CASE REPORT

Constrained Condylar Prostheses for the Treatment of Charcot Arthropathy: A Case Report and Literature Review

Fengyao Mei, MD[1], Jiao Jiao Li, PhD[2], Jianhao Lin, MD, PhD[1], Diange Zhou, MD, PhD[1], Dan Xing, MD, PhD[1]

[1]*Arthritis Clinic and Research Center, Peking University People's Hospital, Beijing, China and* [2]*School of Biomedical Engineering, Faculty of Engineering and IT, University of Technology Sydney, Sydney, Australia*

Background: Neuroarthropathy of the knee or Charcot knee, leading to chronic joint destruction, is a rare disease that is difficult to diagnose. The treatment of this condition is difficult and controversial.

Case Presentation: A 74-year-old Asian woman has had bilateral knee pain for 22 years and deformity for 10 years, which has been aggravating for 2 months. Physical examination showed bilateral knee varus deformity greater than 15°, and −20 to 90° range of motion. X-ray revealed bilateral varus deformity with massive free body hyperplasia. Combined with medical history as syringomyelia, the patient was diagnosed with bilateral Charcot knees and bilateral joint replacements were performed using Legacy Constrained Condylar Knee prostheses (LCCK; Zimmer, USA). The patient reported satisfactory treatment outcomes, pain relief, and improved range of motion in both knees, without postoperative complications or prosthesis loosening at 2 year after operation.

Conclusions: Total knee arthroplasty (TKA) may be considered a viable option for treating the Charcot knee. The use of constrained condylar prostheses can produce satisfactory results. Attention should be given to survival risks, complications, and other potential determining factors associated with TKA when devising a treatment strategy for the Charcot knee.

Key words: Arthroplasty; Charcot Knee; Constrained Condylar Prosthesis; Knee Replacement; Neuroarthropathy

Introduction

Neuropathic arthropathy is a progressive disease characterized by non-infectious degeneration of bones and joints. It is commonly found in weight-bearing joints such as the knee, hip, and ankle, as well as in the shoulder and elbow.[1] Caused by sensory, motor, or autonomic neuropathy, this condition often results in severe joint deformity and dysfunction.[2,3] Neuroarthropathy of the knee, also known as Charcot knee, is a rare joint disease, but is gaining concern with increasing worldwide incidence of diabetes in recent decades.[4–6] Before the turn of the century, the main interventions for Charcot knee were conservative treatments or joint fusion surgery. Joint arthroplasty was once contraindicated for Charcot knee due to the high incidence of serious complications.[2,7,8] More recently, with advances in joint replacement technology and perioperative management, joint arthroplasty has been applied with success for treating Charcot knee.[4,9,10] Nevertheless, the effective management of neuropathic arthropathy has remained a controversial topic, and draws from very limited evidence in the literature.

In this study, we report an elderly woman who underwent total knee arthroplasty (TKA) with constrained condylar prostheses to treat bilateral Charcot knees. We add to the very limited literature on treating Charcot knee using TKA, and also provide a review of other known reports using the same approach published in the last 20 years (Table 1).

Case Report

A 74-year-old Asian woman presented to the orthopaedic department with a history of 22 years of bilateral knee

Address for correspondence Dan Xing MD, PhD, Peking University People's Hospital, Xinzhimen RD, Beijing, China 100044; Email: lovetroy@126.com Diange Zhou MD, Peking University People's Hospital, Xizhimen RD, Beijing, China 100044; Email: zhoudiange@126.com

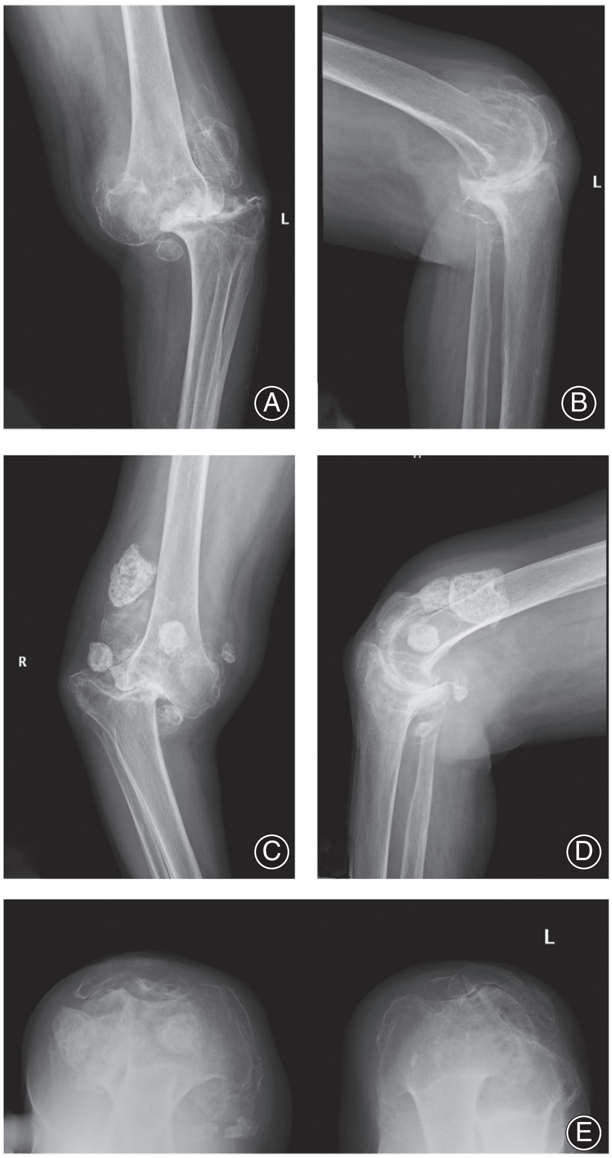
Received 10 October 2022; accepted 29 January 2023

