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USE OF STEM WITH METAPHYSEAL SLEEVES IN REVISION TOTAL KNEE ARTHROPLASTY: IS IT WORTH THE HASSLE? A SYSTEMATIC REVIEW

S. PETRILLO[1], L. SACCONE[2,3], C. CARIA[2], F. FRANCESCHI[3,4], S. ROMAGNOLI[1]

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[1]Department of Joint Replacement, IRCCS Galeazzi Sant'Ambrogio, Milan, Italy
[2]Department of Orthopedic and Trauma Surgery, Campus Bio-Medico University of Rome, Rome, Italy
[3]Department of Orthopedic and Trauma Surgery, Ospedale S. Pietro Fatebenefratelli of Rome, Rome, Italy
[4]Faculty of Medicine and Surgery, Link Campus University, Rome, Italy

CORRESPONDING AUTHOR
Stefano Petrillo, MD; e-mail: stefano.g.petrillo@gmail.com

ABSTRACT – *Objective:* Revision total knee arthroplasty (rTKA) is a technically demanding procedure due to the variability of surgical tools and the lack of standardized protocols. Achieving long-term stable fixation is especially challenging in cases with compromised bone stock. This systematic review evaluates the feasibility of using metaphyseal sleeves without stems as a fixation method in rTKA.

Materials and Methods: We conducted a systematic review of the literature, including clinical studies and biomechanical analyses focusing on the use of metaphyseal sleeves without stems in rTKA. A total of nine studies were selected: five clinical studies (two prospective and three retrospective) and four biomechanical or finite-element analyses. Outcomes assessed included clinical results, radiological findings, complication rates, failure rates, and biomechanical performance.

Results: Stemless metaphyseal sleeves demonstrated promising clinical and radiological outcomes. The overall failure rate due to aseptic loosening was 3%. Proper fixation in zones 1 and 2 was achievable with metaphyseal sleeves alone, while additional stems were necessary when stability in zone 3 was compromised. Biomechanical analyses indicated that smaller sleeves enhanced both rotational and axial stability.

Conclusions: The use of metaphyseal sleeves without stems appears to be a viable fixation option in rTKA, provided that adequate preoperative planning and intraoperative evaluation are performed. These findings suggest that, under appropriate conditions, stemless fixation can achieve reliable stability, potentially reducing the morbidity associated with stem use. However, limitations such as small sample sizes and short follow-up periods in the reviewed studies highlight the need for caution when generalizing these results.

KEYWORDS: Revision total knee arthroplasty, Stems, Metaphyseal sleeves, Metaphyseal fixation.

INTRODUCTION

Revision total knee arthroplasty (rTKA) poses significant challenges in achieving stable, long-term fixation, particularly when residual bone stock is compromised[1]. The integrity of the metaphyseal region is crucial for attaining optimal stability in a revision construct. This area, due to its rich vascularization and reduced susceptibility to surgical damage compared to the epiphyseal bone, facilitates cement interdigitation and implant osteointegration, contributing to superior initial fixation and prolonged implant survival[2]. In cases with substantial bone defects, two commonly adopted global approaches leverage these properties: the use of cones and metaphyseal sleeves[3]. These constructs differ significantly. Cones, which serve as fillers, are used to fill defect sizes and enhance the fixation of cemented implants without structural integration with other components. In contrast, metaphyseal sleeves are integrated parts of the implant, providing primary and direct fixation while aiding in load transfer from the revision components to the metaphyseal region. Additionally, metaphyseal sleeves offer the potential for bony biologic fixation, improving rotational stability and protecting epiphyseal fixation. Compared to fluted cylindrical stems, metaphyseal sleeves are more effective in achieving these objectives[4]. Clinicians typically use stems initially to stabilize sleeves (Figure 1), but there is an increasing trend toward using sleeves without stems (Figure 2). However, studies on this approach are limited by small

Figure 1. Stemmed sleeve configuration in revision total knee arthroplasty.

