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Use of Tourniquets in Total Knee Arthroplasty: A Systematic Review with Meta-Analysis.

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Abstract:

Objective: To compare the efficacy, safety, advantages and complications of the silicone ring tourniquet compared to the pneumatic cuff tourniquet in total knee arthroplasty. **Methodology:** systematic review with meta-analysis, in which a bibliographic search was carried out through the electronic databases:

PubMed/MEDLINE and Cochrane Library without language restriction of publications until October 26, 2023. The search terms "tourniquet" AND "pneumatic cuff" AND "knee arthroplasty" AND "orthopaedic surgeries" were used. **Results:** 292 patients aged between 67 and 74 years were included. Most of the studies presented showed that patients undergoing ischemia with the SRT had less post-operative blood loss, earlier discharge and lower complication rates than other patients. **Conclusion:** The use of the silicone ring tourniquet resulted in better clinical outcomes than conventional pneumatic tourniquets in TKA.

Keywords: tourniquet; pneumatic cuff; knee arthroplasty

INTRODUCTION: The tourniquet acts as an occlusive device with the aim of reducing blood flow. That said, this tool is used effectively in many orthopedic surgeries, so that the surgeon can obtain a better view of the surgical field. In total knee arthroplasty, this instrument is commonly used and is manipulated by the vast majority of orthopaedic surgeons [1, 3, 4].

Over the years, many types of tourniquet have been produced and used according to surgeons' preferences. Currently, the pneumatic tourniquet has been widely used in orthopaedic surgery due to its many advantages: reducing total blood loss during surgery, facilitating cementation and reducing operating time, especially in total knee arthroplasty. However, some studies have reported various complications associated with the use of a tourniquet in total knee arthroplasty , including skin blisters, wound hematoma, muscle damage, rhabdomyolysis, nerve paralysis and deep vein thrombosis (DVT) [2, 3, 4].

Because of this, the use of the silicone ring tourniquet has been introduced into clinical practice as an option to the standard pneumatic tourniquet. This instrument consists of a silicone ring wrapped in an elastic sleeve and two straps attached to handles, and is designed to exsanguinate and occlude blood flow to the limb. The whole device is sterile and comes in various models and sizes, with the appropriate model being chosen for each patient according to the patient's systolic blood pressure. It is believed that this tourniquet will decrease blood loss and reduce soft tissue damage due to a smaller compression area. [5]

Therefore, choosing an appropriate cuff material and adjusting the tourniquet pressure are necessary to reduce postoperative complications and increase the effectiveness of the tourniquet system.[3]The aim of this study was therefore to compare the effectiveness, safety, advantages and complications of the silicone ring tourniquet compared to the pneumatic cuff tourniquet in total knee arthroplasty.

METHODOLOGY

This study is a systematic review with meta-analysis, registered in PRÓSPERO under ID CRD42024572121, in which a bibliographic search was carried out using the electronic databases: PubMed/MEDLINE and Cochrane Library without language restriction of publications until October 26, 2023, using a search strategy combining keywords and MeSH terms and the Boolean operator AND/OR. The search terms "tourniquet" AND "pneumatic cuff" AND "knee arthroplasty" AND "orthopedic surgeries" were used .

As this was a meta-analysis of published works, there was no need for approval by the ethics committee or institutional scientific review board. The reference lists of the included and previously published articles were searched for more relevant studies that met the eligibility criteria.

This systematic review and meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.[6]

Eligibility criteria

Eligibility criteria were determined according to the PICOS principle (Population, Intervention, Comparator, Outcomes).

1) Population: Patients undergoing total knee arthroplasty

2) Intervention: use of a tourniquet in total knee arthroplasty

3) Comparator: use of silicone ring tourniquet versus pneumatic cuff tourniquet in total knee arthroplasty.

4) Outcome: silicone ring tourniquet showed better clinical results

Inclusion and exclusion criteria

1) studies evaluating approaches to total knee arthroplasty. (2) studies comparing the use of the silicone ring tourniquet and the pneumatic cuff tourniquet. (3) population over 18 years of age. (4) randomized clinical trials and retrospective studies.

Studies with the following criteria were excluded: (1) experimental studies with animal models (2) non-original studies - literature review (3) opinion studies (4) studies that evaluated other forms of approach in total knee arthroplasty (5) studies that analyzed the use of tourniquets other than the silicone ring and the pneumatic cuff tourniquet. 5) studies published more than 15 years ago (6) studies that did not meet the other inclusion criteria mentioned above.

In order to prioritize methodological quality, studies classified as "Good" after the NIH quality assessment were included, with studies with more than nine items ticked being considered suitable for inclusion.

RESULT

Initially, 15 articles were selected; after excluding those with more than 15 years of publication, 10 remained. The title and abstract were analyzed according to the proposal of the work, so four articles were excluded, leaving only six for full reading. At the end of the process, four studies were selected for analysis and construction of the work (Figure 1).

