Neck-Preserving Femoral Stems

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Abstract *Background:* Surgeons undertaking total hip arthroplasty (THA) routinely perform a distal femoral neck resection. It has been argued that retaining the femoral neck during THA can provide mechanical and biological advantages. *Purposes:* The objectives of this study were to review: (1) the current evidence on the advantages of femoral neck preservation during THA and (2) the clinical and radiological outcome of neck-preserving femoral stems. *Methods:* A search of the English-language literature on neck-preserving THA and on the individual neck-preserving implants was performed using PubMed, Ovid SP and Science Direct. *Results:* Studies have indicated that neck preservation offers superior tri-planar implant stability and allows more accurate restoration of the hip geometry and biomechanics. The trend towards tissue sparing surgery has contributed to the development of bone-conserving short-stem implants that offer variable levels of neck preservation. Despite an initial learning curve, these implants have generated promising early clinical results, with low revision rates and high outcome scores. However, radiological evaluation of some neck-preserving implants has detected a characteristic pattern of proximal femoral bone loss with distal cortical hypertrophy. The long-term implications of this finding are not yet known. *Conclusions:* Preserving the femoral neck during THA has biomechanical advantages. However, long-term outcome data are needed on neck-preserving femoral stems to evaluate on-going bone remodelling and assess implant performance and survival.

Keywords total hip arthroplasty · neck preservation · femoral stems

Introduction

The debate surrounding femoral neck preservation during total hip arthroplasty (THA) has recently been re-ignited by the introduction of bone-conserving short-stem implants. Traditionally, surgeons undertaking THA have performed a distal neck osteotomy, which invariably necessitated the excision of healthy bone. There is now a growing body of evidence to suggest that retaining the femoral neck can provide mechanical and biological advantages [37, 49].

Freeman and Pipino were early advocates of neck-preserving femoral stems. They argued that the common justifications for neck resection could either be addressed or were now obsolete [16]. Freeman felt that the continued practice of distal neck resection was a historical convention, born from the early designs of Moore [30] and Thompson [47], which were intended to treat patients with intra-capsular femoral neck fractures. The surgical convenience of inserting a curved stem through a resected neck was another factor that was important initially but was now redundant given the production of straight-stem femoral components and modern instrumentation.

Other arguments used against preserving the femoral neck include the potential risk of impingement between the bony neck and the acetabular cup and the threat of calcar resorption. In response, several authors have proposed that the theoretical risk of impingement can be mitigated by positioning the acetabular cup to subtend an angle of 140° [16]. With regards to the risk of calcar resorption, radiological analyses of neck retaining prostheses have demonstrated preservation of the entire calcar region [21, 25]. This, however, is likely to be dependent on individual implant design and stiffness.

The aim of this paper is to review the current experimental and clinical data on femoral neck preservation during THA. In particular, it seeks to address the following questions: (1) What are the advantages of preserving the femoral neck during

Level of Evidence: Level IV: Therapeutic Study. See levels of evidence for a complete description.

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THA? (2) What are the clinical and radiological outcomes of femoral neck-preserving implants?

Search Strategy and Criteria

A search of the English-language literature on neck-preserving THA and on the individual neck-preserving implants was performed using Ovid SP, PubMed and Science Direct in December 2011. Initially, a query was run on Ovid SP using the terms “total hip arthroplasty” AND “neck preserving”. This identified 12 publications, from which five were excluded (three not relevant to the topic, two conference abstracts), leaving seven papers of interest. Searches of “femoral neck preservation” and “femoral neck retention” found a further three papers. This process was then repeated using PubMed and Science Direct and identified another two publications. The references cited in articles identified by the search strategy were then reviewed for further eligible studies. This yielded five more papers.

Each of the search engines were then used to identify publications on specific neck-preserving femoral stems. These were the Biodynamic Hip prosthesis, the Thrust plate prosthesis (TPP), the Collum Femoris-preserving stem, the Freeman hip prosthesis, the Metha short-stem prosthesis, the Proximal Epiphyseal Replacement (PER) and the Birmingham Mid-head Resection (BMHR). Papers that were not published in English were excluded. When searching for implant outcome data, prospective studies were preferred to retrospective analysis. However, some implants had very little published data and conference proceedings were the only source of information.