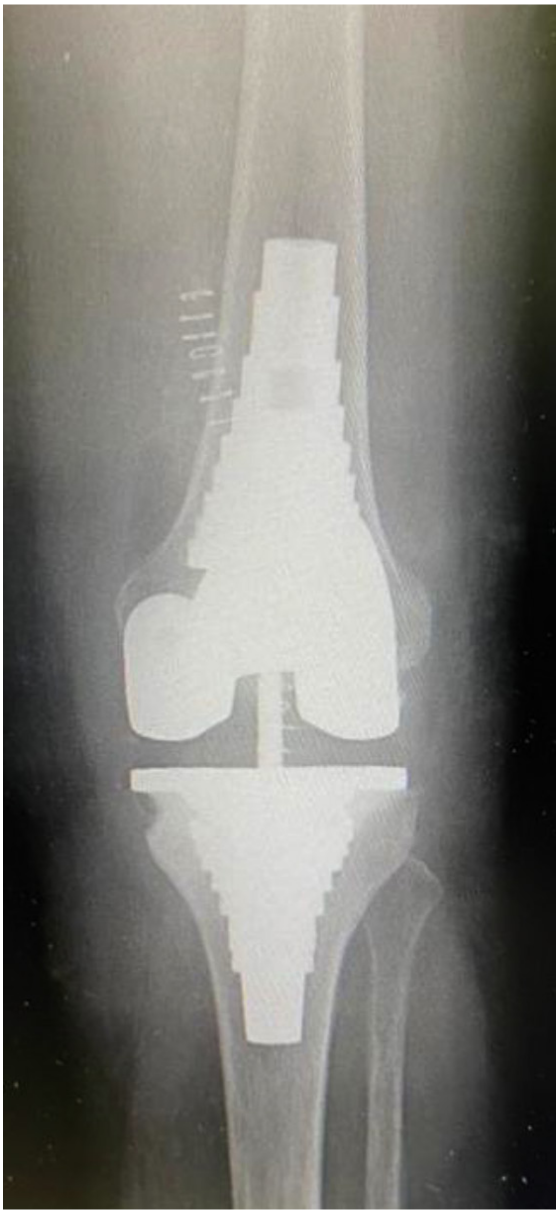

Figure 2. Stemless sleeve configuration in revision total knee arthroplasty.

sample sizes, lack of control groups, and short follow-up periods. Importantly, there is currently no consensus on the necessity of using stems with metaphyseal sleeves. This systematic review aims to summarize the contemporary literature to determine whether using metaphyseal sleeves without stems in rTKA is a valuable option.

MATERIALS AND METHODS

An electronic search was conducted on May 1st, 2024 using the PubMed (MEDLINE) database to investigate the use of sleeves without stems in revision total knee arthroplasty (rTKA). As this was a systematic review, PRISMA guidelines were applied in the selection and synthesis of the literature. This search was conducted with multiple strings, including "metaphyseal AND sleeves" (122 studies) and "sleeve AND stem AND knee" (45 studies), and involved reviewing the titles and abstracts of each study. Out of these, we identified 11 relevant studies that reported clinical results, radiological outcomes, complications, and failure rates, as well as those that conducted finite-element analysis on rTKAs with metaphyseal sleeves without stems.

Articles not written in English, those reporting an inaccurate number of stemless sleeves used, or those that included too few stemless sleeves in comparison to the total cohort evaluated were excluded. Additionally, literature reviews and letters to the editor were also excluded. The references for each of the included papers were reviewed to identify any potential studies that may have been missed.

DATA EXTRACTION

Extracted data included years of follow-up, indications for revision, preoperative Anderson Orthopedic Research Institute (AORI) classification type (Table 1), knee clinical outcomes score, radiological findings, and reasons and rates for failures (Table 2 and Table 3). All data were compiled in a Microsoft Excel spreadsheet (2021; Microsoft Corporation, Redmond, WA, USA). The overall search process (Figure 3) produced 9 studies[4-12] for final inclusion in our analysis: 5 clinical studies[5-9], of which 2 were prospective studies and 3 were retrospective studies (Table 2), and 4 biomechanical studies and finite-element analysis[4,10-12].

