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RESEARCH

CBC Mathys and CLS Spotorno stems: similar in design, different in outcomes. A comparative study of clinical and radiological differences

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Abstract

Introduction Total hip arthroplasty (THA) is a highly successful orthopedic intervention, with non-cemented stems like the CLS Spotorno and CBC Mathys being widely used. While these stems share a similar tapered design, they may produce different clinical and radiological outcomes. This study aims to compare clinical outcomes (Merlé-D'Aubigné scale) and radiological results between the CBC (Mathys) stem and the CLS Spotorno stem, specifically evaluating cortical hypertrophy, radiolucency, stem subsidence, and implant survival.

Materials and methods A retrospective 1:1 matched cohort study was conducted, including 344 THA patients (172 with CBC Mathys, 172 with CLS Spotorno) treated between 2010 and 2019. Radiological assessment included cortical hypertrophy, radiolucency, and stem subsidence using MEDICAD® software. Clinical outcomes were evaluated via the Merlé-D'Aubigné scale. Stem survival was analyzed using Kaplan-Meier curves.

Results Baseline demographics were similar in both groups. Cortical hypertrophy occurred in 42.4% of the CBC Mathys group, significantly higher than the 4.6% in the CLS Spotorno group ($p=0.03$). Radiolucencies were more frequent in the CBC Mathys group (55.2%) compared to CLS Spotorno (18.6%) ($p=0.03$). No significant differences in stem subsidence were observed ($p=0.68$). The average time of cortical hypertrophy appearance and radiolucency was 12.97 (SD: 15.51) and 13.48 (SD: 15.57) months, respectively. At final follow-up, four CBC Mathys stems were revised due to aseptic mobilization, resulting in a 97.6% survival rate, compared to 100% in the CLS Spotorno group ($p=0.182$).

Conclusion The CBC Mathys stem exhibited higher incidences of cortical hypertrophy and progressive radiolucency, suggesting biomechanical and tissue response differences compared to the CLS Spotorno stem. These radiological findings correlated with a slightly reduced survival rate for the CBC Mathys stem over six years, are already observable in many cases by the end of the first year, warranting further investigation into long-term clinical outcomes.

Keywords Total hip arthroplasty · CLS Spotorno stem · CBC Mathys stem · Cortical hypertrophy · Radiolucency · Stem survival

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Introduction

Since John Charnley introduced his tribology studies to the arthroplasty field multiple efforts have been made in order to get a better implant, improving the biomechanics and reducing the implant wear [1]. Among the non-cemented stems, the CLS Spotorno stem has been used widely around the world. It was designed by professor Spotorno and marketed by ZimmerBiomet in 1984 [2]. Its principle is that of initial press-fit anchoring. This means that the primary stability of the titanium alloy prosthesis (Ti_6Al_7Nb, also called Protasul-100) is achieved through a very congruent interaction between bone and prosthesis [2, 3]. The tapered design from proximal to distal allows its anchoring to the metaphyseal region of the bone with little or no fixation in the diaphyseal region, thus improving the stability and fixation of the implant, two crucial aspects for the survival of the stem [2, 3]. Additionally, the stem has flutes in the metaphyseal area, particularly in the trochanteric region. These flutes are arranged to introduce proximal forces that reduce the risk of intraoperative fractures while increasing the contact area with trabecular bone, thereby promoting osseointegration and enhancing the rotational stability of the prosthesis [2]. Experience with this stem is widely supported by publications with over 20 years of follow-up [3].

The CBC stem from Mathys SA Bettlach emerged in 1997, based on the principles of the tapered design and anchoring system. The stem is made of the same titanium alloy as CLS, it has a tapered design from proximal to distal like CLS, as well as flutes in the metaphyseal area, thereby increasing the stability and fixation of the prosthesis. Morphologically, both stems are practically indistinguishable (Fig. 1).

This study aims to compare clinical outcomes (Merlé-D'Aubigné scale) and radiological results between the CBC Mathys stem and the CLS Spotorno stem, specifically evaluating cortical hypertrophy, radiolucency, stem subsidence, and implant survival.

Materials and methods

This is a retrospective review of patients who underwent THA with CBC Mathys stem between 2010 and 2019 in one center. The comparation has been made 1:1 with patients who underwent THA with CLS Spotorno stem in the same period of time.

Inclusion criteria are patients of both sex who underwent THA with CBC Mathys and CLS Spotorno stems. All types of bearing surgeries used during those surgeries were included and are balanced ($p > 0.05$): ceramic-polyethylene, metal-metal, metal-polyethylene, and ceramic-ceramic. Patients with follow-up less than six months were excluded.

A comparison of demographic baseline data (age, side, height, weight, BMI and primary diagnosis) was performed to determine possible differences between each group.