Results

Biomechanical Advantages

The biomechanical environment of the proximal femur is governed by the interplay of load, joint and muscle reaction forces and hip geometry. One of the aims of successful THA is to restore this environment to its native state. Following surgery, femoral components are subject to high torsional and shear forces that can precipitate implant movement. Torsional stability is known to be an important factor in implant fixation and can influence survivorship [45]. The prostheses are also subjected to vertical forces that can produce interface micro-motion or result in migration of the stem into varus [21]. It is argued that neck preservation offers superior tri-planar implant stability and allows more accurate restoration of the hip biomechanics [13].

The tough cortical bone of the femoral neck and the metaphyseal cancellous bone are thought to facilitate good proximal primary fixation of femoral prostheses. Studies have shown that retaining the femoral neck improves component stability by offering greater rotational strength and stiffness, and better resistance to varus-valgus stress and collapse [32, 37]. Cement fixation of femoral stems was found to provide the best rotational stability, but neck retention improved stability in cases of cementless fixation. Other studies have found that neck-retaining designs have lower

rotational interface micro-motion and slippage at the bone-implant interface [48]. Experimental data have shown that the torsional load-bearing capacity of the proximal femur is significantly reduced by resecting the femoral neck below the mid-neck level [49]. Preserving the entire neck was found to reduce micro-motion at low torsional loads, whilst retaining the mid-neck region controlled micro-motion at higher loads. Further studies have confirmed that preserving the femoral neck reduces the level of distal migration of the femoral component [5].

Cadaveric studies have compared the compression forces on the medial cortex of retained and resected femoral necks, following the implantation of a femoral prosthesis [9]. They reported that neck resection resulted in increased contact stress on the medial cortex, with an increased risk of fracture at a lower load. The increased stress is due to a combination of the longer moment arm created by resecting the neck, which acts to tilt the prosthesis into varus and also by the reduced quantity of load-bearing bone. It has been postulated that following resection of the femoral neck, the greater trochanter is stress relieved above the level of resection, with the extra load distributed to the residual medial neck cortex and to the lateral cancellous bone [9]. Furthermore, resecting the neck can decrease the femoral off-set, which reduces the strength of the abductor muscles and increases the forces on the hip joint [39].

Some surgeons believe that it is important to preserve the bony architecture and mechanical stress distribution systems within the proximal femur to maintain physiological load transfer to the medial and lateral diaphysis and allow satisfactory bone remodelling [35]. They also argue that retaining the femoral neck would preserve the endosteal circulation derived from the femoral circumflex arteries, ensuring adequate blood supply and nutrition to the proximal femur [38].

Bone Conservation

In addition to the mechanical benefits, retention of the femoral neck allows greater preservation of native bone stock. The concept of tissue sparing surgery has gained popularity in recent years. In part, this can be attributed to the increasing number of young and active patients with end-stage hip disease seeking joint replacement surgery. These patients have a greater functional demand and expect to return to a high level of activity, with little residual deformity or pain. However, the orthopaedic literature highlights the challenges faced by THA in the young population, with higher rates of failure and dissatisfaction [12, 41]. Furthermore, given the relatively young age of primary replacement, these patients are at a greater risk of needing revision surgery in the future. To address these issues, implant manufacturers have designed bone-conserving femoral stems that maximise the preservation of healthy bone stock, by retaining the femoral neck

Table 1 Summary of the performance of neck preserving femoral stems

Prosthesis	Author	Number of hips	Follow-up (years)	Outcome
Biodynamic	Molfetta et al. [29]	153	1–12	98.7% stem survival at 10 years Mean HHS improved from 52 to 92
Biodynamic	Pipino et al. [39]	44	13–17	Good-to-excellent outcome in 82% Femoral neck survival in 80%
TPP	Fink et al. [39]	214	5	92.8% stem survival for any cause Mean HHS improved from 36.9 to 91.2
TPP	Buerger et al. [8]	102	6	98% stem survival for aseptic loosening Mean HHS improved from 51.6 to 96
TPP	Karatosun et al. [22]	71	2–7	8.4% stem revision for all causes 4.2% stem revision for loosening/technical errors Mean HHS improved from 43 to 93
TPP	Yasunaga et al. [50]	179	13	92.2% stem survival for any cause (97.7% in patients with OA and 90.3% for ON group) 8.7- and 7.5-point increase in Merle d'Aubigne score for OA and ON groups
CFP	Pipino [35]	353	1–7	Excellent outcome in 90.9% Heterotopic ossification in 44%
CFP	Gill et al. [18]	75	3	100% stem survival Mean HHS improved from 50 to 94
CFP	Nowak et al. [31]	50	6	98% stem survival for aseptic loosening Good-to-excellent outcome in 91%
CFP	Briem et al. [6]	155	6	99.4% stem survival for aseptic loosening Good-to-excellent outcome in 95.7%
Metha	Synder et al. [46]	30	6–16 months	100% stem survival for aseptic loosening Mean HHS improved from 54 to 97
Freeman	Journeaux et al. [21]	202	5 7	100% stem survival for aseptic loosening 95.7% stem survival for aseptic loosening Partial neck resorption in 16%
Freeman	Skinner et al. [43]	100	10	100% stem survival for aseptic loosening 1.4 mm mean distal migration at 10 years Radiolucent lines around 1 stem only
Freeman	Mannan et al. [26]	100	17	98.6% stem survival for aseptic loosening Mean HHS improved from 46.9 to 89.6
BMHR	Rahman et al. [40]	35	2.8	100% stem survival for any cause Mean HHS improved from 46.6 to 96.1 No adverse radiological features
BMHR	McMinn [28]	171	2–7.5	98.7% stem survival at 3.5 years