TABLE 1 Characteristics of case reports in the last 20 years on total knee arthroplasty for treating Charcot knee

Study	Year	No. of patients (knees)	Underlying cause	Prosthesis	Complications	Mean follow-up duration (years)
Kim[15]	2002	10 (19)	Syphilis (19)	Hinged (1), Semiconstrained (1), Condylar constrained (17)	Aseptic loosening (1), Dislocation (4), Peri-prosthetic fracture (3), Quadricep rupture (1)	5.2 (range 5–6)
Parvizi[12]	2003	29 (40)	Familial sensorimotor deficit (16), Diabetes (7), Syphilis (4), Lacunar infarct (1), Syringomyelia (1), Idiopathic (11)	Long-stem (27), Rotating hinge (5), Cruciate condylar (8)	MCL avulsion (2), Patellar tendon rupture (1), Tibial tuberosity avulsion (1), Instability (4), Haematoma (1), Deep vein thrombosis (1), Superficial infection (1), Aseptic loosening (2), Periprosthetic joint infection (1), Periprosthetic fracture (2)	7.9 (range 2–15)
Bae[19]	2009	9 (11)	Syphilis (11)	Rotating hinge (11)	Dislocation (2), Infection (1)	12.3 (range 10–22)
Kucera[22]	2010	1 (1)	Diabetes (1)	Condylar prosthesis with preservation of posterior cruciate ligament (1)	Not reported	5
Chun[23]	2016	16 (20)	Syphilis (20)	Condylar constrained (20)	Instability (1), Graft resorption (1)	10.7 (range 8.5–14.4)
Zeng[10]	2016	7 (8)	Syphilis (3), Syringomyelia (1), Diabetes (3)[a]	Rotating-hinge (3), Long stemmed condylar-constrained (5),	Not reported	range 2–6
Tibbo[24]	2018	27 (37)	Diabetes (9), Hereditary motor and sensory neuropathy (5), Inherited small fiber neuropathies (4), Spinal cord injuries (4), Peripheral neuropathy secondary to Turner syndrome (1), Acute demyelinating polyneuropathy (1), Neuropathy secondary to chronic malabsorption from radiation enteritis (1), Myelomeningocele (1), Unknown (1)	Posterior stabilized (7), Condylar constrained (17), Rotating-hinge (13)	Aseptic loosening (2), Periprosthetic joint infection (4), Periprosthetic fracture (3), Deep vein thrombosis (1), Patellar clunk (1), Flexion contracture (1), Hematoma (1), Patellar malalignment (1), Superficial wound infection (1)	6
Nozaka[25]	2019	1 (1)	Syphilis (1)	Posterior stabilized (1)	Not reported	7
Karageorgos[26]	2020	1 (2)	Cauda equine syndrome caused by spinal fracture (2)	Rotating hinged (2)	Not reported	12
Yoshikawa[27]	2020	1 (2)	Lumbar spinal canal stenosis (2)	Rotating hinge (1), Condylar constrained (1)	Not reported	0.5
Alshaygy[6]	2021	1 (1)	Idiopathic (1)	Hinged (1)	Not reported	1.25
Tsamassiotis[5]	2021	1 (2)	Diabetes (2)	Total stabilized (Stryker Triathlon® TS) (2)	Not reported	2
Du[9]	2021	1 (1)	Syphilis (1)	Tibia-femoral rotating-hinge (1)	Not reported	1.5
Alghamdi[28]	2022	1 (1)	Hereditary motor and sensory neuropathy (1)	Hinged (1)	Not reported	1

[a] Number of underlying causes corresponds to the number of patients.