The four articles analyzed corresponded to patients who had undergone knee arthroplasty. Two articles corresponded to unilateral cemented knee arthroplasty and two to bilateral simultaneous knee arthroplasty. All the studies used either a conventional pneumatic tourniquet or a silicone ring. The comparisons associated with each choice of tourniquet and the post-operative results were analyzed, especially with regard to complications and length of use after arthroplasty. The study included 292 patients aged between 67 and 74 years.

Table 1 shows the outcomes of the selected studies[5], [7], [8], [9].

Table 2 shows the average tourniquet time presented by the studies[7], [8], [9].

Figure 2 shows the forest graph analyzing the average garrotting time[7], [8], [9].

In the randomized study by Jenny et al, 72 patients were operated on, 39 using the PCT (pneumatic cuff tourniquet) and 33 the SRT (silicone ring tourniquet). All received a cemented knee prosthesis, intraoperative homeostasis was with electrocautery and left no drainage, neither in the soft tissues nor in the joint. The PCT tourniquet was applied before the surgical drapes were placed, inflated immediately before the skin incision and deflated after the dressing was applied. The SRT, on the other hand, was applied by the surgeon after the drapes were placed, instantly after the skin incision and the ring was sectioned posterior to the dressing. All patients followed the same pre-, intra- and post-operative drug regimen. And the same early rehabilitation, with immediate loading and unrestricted knee range of motion. At the end of the 3-month period, there was no major difference between the two groups in terms of preoperative items. The mean preoperative hemoglobin level was 13.5g/dL (±1.5) in the PCT and 13.7g/dL (±1.2) in the SRT. Calculated blood loss (CBL) was 989 mL (±505) in the PCT group and 901 mL (±488) in the SRT group. The average duration of tourniquet inflation was 95 minutes (±18) in the PCT group and 86 minutes (±18) in the SRT group (p=0.04). The average pain assessment on the third day after surgery was 2.9 (±1.7) in the PCT group and 3.2 (±1.3) in the SRT group. The average drop in hemoglobin was 2 g/dL (±1.0) in the PCT group and 1.8 g/dL (±0.8) in the SRT group. It was observed that the SRT group was discharged

more quickly (3.8 ± 1.9 days) than the other group (5.4 ± 2.8 days) (p=0.05). Furthermore, it was found that the PCT group had higher complication rates (04 cases of skin dehiscence; 03 cases of delayed rehabilitation with prolonged hospitalization, 01 case of post-fall fracture and 01 case of DVT) compared to the SRT group (01 case

of skin dehiscence) (p=0.02).

In the prospective study by León Muñoz[5], 140 patients underwent total knee arthroplasty and all cemented, 70 patients used PCT and the other half SRT. The PCT was placed before the fields were put in place, inflated before the skin incision and deflated after the full dressing was applied. The SRT, on the other hand, was applied by the surgical team after placing the drapes, immediately before the skin incision and the ring was sectioned after the dressing was applied. All followed the same medication regimen pre-, intra- and post-operatively. The average tourniquet time in the PCT group was 98.16 ± 16.5 min, while in the SRT group it was 102.5 ± 17.3 min (p=0.13). Surgical time was 79.96 ± 12.2 min in the PCT group and 77.12 ± 10.6 min in the SRT group. Regarding post-operative serum lactate levels, which were lower in the SRT group (3.499 ± 1.566 mmol/L) than in the PCT group (4.097 ± 2.248 mmol/L; p=0.07), there were no major differences to state that there was a discrepancy in anaerobic metabolism according to the tourniquet system used.

In the prospective randomized study by Bhalchandra Londhe et al[8], 50 patients underwent simultaneous bilateral knee arthroplasty, the choice of which tourniquet to use on each leg was by means of computer-generated random numbers. The average operative time in the PCT group was 81.5 ± 14.5 min and in the SRT group 84.2 ± 13.6 min (p value = 0.392). As for post-operative blood loss, there was a greater loss in the PCT group, with 186.6 ± 26.5 ml and in the SRT group 180.4 ± 28.2 ml (p=0.3444). In the PCT group, pain at the tourniquet site, assessed by the VAS score at 24 hours, was 5.6 ± 2.1 and in the SRT 4.3 ± 1.5 (p=0.0152); the 48-hour assessment was 3.3 ± 1.2 and 2.1 ± 1.5, respectively (p=0.003). In this study, there were no records of any local skin complications with the use of SRT (0%), however, in the PCT group, 08 patients had local hematoma and 02 blisters with superficial skin necrosis. The local skin complication rate with the conventional pneumatic tourniquet group was 20% (p=0.0196).