A total of 190 CBC Mathys patients were included. Eighteen were excluded due to insufficient follow-up (less than 6 months). Sequentially, 172 CLS Spotorno which meet patients patients meeting inclusion/exclusion criteria were selected. In summary; one cohort treated with CBC Mathys stem ($n = 172$) and the other with CLS Spotorno stem ($n = 172$) was included.

Radiological evaluation

Radiographic evaluation was performed with MEDICAD® software using anteroposterior (AP) x-ray view of the hips to asses [4]:

a) Cortical hypertrophy, described following Gruen zones, describing the time of appearance (Fig. 2) [5].

b) Radiolucency (>2 mm): Evaluated in the described areas and the time of appearance. Radiolucency lines were considered progressive and non-progressive. Progressive are those that increase over time, while non-progressive do not evolve once they appear [5].

c) Stem subsidence: Measured as the distance from the greater trochanter to the stem between the first postoperative radiograph and the last one taken (Fig. 3) [6].

d) The diagnosis of aseptic mobilization and/or clinical stress shielding was made in the context of mechanical pain, primarily in the thigh, with a radiological image compatible with progressive radiolucency, with or without associated cortical hypertrophy. Blood tests were negative for C-reactive protein and ESR. The technetium bone scan showed signs suggestive of mobilization.

Clinical evaluation

Functional status was measured using the Merlé-D'Aubigné scale (M-D) before and after surgery. This scale evaluates pain, mobility, and gait, with scores ranging from 0 to 6 for each parameter. The values obtained in each parameter are summed to give a final score: excellent (18 points), very good (17 points), good (16 points), acceptable (15−13 points), fair (12−10 points), and poor (≤9 points). Additionally, complications were recorded, focusing on reoperation and revision, assessing the survival of both stems over time [7].