FIGURE 1 Physical examination of the patient. (A) anteroposterior and (B) posterior of the both knees. (C) lateral of right knee. (D) bilateral elbow deformities



pain, 10 years of joint deformity, and 2 months of aggravating pain. The patient first began to experience knee pain 22 years ago which progressively worsened over time. She started developing deformity in both knees 10 years ago. At the time of clinical presentation, the patient was unable to walk normally and needed to rely on assistive devices for mobility. According to her detailed medical history, the patient had been living at the same location since childhood, suffering from syringomyelia previously (specifically unknown), with no record of metabolic diseases. Six years ago, she has been receiving daily treatment with alcohol and Traditional Chinese Medicine. Physical examination of the patient showed bilateral knee varus deformity of more than 15°, range of motion −20° to 90°, and bilateral elbow deformity (Figure 1). X-ray examination of knee and elbow joints in the outpatient department revealed elbow joint malformation and varus deformity in bilateral knee joints with some free body hyperplasia (Figures 2–4). Laboratory tests showed negative treponema pallidum antibody, fasting blood glucose of 6.35 mmol/L, C-reactive protein of 6.33 mg/L, and erythrocyte sedimentation rate of 25 mm/h. The primary diagnosis was neuropathic arthropathy.

TKA was conducted for the patient using the Legacy Constrained Condylar Knee prosthesis (LCCK; Zimmer). The operation was performed on the right knee, through a midline skin incision and a standard medial parapatellar approach with a pneumatic tourniquet. Several fragments of bone and cartilage were embedded within the synovium. The distal femoral cut angled 6° valgus from the anatomical axis was made using an intramedullary guide, and the proximal tibia was then cut using intramedullary guide perpendicularly to the tibial mechanical axis, with 7° posterior slope. We confirmed the integrity of the collateral ligament during surgery. The decision to use LCCK prosthesis was

FIGURE 2 Preoperative imaging. (A) anteroposterior radiograph and (B) lateral radiograph of left knee. (C) anteroposterior radiograph and (D) lateral radiograph of the right knee. (E) axial radiograph of both patellar

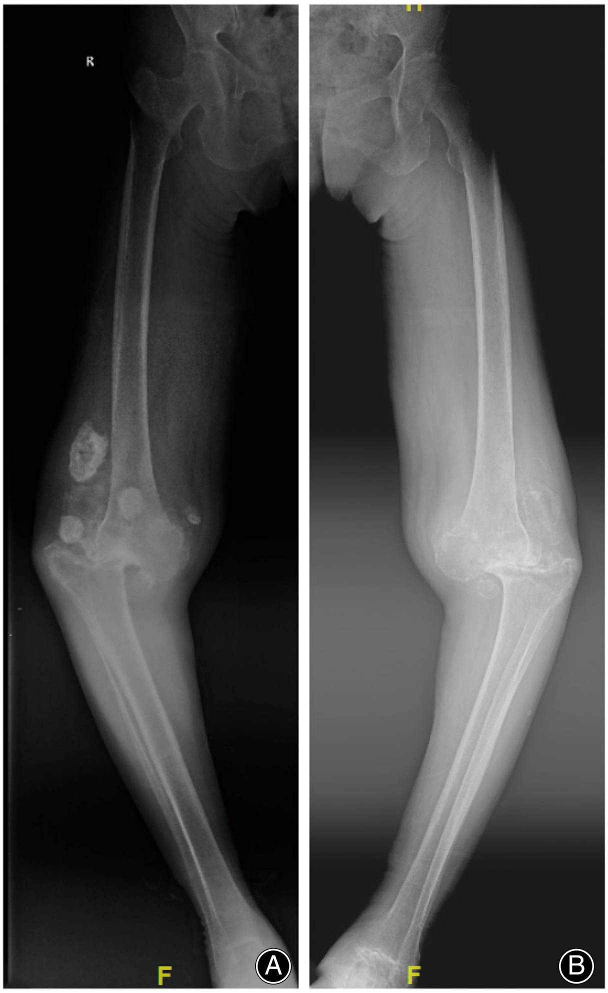


FIGURE 3 Preoperative imaging. Anteroposterior weight-bearing standing radiograph of (A) right lower limb and (B) left lower limb

FIGURE 4 Preoperative imaging. (A) anteroposterior radiograph and (B) lateral radiograph of the left elbow. (C) anteroposterior radiograph and (D) lateral radiograph of the right elbow

intraoperatively made based on the ligament balancing techniques before and after cutting the distal femur and proximal tibia. The femoral and tibial components were implanted and cemented to the cut bone surface, and the stem extensions were press-fitted without cementing. The patella was resurfaced with cemented polyethylene components (Figure 5).

