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GENERAL REVIEW • GENERAL ORTHOPAEDICS - ARTHROPLASTY

Kuntscher's nail removal techniques: an illustrative walk-through its journey

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Abstract
The use of Kuntscher nail for femur fracture dates back to World War 2. Since then, the technique of intramedullary nailing has evolved and the use of Kuntscher nail has become almost obsolete. The orthopaedic surgeons across the globe are facing a new challenge of removal of these Kuntscher nails due to different indications. Different but scattered English literature has been published describing the experiences and techniques of surgeon with K nail removal. Up till now, no systematic analysis has been performed evaluating the available literature. We have planned a systematic review to evaluate and explore the various indications and techniques of K nail removal.

Keywords Kuntscher nail · Broken Kuntscher nail · Incarcerated Kuntscher nail · Intramedullary nail · Femur fracture

Introduction

In 1940s, Gerhard Kuntscher had revolutionized the treatment of femur fracture with introduction of intramedullary nailing technique, which was popularly known as Kuntscher's nail. Since then, various improved generations of intramedullary nails have been introduced and become widely acceptable among the surgeons [1–3]. Over the past few decades, the Kuntscher nail has been replaced almost completely by these new generation interlocking intramedullary nails which provide more fracture stability and better long-term results [4, 5]. A subset of patients, who were previously operated with Kuntscher nail for femur fracture, are now reporting to orthopaedic surgeons for nail removal due to different indications. This has started a new era where removal of these incarcerated, broken or buried K nails has posed a new challenge among the young orthopaedic surgeons. The rising popularity of arthroplasty for degenerative arthritis among both the surgeons and the patients has also emerged as an important indication for its removal. Surgeons across the globe have reported various case reports and technique for removal of Kuntscher's nail. We, therefore, have planned this systematic review to compile altogether various indications and techniques of K nail removal for young budding orthopaedic surgeons.

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Materials and methods

We planned a systematic review based on available English literature and case reports on PubMed and Cochrane database regarding K nail removal, done initially for fixation of femur fracture. The studies were included in the final review after obtaining full text and screening all abstracts and removing duplicates. The studies with the following inclusion and exclusion criteria were included in this systematic review.

Inclusion criteria

1. Kuntscher nail done for femur fracture.
2. Studies focusing on technique of Kuntscher nail extraction in following scenarios:
   - Incarcerated nail.
   - Broken nail.

- Buried nail removal during THR and TKR.
- Distal migration of nail in knee joint.
- With formation of heterotopic ossificans.
- Impingement and chronic pain in limb.

3. Previous studies in English literature.
4. Studies where K nail got jammed during initial surgery.

Exclusion criteria

1. Removal of broken, buried or incarcerated intramedullary interlocking nails.
2. Removal of Kuntscher nail due to infection.

Search sources

The primary search was conducted on the PubMed and Cochrane Database of Systemic Reviews. For secondary search, bibliographies of studies included from the primary search were explored further.

Search methodology

The search strategy used for each database is given in Table 1.

Eleven articles were identified (keyword: Kuntscher nail) on Cochrane database. On further screening of their abstract and references, no relevant article could be traced and included in study.

Study selection

Selection of the studies included in the review was done independently by all the three authors and was considered for final review after mutual agreement. Figure 1 demonstrates the relevant flow chart of study selection.

Table 1 Search methodology

Key word	PubMed (1950–02/10/2018)
	No of studies
Kuntscher nail	309
Kuntscher nail for femur fracture	183
Kuntscher nail removal	30
Kuntscher nail removal and femur fracture	17

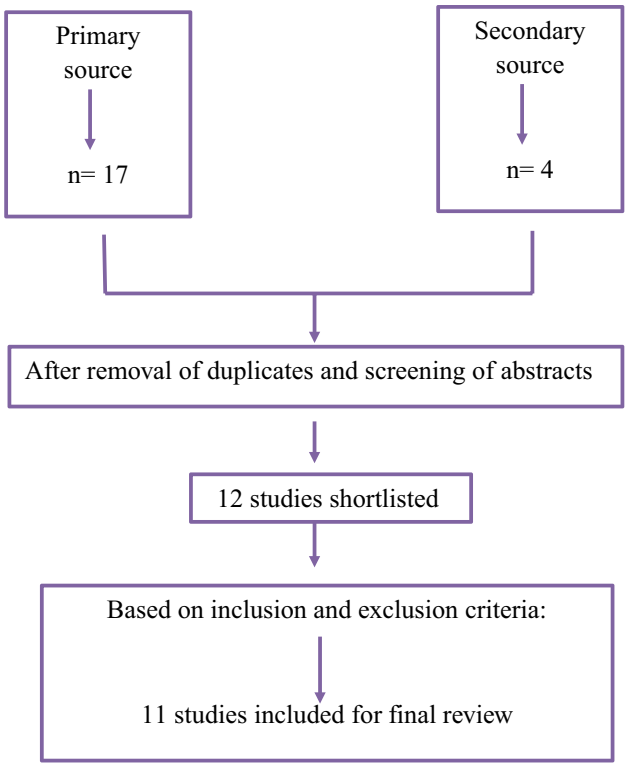

Fig. 1 Flowchart for study selection

Discussion

The technique of intramedullary nail has evolved from non-locking clover leaf designed Kuntscher nail to fourth-generation cephalomedullary nails for unstable femur fractures [3–5]. The use of Kuntscher nail is almost obsolete now and is rarely done for femur fracture. But today, the surgeon faces a new challenge of removal of these Kuntscher nail due to various reasons, which was a routine surgery few decades back.