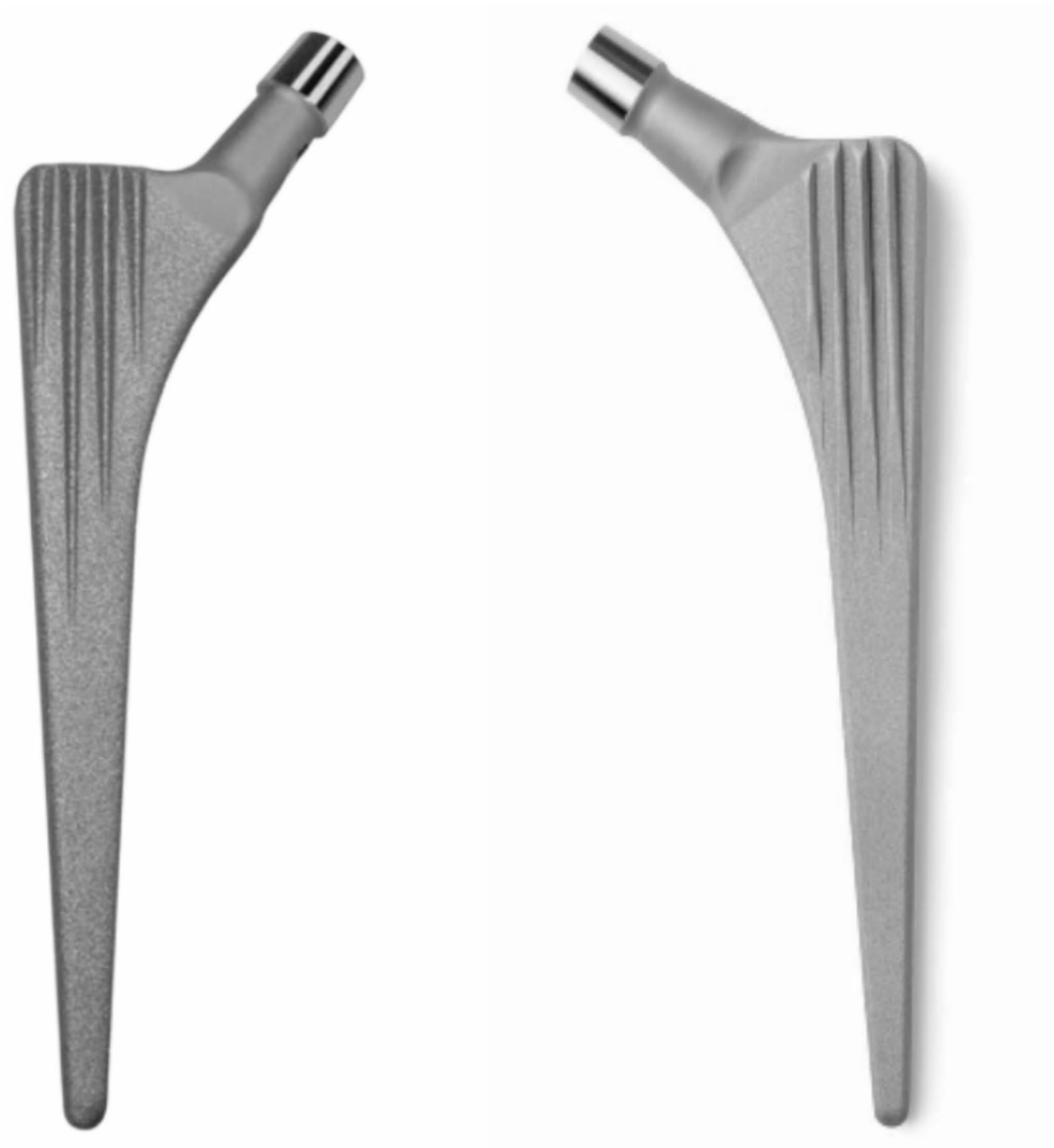

Fig. 1 Visual aspect of CBC Mathys (left) and CLS Spotorno (right) stems

Survival analysis (Kaplan-Meier curves) was performed considering aseptic stem mobilizations, excluding periprosthetic fractures and septic mobilizations from the analysis.

Surgical procedure and postoperative protocol

All patients were operated using the anterolateral Watson Jones approach in the supine position. Prophylactic antibiotics with 2 g Cefazolin were administered, repeating another dose of 1 g every three hours until a final dose 8 h