RESULTS

Clinical Outcomes

We identified several clinical scoring systems across the five clinical studies[5-9] (Table 4). Graichen et al[9] focused on assessing the effectiveness of rTKA in 121 patients who received 119 tibial sleeves and 74 femoral sleeves, including 2 cases of stemless tibial fixation and 49 cases of stemless femoral fixation, measuring the range of motion (ROM) and the American Knee Society Score (AKSS). The results showed a significant improvement in the mean ROM, from 89° ± 6° to 114° ± 4°, and the mean AKSS, from 88 ± 18 to 147 ± 23 ($p < 0.01$). The mean AKS functional score also showed improvement, from 52 ± 18.9 to 68.8 ± 23.3 ($p < 0.01$). The study found no significant difference between the stemless and stemmed groups. A retrospective analysis by Bugler et al[6] included 35 cases of rTKA, with 14 cases involving both femoral and tibial sleeves (69%), 10 cases involving only tibial sleeves (28%), and 1 case involving only a femoral sleeve (3%), 21 (60%) of the tibial prostheses and 12 (34%) of the femoral prostheses included stems, while the remaining sleeves were stemless. The post-operative Knee Society Score (KSS) was reported as good in 20% and excellent in 63% of the patients, and 63% of the patients expressed good satisfaction scores (rated 8 out of 10 or higher). Patients achieved full extension (83%), with a mean flexion angle of 100 degrees, ranging from 70 to 130 degrees. The authors did not report differences between the stemless and stemmed groups. Gøttsche et al[7] reported outcomes of 63 patients who underwent rTKA using sleeves without stem augmentation. They observed a mean AKSS improvement from 62.7 (54.7-70.8) to 109.6 (98.1-121.2) ($p < 0.0001$) and a mean postoperative Oxford Knee Score (OKS) of 27.9 (24.7-31.0). A statistically significant increase in pain scores with increasing functional limitations was noted ($p = 0.028$). Additionally, they reported that 30% of the patients were dissatisfied, while 21% were partially satisfied. Scior et al[8] evaluated 85 rTKAs with 109 stemless sleeves (81 femoral, 28 tibial). They found an average improvement in ROM from 97.7° to 114.1°, as well as increases in the KSS and Functional Knee Score from 88.8 to 159.3 and from 38.2 to 74.1, respectively. The OKS also showed

Table 1. Anderson Orthopedic Research Institute (AORI) classification.

Type	Severity of bone defects in tibia (T) and femur (F)
1 (T1 and F1)	Minor bone defect without compromising the stability of a component
2A (T2A and F2A)	Metaphyseal bone damage and cancellous bone loss in one femoral condyle/tibial plateau requiring reconstruction to maintain implant stability
2B (T2B and F2B)	Metaphyseal bone damage and cancellous bone loss in both femoral condyles/tibial plateau
3 (T3 and F3)	Significant cancellous metaphyseal bone loss compromising a major portion of either femoral condyles or tibial plateau, occasionally associated with patellar tendon or collateral ligament detachment

Table 2. List of included studies.

Study	Year of publication	Type of study	Number of patients and implants	Mean follow-up	AORI (number of patients)	Indication (cases)	Implant (DePuy Orthopedics, Warsaw, IN)
Graichen et al[9]	2015	Prospective study	121 patients, 119 tibial sleeves and 74 femoral sleeves (2 cases of stemless fixation of the tibia and 49 of the femur)	3.6 years	Femur: Type IIB (93), Type III (28). Tibia: Type II (114), Type III (7)	Instability (41), mobile malalignment (24) and loosening (23), polyethylene wear (15), trauma (4), stiffness (9), implant failure (3) and pain (2). In some cases, more than one problem was identified.	The Press-Fit Condylar (P.F.C.) Sigma bearing Revision Knee. In 77 patients a posterior stabilized insert, in 27 a TC3 insert (varus-valgus constrained), and in 17 a rotating hinge was implanted.
Bugler et al[6]	2015	Retrospective study	35 patients. Sleeves configuration: femoral and tibial in 14 (69%), only tibial in 10 (28%) or femoral 1 (3%); stem in 21 (60%) of the tibial and 12 (34%) of the femoral.	3.25 years	Type I: (20), Type II: (13), Type III: (2)	Aseptic loosening (45%), polyethylene wear (26%), malalignment (17%), instability (6%), unexplained pain (6%).	Hinged S-ROM Noiles knee system.
Gøttsche et al[7]	2016	Retrospective study	63 patients	> 2 years	Femur: Type I (7%), Type IIA (33%), Type IIB (56%), Type III (5%). Tibia: Type I (9%), Type IIA (9%), Type IIB (63%), Type III (19%).	Aseptic loosening (32), pain (18), infection (16), stiff knee (2), instability (1), fracture (1), polyethylene wear (1).	The Press-Fit Condylar (P.F.C.) Sigma Rotating Platform TC3 Revision Knee.
Scior et al[8]	2019	Prospective study	85 patients, 109 stemless metaphyseal sleeves (81 femoral, 28 tibial)	4.8 years	Type I or type IIA	Aseptic loosening (34, 36.6%), instability (28, 30.1%),malalignment (18, 19.4%), stiffness (10, 11.8%). In some cases more than one problem was identified.	The Press-Fit Condylar (P.F.C.) Sigma Rotating Platform TC3 Revision Knee.
Stefani et al[5]	2019	Retrospective study	121 knees, 44 in the group without stems and 77 in the group with stems	5.25 years for the stemless group, 7.4 years for the stems group	Type I in 24 femur and 25 tibia, Type IIA-IIB in 98 femur and 102 tibia, Type III in 21 femur and 16 tibia	Aseptic loosening 61 (42%), periprosthetic joint infection 46 (32%), instability 11 (8%), fracture 6 (4%), poly wear 4 (3%), arthrofibrosis 4 (3%), and other causes 11 (8%).	SIGMA TC3 revision implant with a posterior stabilized insert and a TC3 (varus-valgus constrained) insert.