Postoperatively, the patient was managed according to the regular perioperative routine of total knee arthroplasty. On day 2 post-operation, the patient was able to place partial weight-bearing on the operated knee. On day 20 post-operation, the range of motion of the knee was 0° to 120°, together with restoration of knee stability and ability for full weight-bearing. Subsequently, TKA was performed on the other knee using the same technique. Postoperative observations were similar to the first operated knee. Outpatient examination was performed 6 months postoperatively. The range of motion of both knees was 0° to 140°. The patient was able to walk normally without assistive devices. Both knees were stable and in satisfactory alignment (Figure 6). Radiological examination showed no evidence of dislocation or progressive loosening of the prosthesis (Figure 7). When followed up at 2 years after surgery, the patient reported no knee pain and was able to ambulate normally throughout her residence without assistance. She continued to walk approximately 4000 steps daily with 0° to 140° knee range of motion.

Discussion

Neuropathic arthropathy is a rare condition, without a good estimate of its prevalence, and a large portion of the limited literature available on this topic is quite dated. Main clinical manifestations include pain and joint instability.[11] X-ray findings include joint subluxation, fragmentation, joint destruction, and presence of excessive detritus of periarticular cartilage or bone.[12] At present, the mechanism of neuropathic arthropathy is poorly understood. The clinical presentation of neuropathic arthropathy is often misleading, and can easily result in misdiagnosis. Since it can present as painless arthropathy, neuropathic arthropathy of the knee

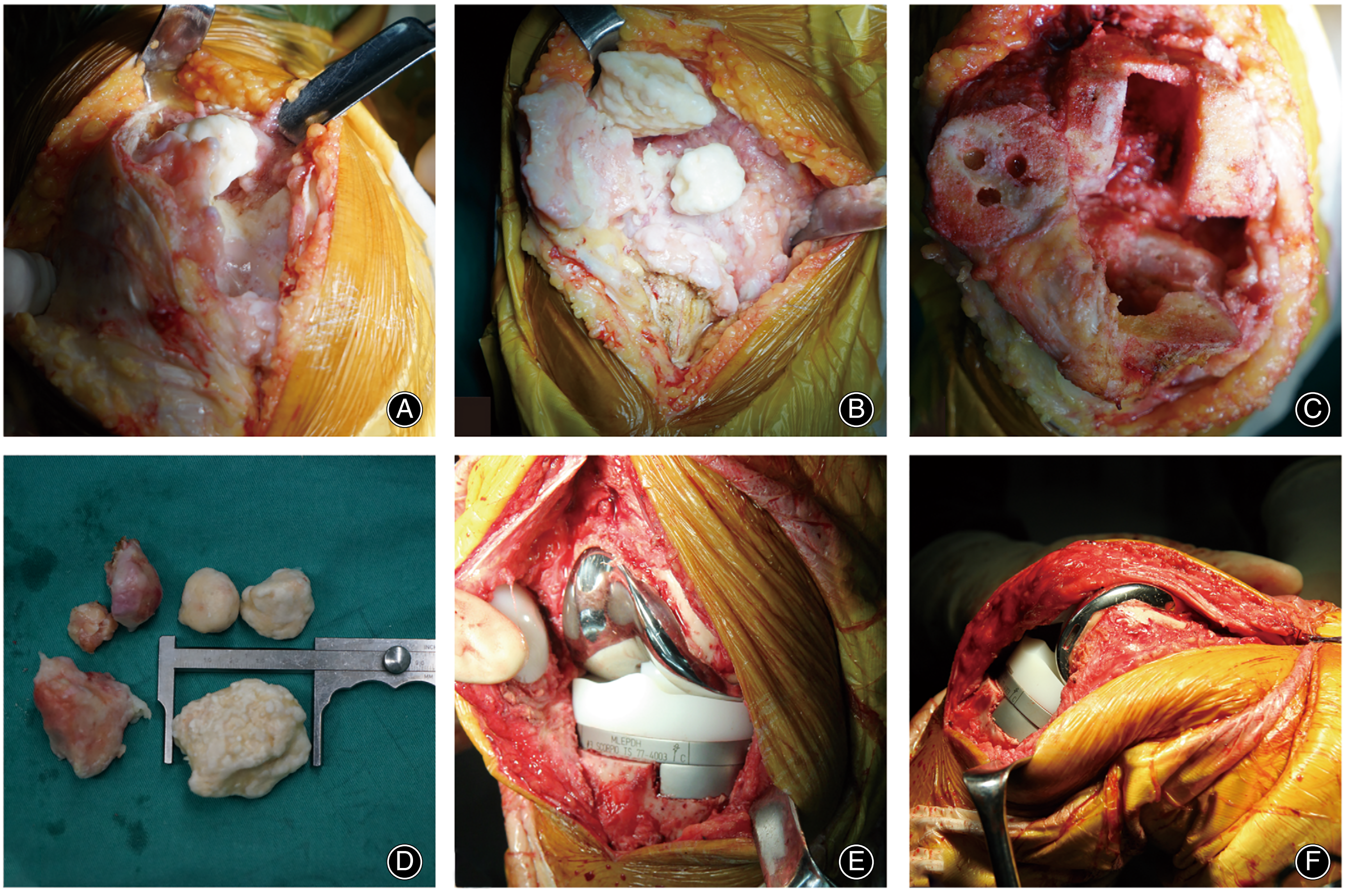


FIGURE 5 Intraoperative findings: (A, B) large amount of synovial hyperplasia of the knee joint and hyperplastic tissue and numerous bone fragments. (C) intraoperative osteotomy. (D) numerous bone fragments. (E) prothesis implantation. (F) patella trajectory