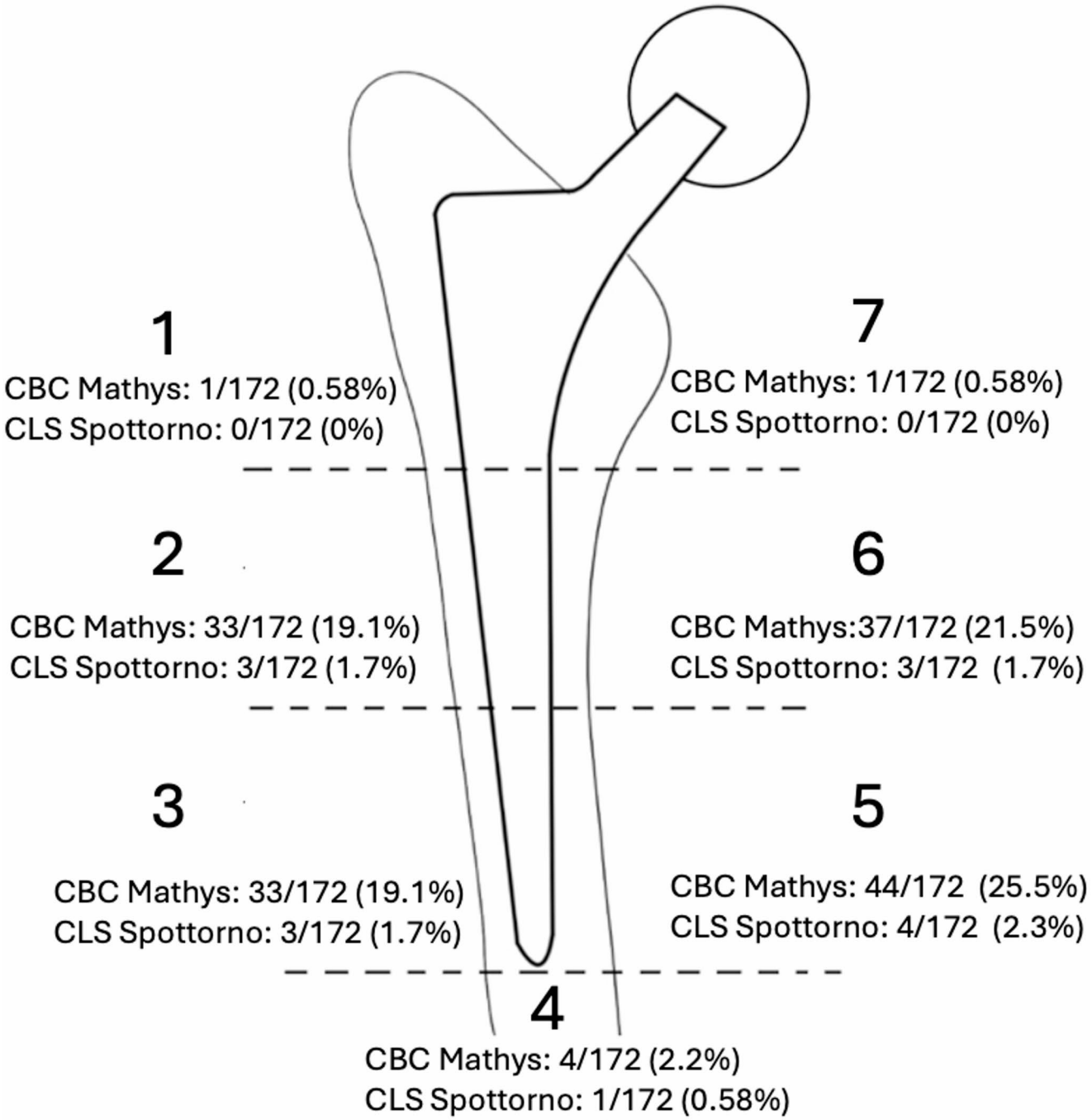

Fig. 2 Distribution of cortical hypertrophy across Gruen zones for both stem types

postoperatively. At the end of the surgery, two drains were placed, one intra-articular and the other superficial to the fascia lata, which were removed 48 h postoperatively.

All patients received antithrombotic prophylaxis with low molecular weight heparin (3500UI Bemiparin) for 30 days, starting 6 h after surgery.

All patients followed the same rehabilitation protocol, starting to bear weight at 24 h with the help of two crutches, which were maintained for four weeks, and abandoning the last one at six weeks. Patients were supervised by a rehabilitation team and a nurse experienced in orthopedics during their stay.

Follow-up during the first year was at six weeks, three months, six months, and 12 months postoperatively. Subsequently, a consultation was conducted at 24 months and then every three years.

