base of the machine that corresponds to the vertical trajectory imposed by its ascending movement as a reference. A second ring-shaped bracket was used for the positioning of the greater trochanter. (Figure 3)

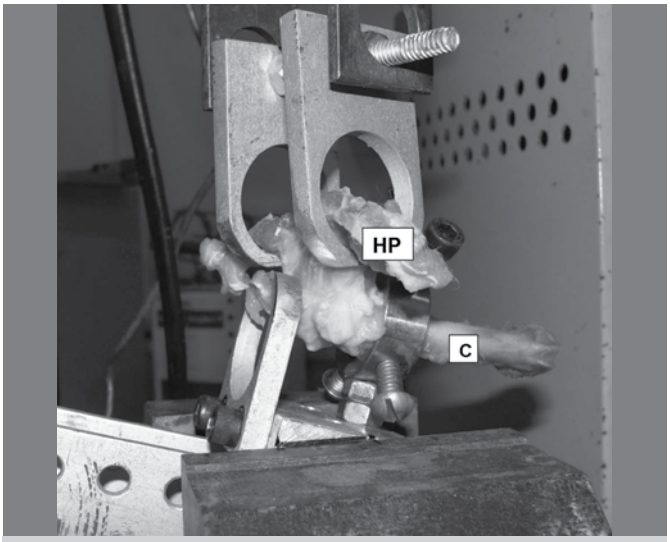

Figure 3. *Piece for biomechanical analysis was composed of the "hemi pelvis and the entire rabbit hip assembly" (HP–hemi pelvis, C- thighbone).*

RESULTS

The (scalar) variables were described with mean, standard deviation, standard error of the mean, median, coefficient of variation, minimum and maximum value. The Mann-Whitney test (significance level of 0.05) was used to compare dependent groups (hip with suture *versus* hip with anchor), since the sample data did not have a normal distribution, a condition that was tested conducting the Kolmogorov-Smirnov test (significance level of 0.05).

Two animals (pilots) died on the second postoperative day. There was no change with the animals from the two study groups.

The values referring to the descriptive statistic of rigidity (Rig) and maximum force (F_{max}), in the suture and anchor groups, are listed respectively in Tables 1 and 2, and represented by Figures 4 and 5. The statistical analysis of the mean energy peak and of maximum deformation (D_{max}), in the anchor and suture group, is listed respectively in Tables 3 and 4 and in Figures 6 and 7.

Table 1. *Comparisons of the variables of rigidity (Rig) between the syntheses performed in the anchor and suture groups.*

	Suture	Anchor	p
Mean sd	61.62 21.44	49.79 32.83	0.355
Median	69.17	48.05	
Minimum Value	27.38	97.76	
Maximum Value	84.27	13.26	

Rig = Rigidity measured in N/mm. Mann-Whitney test

Table 2. *Comparisons of the variables of maximum force (F_{max}) between the syntheses performed in the anchor and suture groups.*

	Suture	Anchor	p
Mean sd	167.56 52.14	160.55 76.49	0.643
Median	181.41	166.15	
Minimum Value	79.89	75.57	
Maximum Value	225.73	285.32	

F_{max} is the mean force at the peak of the graph. Its values are measured in N. Mann-Whitney test.

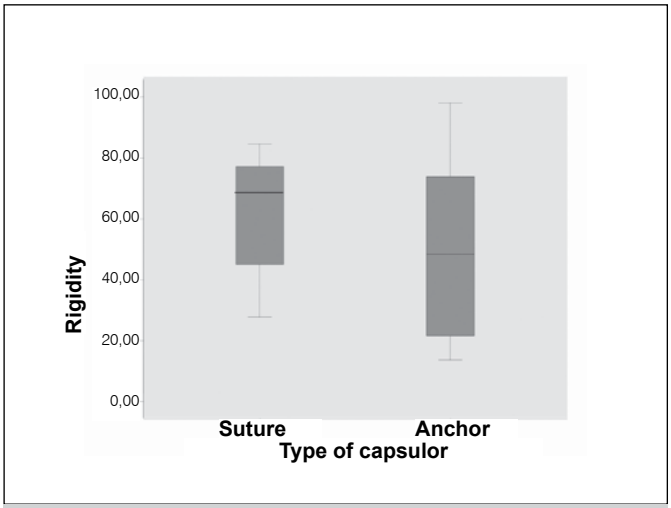

Figure 4. *Description of the mean, median, minimum value, maximum value. for rigidity (Rig) of the suture and of the anchor – N=Newtons.*