Anderson Orthopedic Research Institute (AORI).

Table 3. Failure rate and complications.

Study	Mean BMI	Mean age (years)	Exclusion criteria	Final alignment	Survival rate of stemless sleeves from aseptic loosening	Causes of failure
Graichen et al[9]	32.9 ± 6.9	74 ± 9	< 70% sleeve-bone contact	98.4 % MA ± 3°	120/121 tibial (99.2%) 118/121 femoral (97.3%) 238/242 (98.3%) overall 3/121 radiolucent lines (2 femoral, 1 tibial)	1/121 tibial (0.8%) and 3/121 femoral sleeves (2.7%) aseptic loosening (rotating hinge implant) 4 (3.3%) infection 5 (4.1%) biomechanical reasons: 3 ligament instability, 1 malalignment, 1 extensor mechanism failure 2 failures of the implant (broken at the junction between stem and sleeve)
Bugler et al[6]	30.2 (20-42)	72 (55-86)	Uncontained defects in zone 1, 2 or 3	Not reported	35/35 (100%) No radiolucent lines	3/35 (8.6%) patients with patellofemoral symptoms necessitating patellofemoral arthroplasty
Gøttsche et al[7]	Demographic data not reported	Demographic data not reported	No criteria based on type of defect	49% inside optimal range (2.4-7.2° valgus), 51% outside range	69/71 (97.2%)[¥] 7/63 (11.1%) radiolucent lines	2/71 (2.8%) aseptic loosening 1/71 (1.4%) infection 1/71 (1.4%) instability 1/71 (1.4%) pain without loosening
Scior et al[8]	Demographic data not reported	Demographic data not reported	AORI type IIB or III	100% MA ± 3°	96% tibia (27/28) 100% femur (81/81) 99% (108/109) overall 1/28 radiolucent lines (tibial)	1/28 (3.6%) tibial aseptic loosening 4/28 (4.7%) infection 2/28 (2.4%) patella baja 2 (2.4%) instability 1 (1.2%) periprosthetic femur fracture
Stefani et al[5]	Not reported	73	< 70% sleeve-bone contact or poor bone quality	Not reported	121/121 (100%) 8/121 with radiolucent lines (3 femoral, 5 tibial), 6 of which without symptoms*	3/144 infection*[§] 1/144 instability*[§] 1/144 periprosthetic femoral fracture*[§] 1/144 patello-femoral symptoms*[§]

([¥]) The authors only included the 63 out of 71 patients who at least answered the questionnaire and the subjective part of the AKSS; (*) The authors did not specify whether these complications happened in the stemless or in the stemmed group; ([§]) Excluded from the study since the failure was not related to sleeves. Anderson Orthopedic Research Institute (AORI), Body Mass Index (BMI), Mechanical Alignment (MA), American Knee Society Score (AKSS).