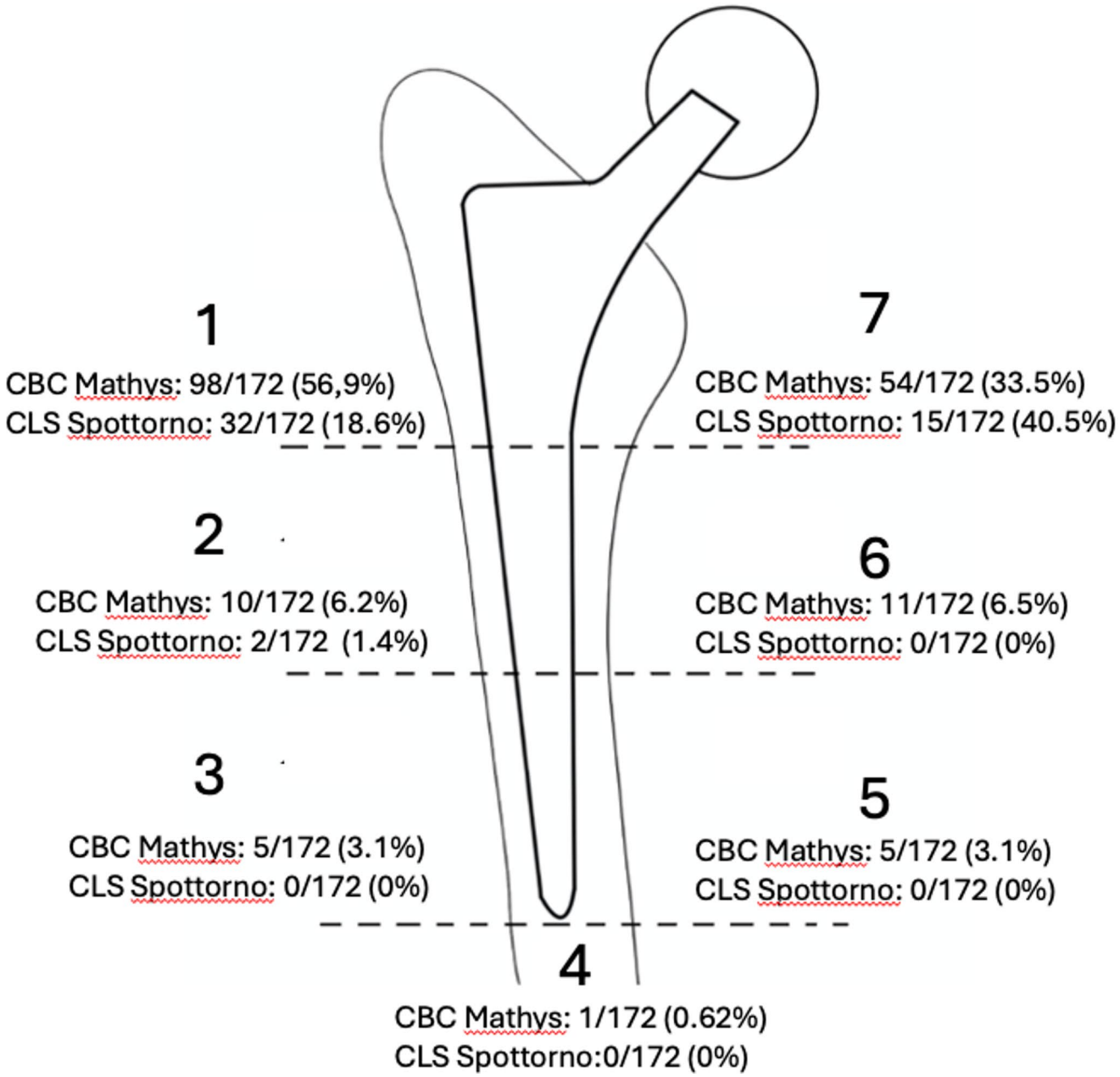

Fig. 3 Distribution of radiolucencies across Gruen zones for both stem types

Statistical methods

Data were expressed as mean and standard deviation (except for follow-up, expressed as mean and range). Independent sample t-tests were used for comparing means between the two independent groups after confirming data normality. Significance level was set at 0.05. Survival data were presented using Kaplan-Meier curves and compared with the Log-Rank test (Mantel-Cox). Statistical analysis was performed using SPSS v15.0.

Results

Demographic and triblogy data

Baseline demographic characteristics of the 344 patients (172 CBC Mathys and 172 CLS-Spotorno are summarized in Table 1. No differences have been reported in age, side, height, weight, BMI and primary diagnosis ($p > 0.05$). Pre-surgical clinical status of the CLS Spotorno group was slightly better assessed by the Merlé D'Aubigné score (CLS-Spotorno 13.62 (SD:2.2) vs. CBC-Mathys 12.97 (SD: 2.1); $p = 0.006$).

Table 1 Basal demographic data. No differences between groups were observed ($p>0.05$), with the exception of the presurgical M-D level (*$p=0.006$)

	CBC Mathys ($n=172$)	CLS Spot-orno ($n=172$)
Age yr. (SD)	66.49 (8,4)	65,94 (10,9)
Sex (n; %)		
Males (%)/Females (%)	87 (50.6)	105 (61)
Side (n; %)		
Right (%)	107 (62.2)	91 (52.9)
BMI (kg/m²; DS)	27.3 (4.2)	28.78 (4,6)
Diagnostic (n; %)		
Osteoarhtirits	166 (96.5)	161 (93.6)
Intracapsular Hip Fracture	1 (0.5)	3 (1.7)
AVN	5 (3)	8 (4.7)
Presurgical M-D (DS)*	12.97 (2.1)	13.62 (2.2)
Follow-up (months (Range:))	76.57 (range: 55–101)	64.77 (30–92)
Bearing Surface		
Ceramic– Poliethilene	170	160
Metal– Metal	0	2
Metal - Poliethilene	2	4
Ceramic - Ceramic	0	6
Head Size (mm)		
28	34	47
32	3	24
36	135	99
50	0	2

Table 2 Acetabular component

	CBC Mathys ($n=172$)	CLS Spotorno ($n=172$)
Allofit (ZimmerBiomet)	171	130
Trabecular Metal Cup (Continuum)	1	0
Durom (ZimmerBiomet)	0	2
Müller (ZimmerBiomet)	0	5
Expansive (ZimmerBiomet)	0	35

The average follow-up in the Spotorno cohort was 64.77 (range: 30–92) months compared to 76.57 (range: 55–101) months in the CBC Mathys group.

Table 2 presents the implanted acetabular cups in each group: predominantly Allofit (ZimmerBiomet) with ceramic-polyethylene. In the CBC-Mathys group, most polyethylene-ceramic, with seven metallic heads (5 metal-metal pairs and 2 metal-polyethylene pairs) in the CLS-Spotorno group.

Radiological results

Cortical hypertrophy (Fig. 2)

Of the 172 patients who received the CBC Mathys stem, 73 (42.4%) showed cortical hypertrophy, whereas and 8 (4.6 with the CLS Spotorno stem ($p<0.05$).

In the CBC Mathys group, the most affected Gruen zone was zone 5, in 25.5% of patients with cortical hypertrophy, followed by zone 6 in 21.5% of cases. The most common pattern involved zones 5 and 6 simultaneously. Zones 2 and 3 were affected in 19.1% of cases, without asynchronous involvement. Other zones were less affected. The average time of cortical hypertrophy appearance was 12.97 (SD: 15.51) months.

For the CLS Spotorno stem, the most affected zone in cases of cortical hypertrophy was zone 5 in 4 (2.3%) cases with cortical hypertrophy. In two of these four cases, cortical hypertrophy was secondary to chronic prosthetic infection.