BMHR Birmingham mid-head resection, *HHS* Harris hip score, *OA* osteoarthritis, *ON*—osteonecrosis)

and metaphyseal cancellous bone (Table 1). When combined with less invasive surgical techniques to preserve soft tissue structures, this new generation of short-stem, neck-preserving prostheses offer an attractive alternative to conventional designs.

DEXA studies investigating the influence of femoral stem length have shown that progressive shortening of the stem produces more proximal loading, which

preserves metaphyseal bone stock and increases bone mineral density (BMD) in the medial zones [2].

One other advantage of the new-generation short-stem implants is that if revision surgery is needed, the implant can be removed and a more conventional distal neck resection performed. However, it is important to note that not all short-stem implants are neck preserving.

Neck-Preserving Implants

Biodynamic Hip Prosthesis

The Biodynamic hip prosthesis is reported to be the first commercially available neck-preserving femoral stem [36]. It was conceived in 1968, with first clinical implantation undertaken in 1979. It consisted of a straight stem, with one medial curve and a Caput-collum-diaphyseal (CCD) angle of 135°. The stem was manufactured from a cobalt chromium alloy and featured a macroporous surface for cementless fixation. Three different finishes were produced (all macroporous surface; macroporous surface proximal (two thirds) with smooth distal (one third); and macroporous surface proximal (two thirds) with a polished distal (one third)) after the first generation stem with a full macroporous surface was found to increase the risk of distal cortical hypertrophy.

Limited data are available on the outcome of the Biodynamic prosthesis. A recent study of 153 patients reported only two stem failures at a mean follow-up of 41.8 months [29]. Good-to-excellent clinical outcomes were documented in 83.4% of patients and survivorship at 10 years was 98.7%. Radiological evaluation revealed total or partial neck resorption in 0.6 and 4.6% of cases, respectively. Another series of 44 implants, with a minimum follow-up of 13 years, reported good-to-excellent clinical outcomes in 82% [39]. No stem revisions were documented, although 12 cases from the initial cohort of 56 (21%) were reported as lost to follow-up. Structural alterations of the femoral neck were observed in 23% of patients and calcar round-off in 27%. This finding led the authors to conclude that the femoral neck only survived and preserved its structure in 80% of cases.

Thrust Plate Prosthesis

The TPP (Sulzer Medica, Baar, Switzerland) was conceived in 1978 as a proximal femoral bone-conserving prosthesis, with metaphyseal fixation. The unique design consisted of a thrust plate, threaded bolt, lateral plate and two cortical screws. The absence of an intramedullary stem left the diaphysis undisturbed and was thought to negate the risk of rotational instability. The TPP aimed to replicate physiological transmission of load to the calcar and medial cortical bone of the femoral neck [20]. Three generations of the stem have been produced, incorporating small design modifications and a change from cobalt chromium to titanium.

Variable outcomes have been observed with the TPP. Survival has been reported as 98% at 6 years [8] to 92.2% at 13 years [50] (revision for any cause). However, a higher rate of failure has been documented in patients with polyarthritis (14.8% failure at a mean follow-up of 26 months) [14] and osteonecrosis of the femoral head (90.3% survival versus 97.7% survival for OA patients at 13 years) [50]. One series of 71 TPP performed in an older patient cohort reported a revision rate of 8.4% for all causes and 4.2% for aseptic loosening and technical error, at a mean follow-up of 4 years [22]. Good clinical performance has generally

been obtained, with mean Harris hip scores improving from 43 to 93 [22], 37 to 91 [15] and 51 to 96 [8] at the latest follow-up.