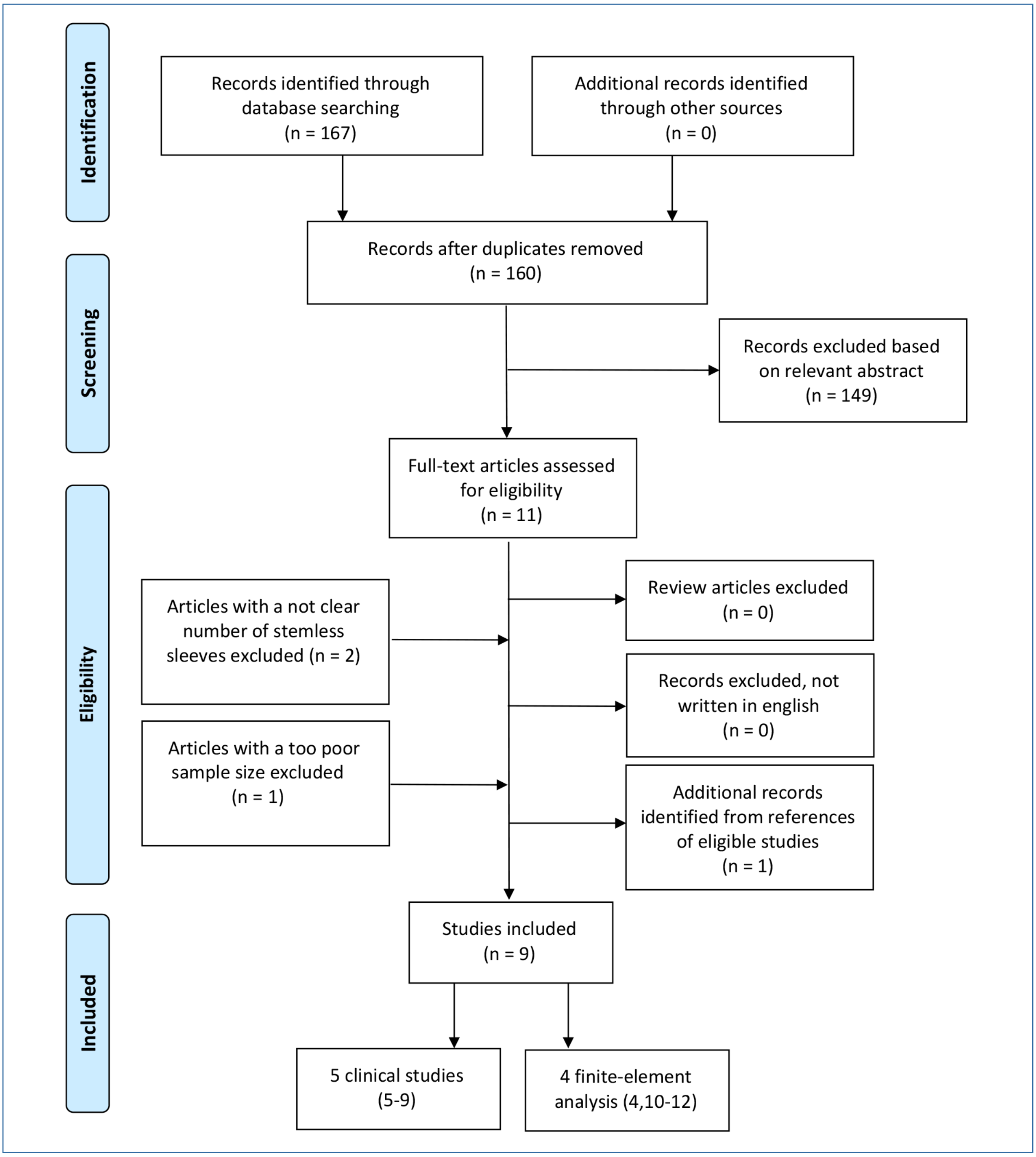

Figure 3. Literature search.

an improvement of 18.6 points, from 21.2 to 39.8. In a more recent retrospective study, Stefani et al[5] investigated 121 rTKA procedures in which metaphyseal sleeves were utilized on either the tibial or femoral side, or both, 44 of which were without stems, and 77 with stems. The authors reported a statistically significant increase in the mean KSS score from 34 to 81 (39 to 81 in the stemless group) ($p < 0.01$), and a significant improvement in the mean Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score from 82% to 39% (76% to 37% in the stemless group) ($p < 0.01$). However, no significant differences were found between the two groups. While it might seem inconsequential to assess clinical scores for evaluating the effectiveness of a mechanically oriented system, it remains valuable to observe the absence of statistically significant variances. The notion of avoiding shaft invasion to enhance fixation is driven by concerns regarding "stem end pain". Intriguingly, the gathered studies consistently indicate that, despite the well-intentioned approach, the presence or absence of the stem does not impact post-operative pain scores.

Table 4. Clinical outcomes.

Study	Number of patients	Range of motion (ROM)	American Knee Society Score (AKSS)	Knee Society Score (KSS)	Post-operative Oxford Knee Score (OKS)	Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)	Differences between stemless and stemmed groups
Graichen et al[9]	121 patients, 119 tibial sleeves and 74 femoral sleeves (2 cases of stemless fixation of the tibia and 49 of the femur)	From 89° ± 6° to 114° ± 4°	From 88 ± 18 to 147 ± 23	-	-	-	NO
Bugler et al[6]	35 patients. Sleeves configuration: femoral and tibial in 14 (69%), only tibial in 10 (28%) or femoral 1 (3%); stem in 21 (60%) of the tibial and 12 (34%) of the femoral.	-	-	20% good, 63% excellent (post-operative)	-	-	NO
Gøttsche et al[7]	63 patients, 63 stemless metaphyseal sleeves	-	From 62.7 to 109.6	-	27.9	-	-
Scior et al[8]	85 patients, 109 stemless metaphyseal sleeves (81 femoral, 28 tibial)	-	-	From 88.8 to 159	-	-	-
Stefani et al[5]	121 knees, 44 stemless metaphyseal sleeves and 77 stemmed metaphyseal sleeves	-	-	From 34 to 81 stemmed group; from 39 to 81 stemless group	-	From 82% to 39% stemmed group; 76% to 37% stemless group	YES ($p < 0.01$)