Radiolucency (Fig. 3)

Radiolucency was observed in 95 patients (55.2%) who received the CBC Mathys stem and in 33 patients (18.6%) with the CLS Spotorno stem ($p<0.05$). All radiolucencies in the CLS Spotorno group were non-progressive, with zone 1 being the most affected in 55.2% of the patients who have radiolucencies, followed by zone 7 (46.87%). In the CBC Mathys group, radiolucencies affected all Gruen zones, with zone 1 (96.84%) and zone 7 (56.84%) being the most commonly affected. Most cases with radiolucencies in zones 1 and 7 were non-progressive. Four of the 95 cases with radiolucencies in the CBC Mathys group had progressive radiolucency, which were associated with aseptic stem revision due to stem mobilization. The average time of radiolucency appearance was 13.48 (SD: 15.57) months.

Stem subsidence

The average subsidence in the Spotorno cohort was 2.3 (SD:0.3) mm compared to 2.4 (SD: 0.4) mm in the CBC Mathys ($p=0.68$).

Clinical, functional and survival results

In the CBC Mathys cohort, the pre-surgery average was 13.6 (SD: 2.2) points and the post-surgery average was 17.4 (SD: 0.9) points ($p=0.06$). In the CLS Spotorno, the pre-surgery average was 12.97 (SD: 2.1) points and the post-surgery average was 17.2 points ($p=0.187$) (Table 3).

At the final follow-up, 4 of 172 CBC Mathys stems were revised due to aseptic stem mobilization caused by thigh

Table 3 Merlé d'aubigné functional scale evolution of the in both groups

	CBS Mathys	CLS Spotorno	*p*
Presurgical M-D	13.62 (2.2)	12.97 (2.1)	0.006
Postsurgical M-D	17.42 (0.9)	17.2 (1.4)	0.187

* Mean (Standard Deviation)

pain that was refractory to conservative treatment, resulting in a cumulative survival rate of 97.6%. Three stems had to be revised in the CLS Spotorno group: one due to periprosthetic fracture and two due to metalosis from a metal-on-metal pair with a Durom cup (Zimmer), but none due to aseptic mobilization, which leads to a cumulative survival rate of 100% ($p=0.182$) (Fig. 4).

Discussion

The CBC Mathys stem exhibited significant clinical and radiological differences compared to the CLS Spotorno, with major complications associated with a higher rate of aseptic mobilization and thight pain. This suggests that, despite macroscopical similarities, potential biomechanical and tissue integration disparities may exist.

All radiolucencies observed in the CLS Spotorno group were non-progressive, with zone 1 being the most affected in 36.04% of cases. The presence of non-progressive radiolucency in Gruen area 1 is well-documented, with similar rates reported in previous studies. Müller et al. reported non-progressive radiolucencies in zones 1 and 2, and progressive radiolucencies in zones 6 and 7 of Gruen [8]. Additionally, these non-progressive radiolucencies in areas 1 and 2 did not correlate with negative clinical effects and are the most common in the CLS Spotorno model [8–10]. Understanding specific stem characteristics during follow-up is