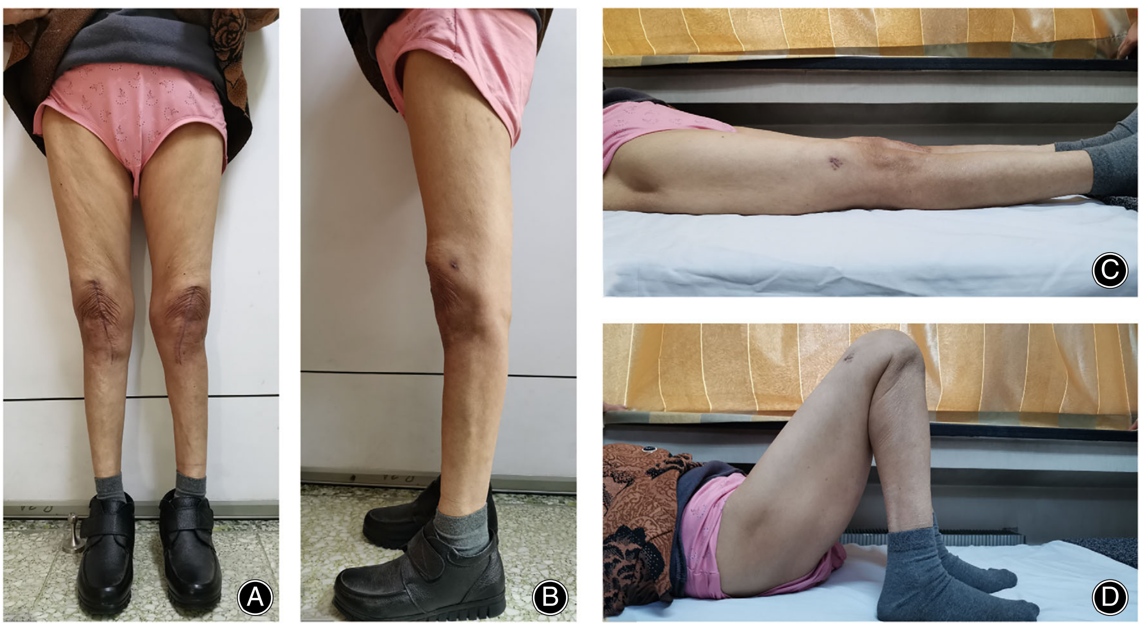


FIGURE 6 Postoperative outpatient examination after 6 months: (A) anteroposterior and (B) lateral of the both knees. (C, D) Range of motion of both knees