Radiographic Outcomes

The radiographic outcomes across the studies included provided encouraging results, demonstrating favorable osteointegration and alignment in the majority of cases, with only a small number of patients experiencing radiolucent lines or other complications. Graichen et al[9] found that the majority of the sleeves (96.4%) exhibited excellent osteointegration in both planes. Only seven patients showed radiolucent lines around the coated area of the sleeves, with five cases involving the femoral side and two cases involving the tibial side. Among these seven patients, three remained asymptomatic. The restoration of leg axis was achieved in almost all cases within a 3° corridor (98.4%), and the mean leg axis shifted from 2.1° ± 2.2° varus preoperatively to 0.6° ± 0.3° varus postoperatively. Bugler et al[6] reported no evidence of osteolysis or loosening of the femoral or tibial prostheses. Gøttsche et al[7] observed radiolucent lines around the prosthesis in only seven patients (11%), with a cortical reaction seen in five patients (8%). Additionally, they noted optimal alignment in 51% of cases, with a mean tibiofemoral alignment of 6° of valgus. Scior et al[8] also observed excellent osteointegration of sleeves in both planes in most patients (99.1%). Moreover, they reported that the mean long leg mechanical axis changed from 3.1° ± 2.5° of varus preoperatively to 1.4° ± 0.3° of valgus postoperatively ($p < 0.01$), with a joint line shift of approximately 2.8 mm compared to the preoperative assessment. Finally, radiological findings from Stefani et al[5] showed good overall osteointegration of prosthetic implants. Only eight radiolucent lines (three femoral, five tibial) were observed around the sleeves, with only two of those having clinical correlations.

Biomechanical Results from Finite-Element Studies

The initial press-fit of the implant achieved during surgery is crucial for determining long-term outcomes[13]. However, natural bone remodeling over time can weaken the local contact areas between the bone and implant[14]. Large metal components can alter the strain-stress behavior at the bone-implant interface. To better understand and predict the biomechanical behavior of stemless metaphyseal sleeves in rTKA in the medium to long term, several authors[4,10-12] have conducted *in vitro* analyses to evaluate this implant fixation technique (Table 5).

Fonseca et al[10] performed an experimental and finite-element analysis using five synthetic femurs to measure cortex strain behavior and implant-cortex micromotions for three types

Table 5. (S+S) stemmed sleeve.

Study	Finding A	Finding B	Finding C
Fonseca et al[10]	S+S is not necessary to achieve a high-level initial fixation of a sleeve-bone construct	S+S may reduce surrounding cancellous bone strain, but its effect appears to be secondary	
Frehill and Crocombe[12]	S+S may reduce stress concentrations	S+S promotes more resorption in the cancellous bone near the sleeve	Smaller sleeves provided better rotational and axial stability with lower surrounding stress concentrations
Awadalla et al[11]	S+S did not significantly improve primary fixation	S+S resulted in distal load transfer to the diaphysis and in a reduction in strain in the surrounding area	
Nadorf et al[4]	A small canal filling stem can improve initial fixation	The increased risk of proximal stress shielding in S+S constructs outweighs the benefits of better initial fixation	

of prosthetic implants in rTKA: femoral-component-only, stemless sleeve, and stemmed sleeve. Their study revealed that a stem is not necessary for achieving high stability in the initial fixation of a sleeve-bone construct. While a stem may affect the strain behavior of cancellous bone, its impact is secondary. Both techniques showed acceptable micromotions ranging from 50 to 150 microns, promoting bone ingrowth. This finding aligns with Wolff's law, stating that bone tissue adapts and remodels in response to the loading it experiences. Mechanical stimuli significantly impact bone ingrowth, alongside biological and biomechanical processes. Higher loading stimulates osteoblasts to strengthen bone, while lower loading leads to osteoclasts reducing bone tissue[14-16]. Research has shown that extensive relative motions exceeding 150 microns can disrupt established bony bridges, leading to fibrous connective tissue formation at the implant-bone interface, complicating osseointegration[17-19]. These processes can result in aseptic loosening and implant failure[20].