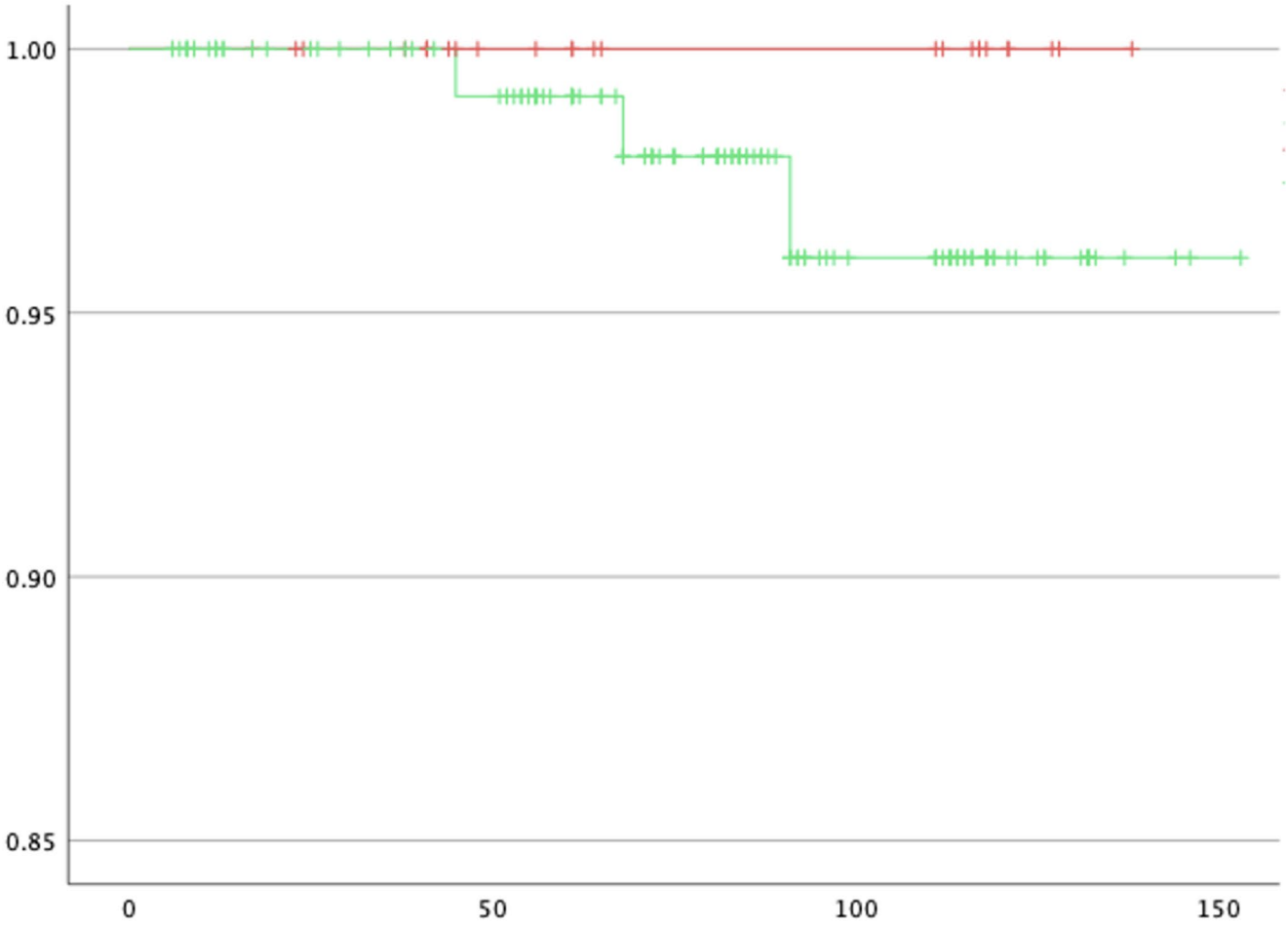

Fig. 4 Kaplan-Meier survival curve for the stem, regarding revisions due to aseptic loosening. Of the 172 CBC Mathys stems (green), four required revision due to aseptic stem mobilization associated with thigh pain unresponsive to conservative treatment, resulting in a cumulative survival rate of 97.6%. In contrast, no revisions for aseptic mobilization were reported for the CLS Spotorno stems (red), yielding a cumulative survival rate of 100% ($p=0.182$)

essential for surgeons to avoid making incorrect decisions in patient management.

In contrast to studies from the second and third decades of Spotorno stem implantation, which reported no cases of cortical hypertrophy our study found cortical hypertrophy in 4.7% of cases, mainly in distal Gruen areas. Two cases were related to prosthetic infection, suggesting a possible reaction to infection. The main cause of cortical reinforcement is load transfer differences, influenced by stem geometry, fixation zones, and bone response to stem coating material, such as hydroxyapatite. Spotorno's design prevents distal loading by increasing metaphyseal pressure, explaining the low incidence and distal location of cortical reinforcement [11]. In an in vitro study by Bieger et al., the CBC Mathys stem showed altered load distribution, particularly distally, possibly explaining the observed cortical reactions in distal Gruen areas [12]. In summary, radiological differences in progressive radiolucency and distal cortical reinforcement suggest potential biomechanical and tissue response disparities between the stems, warranting further investigation.

Stem subsidence was common but clinically irrelevant in both stems, consistent with previous literature indicating minimal impact on long-term survival [13]. In that sense, Dhillon et al. conclude in their systematic review that the collapse and aseptic mobilization of the CLS stem compared to others are minimal, although it is the rule in almost all patients, with no influence on long-term survival [13].

Studies employing comparable methodologies have identified and defined cortical reinforcement zones specific to the anchorage patterns of each stem design [14, 15]. The Taperloc stem commonly exhibits distal without prosthetic loosening [14]. The Fitmore stem demonstrates radiographic alterations due to load transmission differences, with increased lateral cortical reinforcement associated with higher rates of osteolysis and subsidence. The Corail stem rarely shows cortical reactions, and when radiolucencies occur, they are typically non-progressive and in Gruen area 1 [15].

Limitations of this study include its retrospective design, potential inherent biases, and the focus on anteroposterior radiographs, neglecting other Gruen areas visible in axial projections. Radiological assessments were carried out by two different observers, but not all cases were evaluated by both, and inter- or intra-rater reliability testing was not performed, which may limit reproducibility. The single-institution patient cohort may limit generalizability, and the follow-up duration, while reasonable, may not fully capture long-term results. Despite the time elapsed since surgery, motivating longer follow-up for these patients is essential.