Incavo et al. [6] published a technique to remove broken distal K nail. The proximal nail fragment was removed in standard fashion. To remove the distal nail fragment, the extraction device was passed down the medullary cavity and into the distal fragment under fluoroscopic control. Extraction device used was the standard Kuntscher intramedullary reaming guide, which was modified by first creating a 135-degree bend near the end of the rod and then cutting slightly with bolt cutters. A steel file was used to shape the hook. Finally, the guide rod was bent by 15 degrees in the same plane and about five cm proximal to the distal hook. While entering the extraction device in distal piece of the cloverleaf nail, it was coplanar with the two lateral recesses of the nail. As it passed through the distal fragment, some resistance was encountered due

to the 15-degree bend, and some degree of elasticity was thus imparted to the device. The hook, thereby, engaged the nail once it past the distal end of the nail fragment. A T-handled chuck was then attached to the protruding proximal end of the device and a slotted hammer used to remove both the device and the distal nail fragment. The degree of bend proximal to the distal hook should be slightly adjusted, depending on the diameter of the nail fragment.

In 1994, Ofer Levy et al. [7] treated five patients with broken femoral intramedullary nails, all associated with painful delayed union or non-union. Four nails were of the locking type and one was a K nail pattern. The operation was performed with the patient on a fracture table under image intensifier control. The intramedullary canal was opened at the greater trochanter, and any locking screw was removed. The proximal part of the nail was removed, and a 1-mm smaller nail was passed down the intramedullary canal and gently impacted into the opening of the distal nail fragment. Both nails were then removed. They claim it to be very economical and faster technique without requiring any special equipment.

Maini et al. [8] in 2005 published technique of extracting broken K nail in a 20-year-old man who was treated for a closed isthmic fracture femur with a Kuntscher's nail. A closed exchange nailing was planned. With patient placed in a lateral position, the eye of the Ender's nail was negotiated through the Kuntscher's nail slot across the broken area and beyond the tip of the Kuntscher's nail. Once the eye of Ender's nail crossed the tip of the Kuntscher's nail, the Ender's nail was rotated 90 degrees to have a good purchase on the Kuntscher's nail. The Ender's nail was gripped with a T-handle throughout the procedure. Subsequently, the broken Kuntscher's nail was removed with both proximal and distal segments together. The medullary canal was then reamed further to larger size, and a 12-mm interlocking nail was inserted.

Tadros et al. [9] published the method in 2009 of removing a broken K nail. A man in his mid-30 s was evaluated for right greater trochanteric and anterior thigh pain aggravated by activity. He was operated 14 years back with open Kuntscher nail for close femur fracture. On an attempt to remove the K nail, it got fractured into several pieces, and only its most proximal fragment could be removed. In the operating room, the patient was placed in the lateral decubitus position on a radiolucent table. A guide wire was inserted to the level of the first nail segment, and reaming was carried out to approximately 2 mm wider than the nail diameter. An extraction hook after bending it at a 30° angle, 15 mm from its distal end, was then used to remove each segment separately. Subsequently, the canal was reamed down to the next segment for sequential removal of all the pieces of broken K nail. Long alligator forceps were used to remove the segment which had a split, under radiographic control.

Marí et al. [10] in 2016 described a case report of extracting an incarcerated femoral Kuntscher nail. After multiple failed attempts with conical extraction tool and hook extraction system, longitudinal osteotomy was done along the lateral side of the femur from proximal to distal. The nail was found in place with on growth and overgrowth in almost entire length of the nail. The nail was hammer from below and it started to move gradually until the proximal hole of the nail broke. After so many attempts, author proceeded to drill a new hole distally with a diamond drill to finish the nail removal. Subsequently, several encerclage and bone allografts were used to close the longitudinal osteotomy.

Ng et al. [11] in 2010 published a method of removing a buried K nail of femur during total hip arthroplasty procedure in a 63-year-old man with symptomatic posttraumatic osteoarthritis of the right hip. The patient was operated 38 years ago with Kuntscher nail for femur fracture and subsequently underwent for below knee amputation for fracture non-union and persistent chronic osteomyelitis of the tibia. Transtrochanteric approach was used. The greater trochanter was osteotomized. After preparation of acetabulum, the femoral canal was prepared by initially identifying the antegrade entry point of the nail (which was occupied by fibrous tissue). The nail was extracted by fitting a hook into the extraction slot near the driving end of the nail. The nail removal was uneventful and the femoral canal was then prepared in a routine fashion.