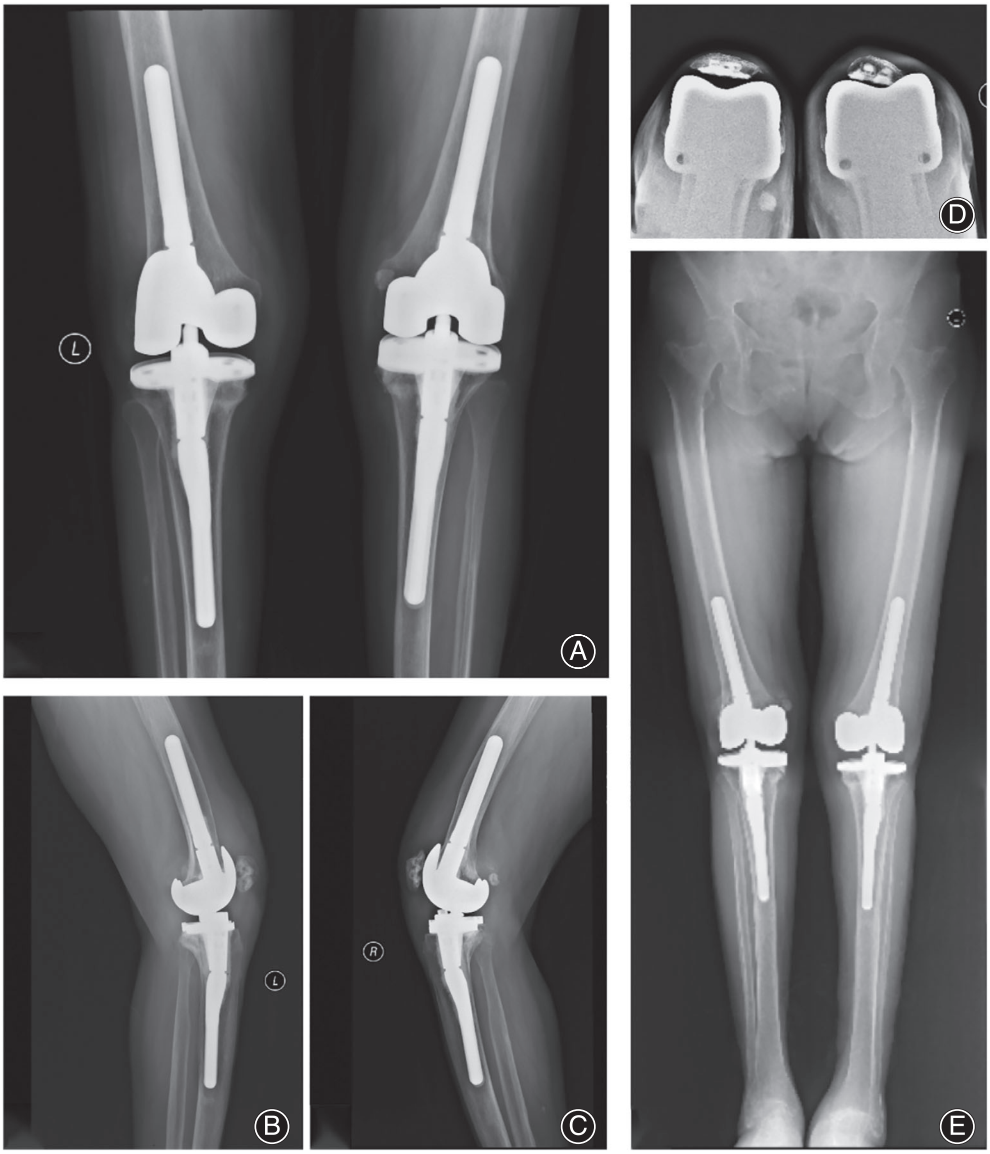


FIGURE 7 Postoperative imaging after 6 months: (A) anteroposterior radiograph of both knees. Lateral radiograph of (B) left knee and (C) right knee. (D) axial radiograph of both patellar. (E) anteroposterior weight-bearing standing radiograph of both lower limbs

should be considered when the severity of pain is not related to joint destruction and severity.[13] The ideal treatment for Charcot knee has remained controversial. Due to previously high failure rate and complication rate of joint arthroplasty, joint fusion was originally considered the treatment of choice. However, it was not widely available due to loss of knee mobility and unsatisfactory results, which were unacceptable for most patients.[14] With advances in joint replacement technology, TKA has become a preferred treatment for Charcot knee, which can effectively relieve joint pain and improve joint function, and has produced satisfactory results in a number of cases.[10] Nevertheless, prosthesis selection and surgical technique should be carefully considered before performing TKA for Charcot knee.[3,10]

We surveyed the available case reports on using TKA to treat Charcot knee in the last 20 years from PubMed database (Figure 8). The etiology, surgical prosthesis, and postoperative complications collectively reported in 14 studies, for 106 patients with Charcot knees who underwent TKA are summarized in Table 1. Kim et al.[15] and Parvizi et al.[12] reported higher incidence of postoperative complications, among which aseptic loosening, prosthesis dislocation, and periprosthetic fracture were the most frequent complications. Severe bone destruction and ligament instability are other major causes of postoperative complications in Charcot knee treated with TKA. Therefore, the choice of prosthesis may be an important factor in providing intrinsic stability of the knee joint and improving postoperative outcomes, in addition to operative factors such as ligament balancing and filling of bone defects. Kim et al.[15] suggested that constrained prostheses, such as hinged prostheses, may provide better intrinsic stability. However, such constraint may also

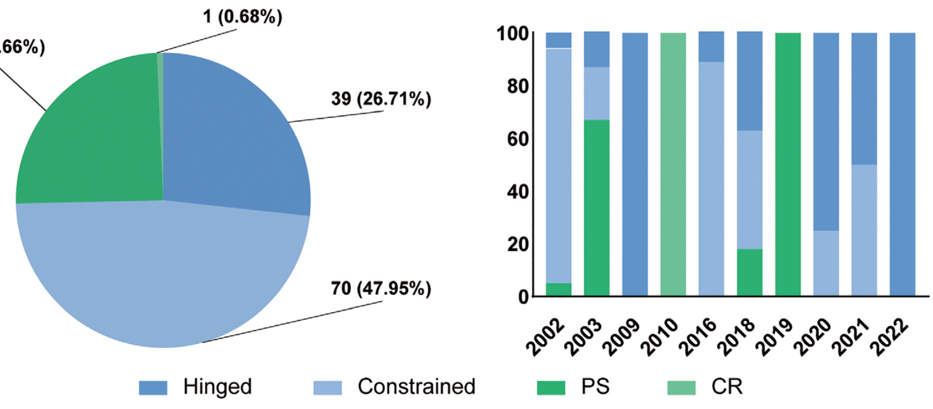


FIGURE 8 (A) Proportion of prostheses used in total knee arthroplasty for Charcot knee in recent 20 years. (B) Proportion of each type of prosthesis in the annual use of prosthesis in the past 20 years