Structurally, a diaphyseal femoral stem in combination with a metaphyseal sleeve may not be necessary in rTKA, particularly where stem usage is impractical. Incorporating a diaphyseal stem increases the risk of cortical bone resorption compared to the stemless sleeve approach. Frehill and Crocombe[12] assessed the effectiveness of using stems with cementless metaphyseal sleeves for treating AORI Type III bone defects in rTKA. Their findings showed that a press-fit stem could reduce stress concentrations but also promote more resorption in the cancellous bone surrounding the sleeve. Consequently, they did not recommend using stems to treat AORI Type III bone defects with metaphyseal sleeves. Additionally, the study compared different sizes of metaphyseal sleeves and concluded that smaller sleeves provided better rotational and axial stability, resulting in lower stress concentrations in the proximal cancellous bone and better preservation of the metaphyseal bone stock. Awadalla et al[11] used computed tomography (CT) scans to create finite element models to investigate proximal tibial bone strain distribution and primary stability of a cementless rotating platform tibial tray with a sleeve, with or without a stem, in an AORI Type IIB defect. They analyzed data from applying joint contact forces mimicking level gait, stair descent, and squat movements. The results showed that stemless sleeved implants exhibited satisfactory primary stability, with micromotions below 50 microns and strains well below the bone yield point under various loading conditions. The addition of a stem did not significantly enhance primary stability when the sleeve already provided adequate mechanical stability but led to distal load transfer to the diaphysis and reduced strain in the bone adjacent to the implant. Nadorf et al[4] investigated the use of stems in AORI Type I bone defects and the benefits of different stem options combined with large metaphyseal sleeves in a modular tibial revision knee system. Their tests applying axial and varus-valgus torques showed that a short (one size thinner but still canal-filling) or flexible stem provided better initial stability and supported metaphyseal fixation while allowing bending similar to intact bone. However, there was an increased risk of proximal stress shielding in constructs with incorporated stems, outweighing the benefits of better initial fixation.

Complications and Failure Rate

The analysis of data from five clinical studies[5-9] underscores the favorable outcomes associated with the use of stemless metaphyseal sleeves in revision total knee arthroplasty (rTKA). These outcomes include low rates of septic and aseptic loosening, a reduced incidence of intraoperative fractures, and satisfactory short-term follow-up results. Graichen et al[9] reported 14 revisions during a mean follow-up of 3.6 years, accounting for 11.4% of cases. Among these, four revisions (3.3%) were attributed to periprosthetic joint infection (PJI). Aseptic revisions, comprising 5 cases (4.1%), were primarily due to biomechanical complications: ligament instability (three cases), malalignment (one case), and extensor mechanism failure (one case). Additionally, implant failure at the junction between the stem and sleeve occurred in two patients. The overall aseptic survival rate for metaphyseal sleeves was 98.3% at 3.6 years, with no significant differences between stemmed and stemless groups. Bugler et al[6] documented two cases of wound infection, one case of knee instability, three cases of patellofemoral symptoms, and one case of late femoral condyle fracture. Notably, no early loosening was observed, and none of the patients required re-revision. The authors reported no significant differences between the outcomes of stemmed and stemless groups. In the study by Gøttsche et al[7], two cases of aseptic loosening (2.8%) were identified, while Scior et al[8] noted a total of 4 patients (4.7%) with PJI, 2 patients (2.4%) with stiffness due to patella baja, 2 patients (2.4%) with knee instability, 1 patient (1.2%) with a periprosthetic femur fracture, and 1 patient (1.2%) with tibial loosening. The overall survival rate was 88.2%, with an aseptic survival rate of 99% at five years. No complications or implant failures were reported in the study by Stefani et al[5]. In summary, across the five included studies encompassing a total of 214 stemless sleeves in rTKA, only seven cases (3%) of aseptic loosening were reported at the latest follow-up. While these results are promising, they should be interpreted with caution due to potential numerical biases and the relatively small patient sample sizes and limited follow-up periods. Nonetheless, current evidence suggests no significant differences in clinical outcomes between the use of stemmed and stemless sleeves in rTKA.

DISCUSSION

The most important finding highlighted by this systematic review is that stemless metaphyseal sleeves demonstrated promising results, with an overall failure rate of only 3% due to aseptic loosening.