There have been few studies that mentioned the removal of incarcerated Kuntscher nail during index surgery of patient itself. Nimberg et al. [12] in 1970 described a method of removing an incarcerated Kuntscher nail. After locating the site of compression of nail in narrow canal on X-ray, a window of 5–7 cm in length was made, about one-fifth of circumference of femoral shaft. Through the window, a chisel was then used to remove bone from endosteal wall, thus enlarging the canal which relieved compressing forces over nail and allowed easy extraction. Likewise, Broad et al. [13] published a method of releasing jammed K nail by doing longitudinal osteotomy at the compression site.

Rohilla et al. [14] published a technique in 2006 for removal of incarcerated femoral K nail. While Kuntscher nail was driven into the proximal fragment in a retrograde manner, it got jammed at the isthmus. The protruding end of the incarcerated nail in proximal fragment was then bent slowly at about 90 degrees about 5 cm distal to the distal end of proximal fragment. The bent portion of the nail was used as a lever arm, and the nail was then slowly rotated. Finally, after several attempts with to-and-fro movements of the nail to its sideways, the nail got loosened at the impacted site and could be removed.

Table 2 List of published literature with their corresponding techniques of K nail removal

Author	Year	Indications	Number of cases	Journal	Technique
1. Nimberg et al. [12]	1970	Incarcerated nail	1	Clinical Orthopaedic and Related Research	Making window and using chisel
2. Broad et al. [13]	1977	Incarcerated nail		Injury: the British Journal of Accident Surgery Vol. g/No. 2	Oscillating saw and longitudinal osteotomy
3. Incavo et al. [6]	1986	Broken K nail at distal half	3	Clinical Orthopaedic and Related Research	Modified Kuntscher reaming guide and close technique
4. Levy et al. [7]	1994	Four broken interlocking nails, one broken K nail at distal level	5	The Journal of Bone and Joint surgery	Using smaller nail to remove distal fragment
5. Maini et al. [8]	2005	Broken K nail at mid-level	1	The Journal of Trauma	Use of Ender's nail
6. Rohilla et al. [14]	2006	Jammed nail	1	The Internet Journal of Orthopedic Surgery, Volume 5, Number 1	Bending nail 90 degree
7. Tadros et al. [9]	2009	Segmental broken K nail	1	American Journal of Orthopedics; April 2009	Extraction hooks and alligator forceps
8. Singh et al. [15]	2011	Distal migration of K nail in knee joint	1	European Orthopaedics and Traumatology, July 2011	Using cancellous Schanz screw and hand reamer
9. Marí et al. [10]	2016	Incarcerated K nail	1	Journal of Orthopaedic Case Reports 2016 July–August	Osteotomy and use of diamond drill
10. Ng et al. [11]	2018	Buried K nail	1	Hip Int 2010	Greater trochanteric osteotomy, identification of antegrade nail entry point and use of hook.
11. Kumar et al. [16]	2019	Proximal migration of K nail in gluteal region	1	Journal of Clinical and Diagnostic Research	Small incision longitudinal osteotomy via two bony windows with Gigli saw

Singh et al. [15] in 2011 published a technique of removal of Kuntscher nail which had migrated distally into the knee joint and got embedded in proximal tibia. The patient was operated with K nail (10 cm × 11 mm) for shaft femur fracture, around 1 year back and presented with knee pain and restricted joint movement. With the patient in lateral decubitus position, using transtrochanteric approach, the proximal femur was reamed up till the proximal most end of nail with the straight, non-flexible hand reamers about 2 mm wider than the nail diameter. Under image intensifier control, a 6.5-mm cancellous Schanz screw mounted over a T-handle was inserted and driven into the nail and the nail was extracted by back hammering on the T-handle.

Kumar et al. in 2019 published a small incision osteotomy technique for proximally migrated K nail. The patient was a 53-year-old male who presented with painful gluteal swelling post-K nail fixation of femur fracture which was done 20 years back. Two small incisions of about 5 cm were given over proximal and distal aspect of K nail on lateral thigh under image intensification. Cortical windows were made and Gigli saw was passed through these windows from above downward along the longitudinal slot of K nail, present along the anterolateral aspect of femur. Longitudinal osteotomy of femur was done with saw in a controlled manner followed by praying of cortex with small osteotome at osteotomy sites. The nail was further hammered to extract it from the entry site.

The prime goal of this study is to highlight and make young budding surgeons aware of different existing ancestral and modern techniques of K nail removal. Through detailed review of the literature, this study also highlights various indications for K nail removal and about the special instruments that surgeon may need in such cases (Table 2).

Conclusion

K nail is a time-tested nailing method for femur fracture; its removal can be troublesome. We have enlisted different methods adopted by various surgeons over time for methods of K nail removal (Table 2). Surgeons should keep these techniques in their mind and should be well prepared, before getting stuck during surgery.

Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

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