Conclusions

Radiolucencies in Gruen zones 1 and 2 were common in both stems but exhibited non-progressive behavior and no clinical relevance.

The CBC Mathys stem exhibited higher incidences of cortical hypertrophy and progressive radiolucency, suggesting biomechanical and tissue response differences compared to the CLS Spotorno stem, particularly when radiolucency affected Gruen zones 6 and 7 and hypertrophy in zones 5 and 6.

These radiological changes were associated with a 3% decrease in the survival of the Mathys stem at 6 years of follow-up, and they are already observable in many cases by the end of the first year, warranting further investigation into long-term clinical outcomes.

Author contributions J.M.L.E. designed the study. J.M.L.E., M.S.J., and P.B. wrote the main manuscript text. P.B., J.G.A., G.V., and J.M.L.E. collected the data. P.B., J.G.A., and J.M.L.E. prepared the figures. All authors reviewed and approved the final manuscript.

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

References

1. Charnley J (1961) Arthroplasty of the hip. A new operation. Lancet 1:1129–1132. https://doi.org/10.1016/S0140-6736(61)92063-3
2. Evola FR, Evola G, Graceffa A et al (2014) Performance of the CLS Spotorno uncemented stem in the third decade after implantation. Bone Joint J 96–B:455–461. https://doi.org/10.1302/0301-620X.96B4.32607
3. Graceffa A, Indelli PF, Latella L et al (2016) Clinical outcome of design modifications to the CLS Spotorno stem in total hip replacement. Joints 4:134–141. https://doi.org/10.11138/JTS/2016.4.3.134
4. Bono JV (2004) Digital templating in total hip arthroplasty. J Bone Joint Surg Am 86-A Suppl 2:118–122. https://doi.org/10.2106/00004623-200412002-00016
5. Lamo-Espinosa J, Duart Clemente J, Díaz-Rada P et al (2013) The Burch-Schneider antiprotrusio cage: medium follow-up results. Musculoskelet Surg 97. https://doi.org/10.1007/s12306-012-0233-0
6. Lamo-Espinosa J, Troncoso S, Valentí-Azcárate A et al (2015) Clinical and radiological short-term complications after single-stage bilateral uncemented total hip arthroplasty. Musculoskelet Surg 99. https://doi.org/10.1007/s12306-014-0342-z
7. D'aubigne R, Postel M (1954) Functional results of hip arthroplasty with acrylic prosthesis. J Bone Joint Surg Am 36–A:451–475
8. Müller LA, Wenger N, Schramm M et al (2010) Seventeen-year survival of the cementless CLS Spotorno stem. Arch Orthop

Trauma Surg 130:269–275. https://doi.org/10.1007/S00402-009-0969-7
9. Streit MR, Schröder K, Körber M et al (2012) High survival in young patients using a second generation uncemented total hip replacement. Int Orthop 36:1129–1136. https://doi.org/10.1007/S00264-011-1399-Z
10. Kutzner KP, Donner S, Loweg L et al (2019) Mid-term results of a new-generation calcar-guided short stem in THA: clinical and radiological 5-year follow-up of 216 cases. J Orthop Traumatol 20. https://doi.org/10.1186/S10195-019-0537-Z
11. Cho YJ, Chun YS, Rhyu KH et al (2016) Distal femoral cortical hypertrophy after hip arthroplasty using a cementless doubletapered femoral stem. J Orthop Surg (Hong Kong) 24:317–322. https://doi.org/10.1177/1602400309
12. Bieger R, Ignatius A, Reichel H, Dürselen L (2013) Biomechanics of a short stem: in vitro primary stability and stress shielding of a Conservative cementless hip stem. J Orthop Res 31:1180–1186. https://doi.org/10.1002/JOR.22349
13. Dhillon MS, Jindal K, Kumar P et al (2022) Long-term survival of CLS Spotorno femoral stem: a systematic review of literature. Arch Orthop Trauma Surg 142:1239–1251. https://doi.org/10.1007/S00402-021-03975-0
14. Rivière C, Grappiolo G, Engh CA et al (2018) Long-term bone remodelling around legendary cementless femoral stems. EFORT Open Rev 3:45–57. https://doi.org/10.1302/2058-5241.3.170024
15. Schader JF, Thalmann C, Maier KS et al (2023) Prospective evaluation of clinical and radiographic 10-year results of fitmore short-stem total hip arthroplasty. J Orthop Surg Res 18. https://doi.org/10.1186/S13018-023-04359-3