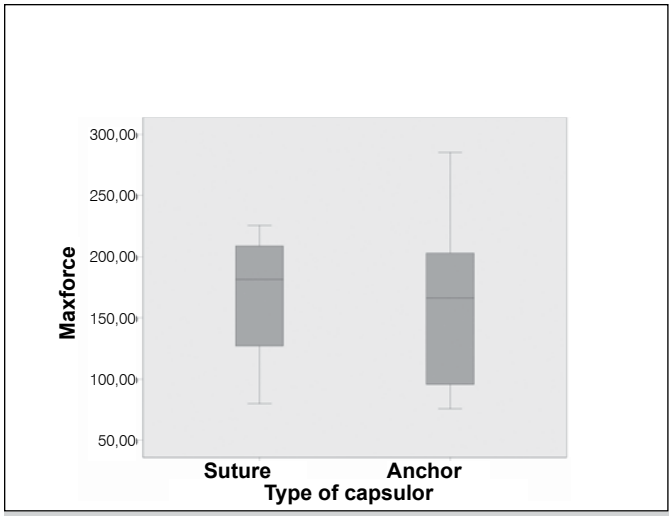

Figure 5. *Description of the mean, median, minimum value, maximum value for maximum force of the suture and of the anchor – N=Newtons*

Table 3. *Comparisons of the variables of energy (E) between the syntheses performed in the anchor and suture groups.*

	Suture	Anchor	p
Mean sd	383.07 185.84	437.21 179.33	0.298
Median	389.64	477.60	
Minimum Value	153.24	165.43	
Maximum Value	761.73	645.32	

Energy, or work, is measured up to the peak of the graph. it is measured in mJ. Mann-Whitney test.

Table 4. *Comparisons of the variables of maximum deformation (D_{max}) between the syntheses performed in the anchor and suture groups.*

	Suture	Anchor	p
Mean sd	7.10 2.16	8.01 2.33	0.298
Median	6.89	7.26	
Minimum Value	4.89	5.29	
Maximum Value	11.86	12.66	

D_{max}= Deformation suffered up to the peak of the graph, measured in mm. Mann-Whitney test.

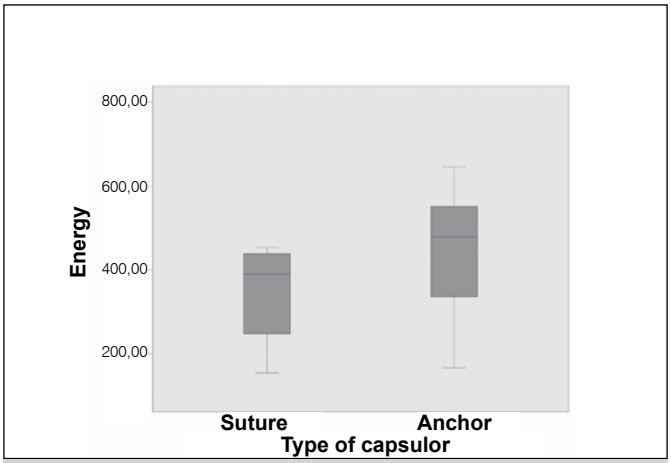

Figure 6. *Description of the mean, median, minimum value, maximum value for energy measured up to the peak of the graph (E) of the suture and of the anchor – mJ= millijoules.*

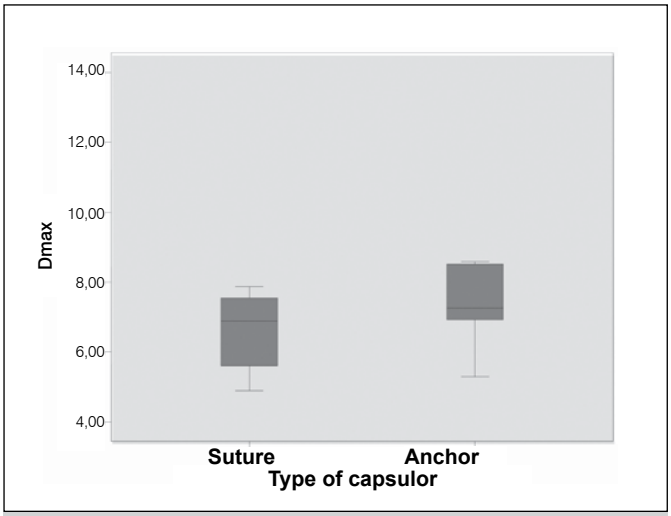

Figure 7. *Description of the mean, median, minimum value, maximum value for maximum deformation suffered up to the peak of the graph (D_{max}) of the suture and of the anchor.*

DISCUSSION

Developmental Dysplasia of the Hip (DDH) is a term that expresses the pathological spectrum of alterations of newborn hips, which ranges from acetabular dysplasia to irreducible dislocation of the coxofemoral joint.[14]

When the hip disorder is diagnosed in the first six months of the child's life, treatment with a Pavlik harness frequently brings about a good result.[15,16] In children over six months of age, the obtainment of a concentrically reduced and stable joint poses a challenge to the pediatric orthopedist. In the age bracket from six months to four years of age, ortheses, traction, closed reduction, open reduction and both femoral and pelvic osteotomies can be used.[8]

Pelvic osteotomies in association with capsulorrhaphy continues to be the treatment of choice for patients over 18 months of age.[17]

A relatively frequent complication in the treatment of DDH is the recurrence of dislocation, with loss of the reduction obtained previously.[18]

The stability of the open reduction depends on several factors, including mechanical resistance of the articular capsule.