transmit increased stress to the cement-bone and cement-implant interfaces, leading to higher rates of aseptic loosening compared to less-constrained designs. Condylar constrained prosthesis designs aim to reduce the amount of bone material needed for subsequent repair, thus reducing the risk of aseptic loosening. This has been the prosthesis of choice in TKA for treating Charcot knee for nearly 20 years (Figure 1).[16,17] Parvizi et al.[12] also reported that only one failure was among 10 TKA with condylar constrained prostheses in a study by Doherty et al.[18]

On the other hand, Bae et al.[19] reported that severe deformity of the Charcot knee leads to the need for extensive bone excision, resulting in greater bone loss, and is hence difficult to treat due to poor bone quality. A rotating hinge prosthesis could be recommended for patients with severe deformities and bone defects. In this case, ligamentous laxity could stabilize internal fixation and axial rotation could protect tibial stem anchorage. Using this prosthesis, it is necessary to achieve good cement implantation during the operation, and provide postoperative care education for patients. Rotating hinge prosthesis could provide better three-dimensional freedom, and has been more frequently chosen for TKA to treat Charcot knee in the last 10 years (Figure 2).[20,21] Recently, more studies[5,6,9,10,22–28] reported the use of condylar constrained prostheses and rotating hinge prostheses with satisfied results for TKA in Charcot knee.

It should be noted that there is currently no "standard" treatment of Charcot knee. Although TKA has provided good outcomes, the available clinical evidence is limited, and TKA may be associated with a high complication rate and revision rate due to the complexity of the disease etiology. Meanwhile, due to significant bone loss, poor bone quality, and ligament relaxation in patients with Charcot knee, postoperative complications and methods to reduce their incidence should be specifically considered during preoperative planning, including possible periprosthetic fracture, aseptic loosening, knee instability, and joint infection.[19] Condylar constrained prothesis appears to be a suitable choice for TKA of Charcot knee, while rotating hinge prosthesis may be recommended for severely unstable knee joints.[12,15] Some common operating principles of TKA are also recommended, such as ensuring intraoperative ligament balance, bone alignment, replacement of bone defects, and use of restrictive prostheses. Postoperative analgesia, anticoagulation, infection prevention, detumescence, and other treatments, together with avoidance of weight-bearing for 6 weeks may help to further improve recovery.[9,12]

For various reasons, the patient in this paper could not be followed up in the outpatient clinic, and we interviewed the patient by telephone 2 years after surgery. The patient was satisfied with the results of her treatment. Therefore, this paper focused more on the surgical approach, prosthesis application, and perioperative management, and we will continue to follow-up the patient's postoperative knee function and prosthesis survival rate in the future.

Conclusion

TKA with restrictive prosthesis designs may be considered a viable option for treating Charcot knee. The choice of prosthesis and the management of ligaments and damaged joint structures will affect the postoperative outcomes. In addition, understanding the underlying determinants, risk of survival, and complications associated with TKA may help surgeons during decision-making for patients with Charcot knee.

Acknowledgments

This study was supported by Beijing Natural Science Foundation Funds (No. 7214261, No. L222087).

Conflicts of Interests

The authors declare that they have no conflict of interest.

Author Contributions

Project conceptualization: Mei, F.Y., Xing, D., & Lin, J.H.

Reporting & editing: Mei, F.Y., Li, J.J., Xing, D., & Lin, J.H.

Final approval of the version to be submitted: Mei, F.Y., Li, J.J., Zhou, D.G., Xing, D., & Lin, J.H.

Project guarantor: Xing, D. & Zhou, D.G.

All authors have read and approved the manuscript.