In the study by Lee et al, 30 patients underwent bilateral knee arthroplasty. The ratio between the exposed surgical field and the total length of the thigh was, on average, 49.2 ± 6.1% in the SRT and 36.9 ± 5.6% in the PCT (p<0.001), a big difference. The operative time was 51.10 ± 5.58 min in the PCT and 52.60 ± 8.20 min in the SRT (p=0.230), with no major differences. Tourniquet time was 54.07 ± 3.96 min in the PCT group and 55.33 ± 6.15 min in the SRT group (p=0.325).

The PCT group had a total amount of bleeding of 44.10 ± 18.16 ml and the SRT 47.3 ± 15 ml(p-0.242).The total amount of drainage was 436.59 ± 191.83 ml in the PCT and 476.61 ± 203.55 in the SRT(p=0.242). The VAS score at 06 hours was 0.97 ± 1.03 in the PCT group and 0.87 ± 0.82 in the SRT group (p=0.326). At 24 hours, 0.90 ± 1.03 and 0.77 ± 0.82, respectively (p=0.211). At 48 hours, 0.30 ± 0.60 in the PCT and 0.27 ± 0.58 in the SRT (p=0.622). Regarding the patient's report of which leg was more painful , 04 patients felt more pain in the extremity used PCT, 03 felt more pain with SRT and 23 felt the same. As for complications, 03 patients in the PCT group had blisters or local skin complications and 01 in the SRT group (p=0.301). There was also 01 case of nerve complication with the use of PCT (p=0.313). However, there were no reports of venous complications or post-operative infections.

DISCUSSION

Most of the studies presented showed that patients undergoing ischemia with SRT had less post-operative blood loss, earlier discharge and lower complication rates than other patients. Even though the tourniquet time in the TCP group was shorter, the pain assessment, according to the VAS score at 24 and 48 hours, showed that the silicone ring tourniquet generates less pain than the other, favoring a faster recovery[5] (,) [7] (,) [8] (,) [9.]

The use of a tourniquet remains controversial during total knee arthroplasty (TKA)[4] , [10],[11]. The advantages of its use are a bloodless operating field, less intraoperative blood loss and better cement penetration[12],[13],[14]. However, the disadvantages can be a greater occurrence of venous thrombosis, post-operative blood loss, skin or neuromuscular lesions and a delay in rehabilitation[4] , [11] , [15], [16], [17]. To reduce tourniquet complications, the inflation time should be less than 100 minutes[15] , [18].

PCT has been used in TKA for almost a century, with the

aim of creating a relatively blood-free operating field, achieving better visualization of structures and reducing intraoperative blood loss[19]. In addition, it is economical, reusable and can be deflated and re-inflated at any time during the surgical procedure, but it is not without disadvantages and complications related to its use[10].

Its disadvantages are that it is not sterile, it needs to be calibrated frequently to ensure its accuracy, it needs an additional cover during the procedure and consequently tends to produce non-uniform pressure in the area of application[8], in addition to the risk of edema and pain in the limb, nerve paralysis, necrosis of the subcutaneous fat of the thigh, vascular lesions, early infection and rhabdomyolysis[13], [19], [20], which the long period of hypoxia, constriction of the thigh and reperfusion injury explain[21], [22].

The silicone ring tourniquet (SRT) has been introduced into clinical practice over the last decade and comparative studies have been published studies have been published on its efficacy and segurança[23], [24], [25], [26], [27], [28], [29], [30], [31]. It is a narrow silicone ring applied at a predetermined pressure, with the tourniquet model selected according to the patient's blood pressure[31].

SRT is effective in orthopaedic surgical procedures, and is also widely used in other fields of surgery due to its advantages[30], [32]. Its advantages include precise and uniform tourniquet pressure at the site of application, which consequently generates less pain for patients and local skin problems[8], [33]. In addition, the SRT allows for a longer surgical field compared to the PCT, which is important in cases of revision or complex TKA with rigidity or distal femur fracture surgery[9].

CONCLUSION

The use of the silicone ring tourniquet resulted in better clinical results than conventional pneumatic tourniquets in TKA, especially as it generates minimal or no local complications, with less local pain, exact pressure on the tourniquet site and a wider operative field.