Complications of the TPP include peri-prosthetic fractures from over-tightening of the screws, spontaneous distal femoral fractures and extensive osteonecrosis. Concern has been raised about the incidence of tensor fasciae lata irritation from the lateral plate or bolt. Some authors have also reported a higher rate of infection and septic loosening with the TPP, compared with cementless stemmed prostheses [15]. Evidence of stress shielding has been observed below the thrust plate, with one study reporting radiolucency in 51.3% of patients [44]. Mechanical studies have also suggested that the TPP failed to reproduce a more accurate restoration of gait, hip geometry and biomechanics, when compared with a conventional THR [23, 44].

The Collum Femoris-Preserving Stem

The Collum Femoris-preserving (CFP) stem (Waldemar Link, Hamburg, Germany) was introduced in 1996. The CFP stem was made from titanium alloy and featured a 70- μ m microporous surface with a 20- μ m hydroxyapatite (HA) coating. The prosthesis had two stem curvatures to enhance fitting onto the medial bone structures of the femoral neck. The stem featured built-in anatomical anteversion and came in two CCD angles (117° and 126°). It had an oval cross-sectional shape with bilateral longitudinal ribs to enhance fixation and oppose torsional forces. A cemented version of the CFP stem, which lacks the longitudinal ribs, has been created for patients with poor-quality bone stock who are unsuitable for cementless fixation. The CFP stem aims to preserve the femoral neck, greater trochanter and most of the metaphyseal cancellous bone.

Survival of the CFP stem has been reported as 100% at 3 years [18] and 98–99.4% at 6 years [6, 31]. One series reported good-to-excellent clinical outcome in 91% of patients, with 96% of stems showing complete bony ingrowth [31]. However, evidence of stress shielding was observed in zones 1 (36% of stems) and 7 (26%), with cortical hypertrophy occurring in zones 3 (23%) and 5 (23%). Similar outcomes have been reported in a series of 393 CFP stems at a maximum of 8 years [38]. Ninety-one per cent of patients had an excellent clinical outcome at their latest review, with radiological analysis demonstrating evidence of good osseointegration in 99% of patients and good bone remodelling in 10%.

A retrospective study of 155 CFP stems reported good-to-excellent outcomes in 95.7% of patients at a mean follow-up of 6 years [6]. However, they noted osteopenic changes in the proximal femur and osteosclerotic transformation distally. This has been confirmed by a DEXA study of ten CFP prostheses over 4 years [4]. Although the study reported minimal peri-prosthetic bone loss in comparison to conventional stems, bone loss was observed in Gruen zones 1 and 7. An increase in BMD was found in zones 3, 5 and 6.

Reported complications of the CFP stem include undersizing of the stem intra-operatively, recurrent dislocation due

Fig. 1. **a** A photograph of a Freeman prosthesis implanted within a femoral bone model, demonstrating the level of neck resection. (Picture courtesy of Professor Michael Freeman). **b** Antero-posterior radiographs of the left hip showing a Freeman prosthesis at 1 and 17 years, with excellent preservation of the neck and calcar. The area in *green* corresponds to the part of the stem that is HA coated (picture courtesy of Mr. Gareth Scott)

to low femoral neck osteotomy, displacement of the stem collar and early retroversion of the stem [42]. The incidence of thigh pain, which can suggest stem micro-motion, has been reported as 0% to 14% [6, 39], with one series reporting a residual limp in 9% [31].

Freeman Hip Prosthesis

The Freeman hip prosthesis (Finsbury Orthopaedics, Leath-erhead, UK) was designed as a long-stemmed, neck-retain-ing femoral implant (Fig. 1). It was originally manufactured from titanium alloy, but this was later changed to cobalt chrome. Different finishes were available for cemented or cementless fixation. Stems intended for cementless fixation featured a proximal plasma-sprayed HA coating with longi-tudinal ridges and stipples to engage the cancellous bone on insertion. The distal stem was polished, tapered and circular in cross-section. Studies investigating four different methods of fixation (cemented, HA and two types of press fit) found that the cemented and HA-coated stems achieved better results than the press-fit stems [11].

The Freeman hip prosthesis has demonstrated excel-lent clinical and radiological performance at medium and long-term follow-up. Centres have reported 100% survival of the HA coated femoral stem at 10 years, with revision or impending revision for aseptic loosening as the end-point [43]. Longer-term follow-up revealed a 98.6% survivorship at 17 years, with aseptic loosening as the end-point, and 91.6% survival for revision for any cause [26]. Survival of the cemented Free-man stem has been reported as 100% at 5 years and 95.7% at 7 years [21].