A properly executed capsulorrhaphy is one of the important stages in the open reduction of DDH. Providing it is well done, it is one of the joint stability factors.[9,17,19]

With the intention of improving the performance of the capsulorrhaphy, we thought about using surgical anchors, both to facilitate, and to reinforce the suturing of the articular capsule.

For this purpose, we came up with an experimental model in rabbits to analyze hip capsulorrhaphy with and without anchors.

The search for the minimally invasive technique for surgical correction of DDH is still a challenge to orthopedic surgeons and researchers. The ideal reduction would produce considerable resistance through surgical techniques that would respect the local biological factors such as cartilaginous injuries and capsular blood supply. The appearance of new materials, such as specific instruments for arthroscopy and the anchors enabled the use of less aggressive techniques for this repair. Thus, based on the results of the present study, we verified that the use of the anchor proved of equal magnitude when compared with the traditional suture technique, becoming a positive treatment for the correction of DDH.

The choice of the non-immobilization of the operated limbs was due to studies that produced, experimentally, a hip subluxation and acetabular dysplasia, through immobilization in the knees of young rabbits, in the extension position. This would compromise the efficacy of the present study.[20]

There is a shortage of articles in literature about this topic. With reports referring to the importance of acetabular development, of the ideal maturity for acetabular procedures and of the post-osteotomy integration of the articular capsule of the hip, the search for minimally invasive capsulorrhaphy methods that lead to a smaller lesion in this joint, which is a region susceptible to various alterations in its development, is of crucial importance.

We chose rabbits of the *Oryctolagus cuniculus* breed as they are easily obtainable, of a suitable size for maintenance in the vivarium and as we are familiar with their use.[13] In the literature, there are several studies that also used the rabbit.[21-27]

Greater ease was observed in the capsulorrhaphy using the anchor, than in the capsulorrhaphy using the suture. We recorded death with the loss of two animals (8.7%). We found studies with rabbits in the literature that also presented loss of 5.4%, 22% and 16% of the animals.[2,22,26]

Thirty days after surgery, we started the biomechanical tests. We did not find any definition in the literature of the ideal maximum or minimum time for the performance of the biomechanical tests.[27]

A problem faced in the pilot trials was capsular fragility at the time of the capsulorrhaphies. This impasse was remedied when we used aponeurosis of the extensor muscles adjacent to the hip joint, producing greater resistance to the capsulorrhaphies. There are no reports in literature of similar procedures with experimental studies on rabbits or on other animals.

We observed that there was no significant statistical difference when we compared the groups of rabbits submitted to capsulorrhaphies with anchors and those with simple suture. For this conclusion, we used the Mann-Whitney test in the composition of the graphs and of the tables that represent rigidity, maximum force, energy and maximum deformation between the syntheses with suture and anchor.

When evaluating rigidity (Rig) in Figure 3, equivalence between suture and anchor was verified in the description of the mean, with greater variation of the suture in the minimum value.

When we made the comparison of maximum force (Fmax) in Figure 4, even though the anchor presented a higher maximum value than the suture, we did not obtain significant difference with regards the calculation of the mean.

When analyzing energy (E) or work measured up to the peak of the graph, we once again failed to observe any material differences in the calculation of the mean, although the maximum value of the suture was slightly higher than that of the anchor. (Figure 5)

Finally, when analyzing maximum deformation (Dmax) between the capsulorrhaphies performed with anchor and suture in Figure 6, an almost imperceptible difference was observed in the mean, and in the minimum and maximum values. Experimental studies cannot have direct conclusions on the decisions in the choice of techniques applied to humans. Nonetheless, in our study we obtained clearly similar results between the traditional suture technique and the anchor in the biomechanical trials. This shows that the use of anchors constitutes a new, viable and safe treatment method in DDH cases, with the advantage of usability in arthroscopy.

Some authors demonstrated that the ideal biomechanical tests should be carried out with dynamic trials with cyclic load, attempting to simulate the physiological loads.[28] Most authors demonstrate in their biomechanical studies that they conduct their trials with slow and progressive loads that are almost static, in a continuous manner as chosen by us.[23-25,29,30]

The performance of biomechanical tests is an important tool in research into the quality of capsular sutures. Although their application does not have an exact reproduction in humans, they serve as a parameter for clinical trials. The major issue of capsular repair is managing to achieve a suturing technique that is as resistant as possible without prejudice to the local biology.

CONCLUSION

By means of biomechanical tests, having rigidity (Rig), maximum force (F_{max}), maximum deformity (D_{max}) and energy (E) as a parameter, it was demonstrated that capsulorrhaphies on rabbit hips with simple suture and with anchor are similar to each other.

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