In planning rTKA, Morgan-Jones et al[1] introduced a zonal fixation approach based on the identification of three crucial anatomical zones for fixation in the distal femur and proximal tibia: zone 1 (joint surface or epiphysis), zone 2 (metaphysis), and zone 3 (diaphysis), allowing for pre-operative planning and providing an understanding of where secure fixation can be achieved. It is recommended that implant fixation be achieved in at least two of these zones. In most cases of rTKA, zone 1 is frequently compromised, leading many surgeons to use stems to improve the stability and fixation of prosthetic components. However, metaphyseal sleeves have emerged as a popular option for patients with severe metaphyseal bone defects. The sleeves can provide reliable fixation in zones 1 and 2; moreover, smaller sleeves were found to offer better rotational and axial stability. Haidukewych et al[2] suggest that the use of sleeves or cones, rather than stems, may provide the necessary stability by allowing ingrowth of both components. Despite metaphyseal sleeves being initially used in conjunction with stems, the specific advantages and contributions they offer are not thoroughly understood. Currently, there is no consensus on whether metaphyseal sleeves should be employed without stems. The introduction of this fixation method in rTKA was initially motivated by concerns about “end-of-stem pain” and malalignment in bowed tibia and femur[21]. An 11% incidence of “end-of-stem pain” was reported for femoral stems and 14% for tibial stems in a study conducted by Barrack et al[21], which included 66 femur and 50 tibia cases. Their study also revealed a close correlation between this pain and patient satisfaction, as reported by Gøttsche et al[7]. They found no significant difference in functional scores and satisfaction, suggesting that patients can tolerate functional disability better than pain. In our review, we found that regardless of whether the stem is present or absent, there is no substantial impact on postoperative pain scores, despite the well-meaning intentions. Although sleeves are designed to achieve fixation mainly in the metaphyseal area, with the components averaging approximately 70 mm in length, the commonly observed phenomenon of “end-of-stem pain” may persist. Another hypothesis to consider is that the high percentage of patients experiencing pain could be attributed to the large number of knees with suboptimal alignment, which is a typical issue associated with the use of stems. Gobba et al[22] found that in revision implants, the use of a 120 mm tibial stem could cause the tibial tray to be positioned excessively valgus, while using a 200 mm tibial stem could force the tray into a posteromedial position. Additionally, Stefani et al[5] suggested that the use of a stem in the femur could complicate flexion of the femoral component, even with available offset stems that are difficult to use. Without a stem, achieving up to 7 degrees of flexion is feasible, filling a flexion gap of up to 5 mm without causing any extension deficit. By employing metaphyseal fixation, as seen in sleeves, it becomes feasible to make alignment adjustments and prevent deformities in the same-side limbs or hardware, which would not be achievable through diaphyseal engagement. These advantages hold true when the procedure is performed by a skilled surgeon. Without the guidance provided by the diaphyseal guide, the available references for ensuring accurate alignment of the components diminish, posing a significant risk in rTKA. An additional aspect worth considering is the biomechanical perspective: the utilization of sleeves, rather than stems, places the implant fixation in closer proximity to the joint line. This proximity aids in achieving a more favorable soft tissue balance[23] and permits the use of untethered implants[24]. This makes sleeves without stems a promising option that simplifies bone preparation, reduces operating time, and lowers revision costs.

CONCLUSIONS

While higher-quality studies than those included in this systematic review may offer additional insights, the use of sleeves without stems appears to be a promising treatment option. This approach simplifies bone preparation, reduces operative duration, and lowers revision costs. However, further research involving larger patient cohorts is necessary to draw definitive conclusions.

Ethics Approval:

Not applicable due to the nature of the study.

Informed Consent:

All images used were taken from patients who underwent surgery by the authors, and who gave informed consent for their clinical and radiographic data to be used for scientific diffusion and research purposes. The images are fully anonymous, and no personal information is included.

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S. Petrillo and L. Saccone: study design, manuscript draft.
C. Caria: study design, manuscript revision.
F. Franceschi and S. Romagnoli: manuscript revision, supervision.
All authors provided final approval of the version of the article to be published.

ORCID ID:

S. Petrillo: 0000-0003-0843-2273
L. Saccone: 0000-0001-8660-3213
C. Caria: 0009-0008-0819-343X
F. Franceschi: 0000-0003-3917-8511
S. Romagnoli: 0000-0003-0152-4255

Conflict of Interest:

All authors have no conflict of interest to disclose.

Data Availability:

Data sharing does not apply to this article as no datasets were generated or analyzed during the current study.

AI Disclosure:

Artificial intelligence was not used to create any original intellectual content presented in this article.

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