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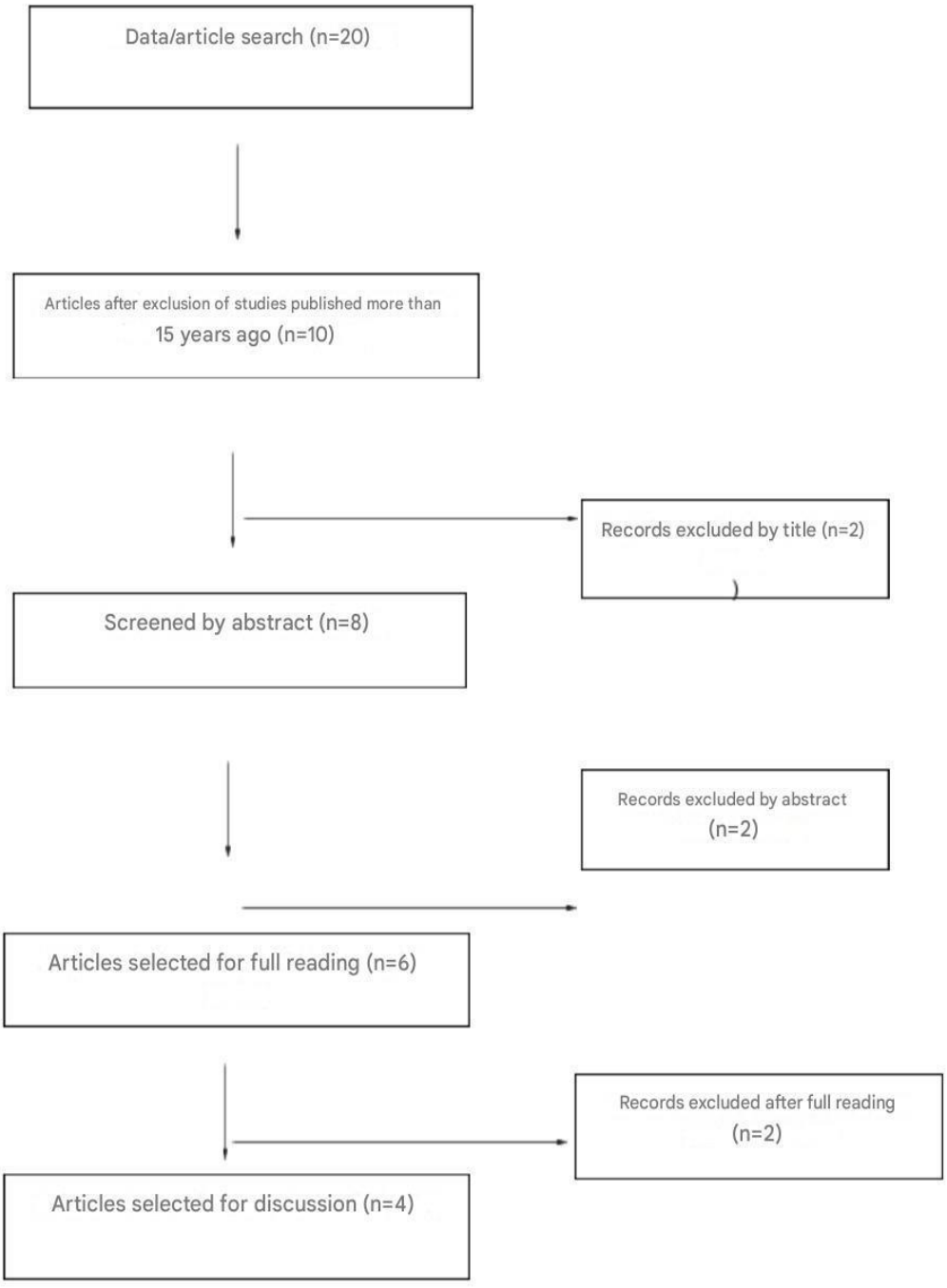
Figure 1 - Studies selected according to the PRISMA methodology.



source: own work (2024)

Table 1 - Completed the selected studies.

Study	Patient is F/M	Average age (years)	BMI (kg/m2)	Primary and secondary outcomes
Jenny et al.	48/24	67 ± 10	32.9 ± 8.9	Average hemoglobin level; estimated blood loss; average duration of insufflation; average assessment of sleep on the third day; average hemoglobin remaining; complications.
León Muñoz et al	110/30	74 ± 6	32.1 ± 4.2	Average cramping time; surgical time; serum lactate levels.
Lee et al	27/03	69.2 ± 4.9	27.7 ± 3.8	Ratio of exposed surgical field to total hip compression; operative time; tourniquet time; total amount of bleeding; total amount of drainage; VAS score; complications.
Bhalchandra Londhe et al	50/0	68.5 ± 7.8	29.6 ± 6.8	Average operative time; postoperative blood loss; VAS score; complications

Table 2 - Average garroting time presented by studies (minutes).

Study	Shows	Conventional pneumatic cuff tourniquet (PCT)	Silicone ring tourniquet (SRT)
Jenny et al	72 patients	95 ± 18	86 ± 18
León Muñoz et al	140 patients	98.16 ± 16.5	102.5 ± 17.3
Lee et al	30 patients	54.07 ± 3.96	55.33 ± 6.15

Figure 2 - Forest plot of the analysis of the average time of cudgeling.