Radiological analysis of the Freeman stems at 10 years has shown evidence of trabecular streaming of bone onto the proximal stem in 83% of patients [43]. Radiolucent lines were infrequently observed and reported in 0.5% at 7 years [21], 1% at 10-year review [43] and 2% at 17 years [26]. When present, they were found in Gruen zones [19] 1, 2 and 7. One series identified reactive lines around 50% of stems, but the authors argued that most were non-progressive with no clinical significance [43]. Partial resorption of the femo-ral neck has been observed in 16% of patients undergoing THA with the cemented stem. In all cases this was found to be less than 25% of the original length [21].

Migration studies have revealed a mean distal migration of 0.4, 0.8 and 1.4 mm after 1, 2 and 10 years, respectively [43]. The mean migration after 2 years was reported to be less than 0.1 mm/year, and no migration was detected after 10 years [26, 43]. This compares favourably to previous studies that have suggested that early vertical migration of more than 1.2 mm/year, in uncemented and unpolished cemented stems, is a good predictor of late aseptic failure [17].

Based on their experiences with the cemented Freeman stem, Journeaux et al. proposed that additional benefits of retaining the neck were superior cement pressurisation and the provision of a seal against the migration of wear debris within synovial fluid [21].

The Metha Short Hip Stem

The Metha stem (Bbraun, Melsungen, Germany) is a bone-conserving, modular, short-stemmed implant intended for cementless fixation (Fig. 2). It was based on the concept of the Mayo stem but offers greater

Fig. 2. **a** A photograph of the Metha Stem. **b** Antero-posterior radiograph of the left hip showing femoral neck preservation with the Metha stem

neck preservation. The stem is designed to achieve proximal fixation through metaphyseal anchoring within the closed ring of the femoral neck. The proximal part of the stem is dual coated with a microporous layer of pure titanium and a thin layer of calcium phosphate dehydrate to support secondary fixation. The stem is provided with a choice of three CCD angles ($130^{\circ}/135^{\circ}/140^{\circ}$) and the option to correct antetorsion. First clinical implantation was undertaken in 2004. The early results of the Metha stem are promising, with one centre reporting 100% stem survival at 1 year, with radiological evidence of rapid osseointegration [46]. Another series has reported an increase in the mean Harris hip score from 50 pre-operatively to 94 at 1 year [3]. All stems demonstrated evidence of osseointegration by 3 months.

However, incidents of broken modular titanium adapters have been reported. This forced a change in the adapter material to cobalt chromium and the phasing out of modular implants. DEXA studies on the Metha stem have revealed evidence of stress shielding, with a significant reduction in the BMD in the greater trochanter [25]. However, an increase in BMD was observed in the calcar region, in keeping with the proximal load transfer facilitated by the implants design.

Fig. 3. **a** A photograph of the mid-head resecting proximal epiphyseal replacement. **b** Antero-posterior radiograph of the right hip showing bone conservation with the proximal epiphyseal replacement

Mid-head Resection Implants

Proximal Epiphyseal Replacement

The PER (Stryker, Mahwah, NJ) is a mid-head resection femoral implant that was designed for use across an extended age range. It is indicated for cases where irreversibly damaged bone is confined to the femoral capital epiphysis, in patients with reasonable bone quality and relatively normal proximal femoral geometry. The principle of the PER is to excise only the diseased and vulnerable epiphyseal bone, with minimal intrusion into the proximal femur to achieve stable cemented fixation. The design features a curved mini-stem that strengthens and protects the femoral neck, and a head-neck chamfer to optimise range of movement and reduce the risk of impingement (Fig. 3). Pre-clinical studies have predicted a low risk of implant cement fretting, cement failure, adverse bone remodelling, stem loosening or stem fracture [27]. Mechanical tests demonstrated that the PER strengthens the femoral neck by 15% in normal bone and 50% in porotic bone and cadaveric studies have shown that it reduces the risk of neck fractures [10].

The first clinical implantation of the PER was undertaken in 2007. At our institution, 405 PER femoral components have been implanted by seven surgeons. There were 237

males and 168 females, with a mean age of 56.4 years (range, 22 to 74). The mean follow-up is 2.9 years (range, 6 to 58 months). The mean Oxford hip score has improved from 22 pre-operatively, to 43.3 at latest follow-up. Radiological studies of the PER demonstrate good restoration of the hip geometry with no significant difference in total offset or limb length.

Nine PER revisions have been performed to date. The reasons for revision include femoral neck fracture (3), aseptic loosening (3), metal debris disease (2) and unexplained pain (1). A 2.2% revision rate of the PER at 3 years compares favourably with the current performance of hip resurfacings [1].

Birmingham Mid-head Resection

The BMHR (Smith and Nephew, Warwick, UK) was developed as a bone-conserving option for young patients needing joint replacement surgery but were unsuitable for resurfacing because of abnormal proximal femoral morphology or poor bone quality. It has demonstrated a 100% survival at 2 years [40] and a 98.7% survivorship at 3.5 years, with revision for any reason as the end-point [28]. An independent centre has reported no early evidence of stress shielding, loosening or femoral neck thinning [40].

Biomechanical studies on the BMHR have reported conflicting findings. Whilst some studies have suggested that the BMHR might be more tolerant of minor errors in implant alignment and femoral neck notching than standard hip resurfacings [33], others have reported that the BMHR offers less resistance to femoral neck fractures [34]. Tests on human cadaveric femurs revealed that the BMHR prosthesis failed at a mean load that was 23% less than typical hip resurfacing.

Discussion

The concept of femoral neck preservation during THA was originally proposed several decades ago and continues to divide orthopaedic opinion. The recent trend for bone-conserving surgery has seen a proliferation of cementless short-stem implants enter the market. The Mayo, Nanos and CUT stems are further examples of implants that offer variable levels of neck preservation, but have not been discussed in this review. The questions that therefore arise are: (1) what are the advantages of preserving the femoral neck during THA? and (2) what are the clinical and radiological outcomes of femoral neck-preserving implants?

The current literature suggests that there is a biomechanical advantage to retaining the femoral neck. Neck preservation enhances the stability of the femoral prosthesis by reducing interfacial micro-motion and offering greater rotational strength and stiffness, and better resistance to varus-valgus stress [32, 37, 48]. Furthermore, the implantation of a neck-preserving stem has been shown to generate less contact stress on the

medial cortex, than a neck resecting implant [9]. Finally, migration studies have reported that preserving the femoral neck reduces distal migration of the femoral stem [26, 42, 43].

The other significant benefit of retaining the femoral neck is greater preservation of native bone stock. Given the increasing number of young patients undergoing THA, the use of a neck-preserving short-stem implant conserves native bone and allows revision to a standard prosthesis at a future date.

A number of femoral components that offer neck preservation have been developed. These vary in generic design from long-stemmed prostheses, to bone-conserving short-stem implants, to mid-head resection implants, with mini-stems into the femoral neck. The current controversy surrounding the phenomenon of adverse reaction to metal debris has resulted in large diameter metal on metal resurfacings and replacements losing popularity [7, 24]. However, further work is needed on this subject to fully understand the mechanism and quantify the risk.

It is clear that there is a learning curve associated with this new generation of stems. Despite this, the early results are promising, with most studies reporting good-to-excellent clinical outcomes in over 80% of their patient cohort, at various time-points. However, one of the main limitations of this review was the variable quality of the studies documenting the performance of the implants. Several studies were retrospective analysis of case series, and some demonstrated inconsistent data collection or large numbers of patients lost to follow-up. The paucity of data on some of these implants meant that these studies had to be included as they represented the only source of information. The second limitation was that most implants only had published data on their short- or medium-term outcome. To critically assess the clinical performance of these implants, it is essential that future studies report high quality, long-term prospective data.

The radiological analysis of several neck-preserving stems has highlighted some interesting findings. One of the main arguments against neck-preserving THA is the potential risk of calcar resorption. Studies on the Bio-dynamic hip prosthesis demonstrated calcar round-off in 27% and the cemented Freeman prosthesis showed partial resorption of the femoral neck in 16% [21, 39]. Radiological evaluation of the short-stem implants has also revealed a characteristic remodelling pattern of bone loss in the proximal femur, with distal cortical hypertrophy. Further evidence is therefore required to substantiate the claim that these implants prevent proximal stress shielding through proximal transfer of load to the metaphyseal bone.

In conclusion, preserving the femoral neck during THA appears to offer a biomechanical advantage and allows greater conservation of native bone stock. However long-term outcome data are needed on neck-preserving stems in order to monitor bone remodelling, verify performance and survival and validate their design rationale.

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