References

1. Lee L, Blume PA, Sumpio B. Charcot joint disease in diabetes mellitus. Ann Vasc Surg. 2003;17:571–80.
2. Fullerton BD, Browngoehl LA. Total knee arthroplasty in a patient with bilateral Charcot knees. Arch Phys Med Rehabil. 1997;78:780–2.
3. Babazadeh S, Stoney JD, Lim K, Choong PF. Arthroplasty of a Charcot knee. Orthop Rev. 2010;2:e17.
4. Rattanaprichavej P, Towiwat P, Laoruengthana A, Dilokthornsakul P, Chaiyakunapruk N. Mid- to long-term outcomes of contemporary total knee arthroplasty in Charcot neuroarthropathy: a systematic review and meta-analysis. EFORT Open Rev. 2021;6:556–64.
5. Tsamassiotis S, Windhagen H, Ettinger M. Bilateral primary total knee arthroplasty and reconstruction of the medial tibial plateau by an asymmetric cone in a patient with Charcot arthropathy. Case Rep Surg. 2021;2021: 9965640.
6. Alshaygy I, Alzahim M, Alhamdan H, Aljassir F. Total knee arthroplasty with megaprosthesis for idiopathic Charcot knee. J Am Acad Orthop Surg Glob Res Rev. 2021;5:e2000158.
7. Hanft JR, Goggin JP, Landsman A, Surprenant M. The role of combined magnetic field bone growth stimulation as an adjunct in the treatment of neuroarthropathy/Charcot joint: an expanded pilot study. J Foot Ankle Surg. 1998;37:510–5.
8. Soudry M, Binazzi R, Johanson NA, Bullough PG, Insall JN. Total knee arthroplasty in Charcot and Charcot-like joints. Clin Orthop Relat Res. 1986;208: 199–204.
9. Du W, Dai R, Chen R, Shen F. Rotation-hinged knee prosthesis for the treatment of Charcot arthropathy: a case report and literature review. J Int Med Res. 2021;49:3000605211058871.
10. Zeng M, Xie J, Hu Y. Total knee arthroplasty in patients with Charcot joints. Knee Surg Sports Traumatol Arthrosc. 2016;24:2672–7.
11. Strauss E, Gonya G. Adjunct low intensity ultrasound in Charcot neuroarthropathy. Clin Orthop Relat Res. 1998;349:132–8.
12. Parvizi J, Marrs J, Morrey BF. Total knee arthroplasty for neuropathic (Charcot) joints. Clin Orthop Relat Res. 2003;145–50.
13. Pitocco D, Scavone G, Di Leo M, Vitiello R, Rizzi A, Tartaglione L, et al. Charcot neuroarthropathy: from the laboratory to the bedside. Curr Diabetes Rev. 2019;16:62–72.
14. Drennan DB, Fahey JJ, Maylahn DJ. Important factors in achieving arthrodesis of the Charcot knee. J Bone Jt Surg. 1971;53:1180–93.
15. Kim YH, Kim JS, Oh SW. Total knee arthroplasty in neuropathic arthropathy. J Bone Jt Surg. 2002;84:216–9.
16. Fujiwara T, Fujimura K, Hamai S, Kamura S, Nakashima Y, Miyahara H. Mid-term clinical outcome of constrained condylar knee prosthesis for patients with rheumatoid arthritis. Mod Rheumatol. 2019;29:596–601.
17. Kim YH, Park JW. Long-term (up to 21 years) survival of revision Total knee arthroplasty with use of a constrained condylar knee prosthesis: a concise follow-up of a previous report. J Bone Jt Surg. 2020;102:674–8.
18. Doherty WPRJ, Bryan RS. Total knee arthroplasty in neuropathic arthropathy. In: Rand JA, Dorr LD, editors. Total Knee Arthroplasty of the Knee: Proceedings of the Knee Society, 1985–1986. Rockville, MD: Aspen Publishers, Inc; 1987. p. 279–85.
19. Bae DK, Song SJ, Yoon KH, Noh JH. Long-term outcome of total knee arthroplasty in Charcot joint: a 10- to 22-year follow-up. J Arthroplasty. 2009;24: 1152–6.
20. Samiezadeh S, Bougherara H, Abolghasemian M, D'Lima D, Backstein D. Rotating hinge knee causes lower bone-implant interface stress compared to constrained condylar knee replacement. Knee Surg Sports Traumatol Arthrosc. 2019;27:1224–31.
21. León-Román VE, García-Mato D, López T II, Vaquero-Martín FJ, Calvo-Haro JA, Pascau J, et al. The knee prosthesis constraint dilemma: biomechanical comparison between varus-valgus constrained implants and rotating hinge prosthesis. A cadaver study. J Orthop Res. 2021;39:1533–9.
22. Kucera T, Urban K, Sponer P. Charcot arthropathy of the knee. A case-based review. Clin Rheumatol. 2011;30:425–8.
23. Chun KC, Kweon SH, Jeong KJ, Kim KM, Chun CH. The fate of allogeneic femoral head bone grafts using Varus-Valgus constrained total knee arthroplasty in neuropathic joints. J Arthroplasty. 2016;31:2778–83.
24. Tibbo ME, Chalmers BP, Berry DJ, Pagnano MW, Lewallen DG, Abdel MP. Primary total knee arthroplasty in patients with neuropathic (Charcot) arthropathy: contemporary results. J Arthroplasty. 2018;33:2815–20.
25. Nozaka K, Miyakoshi N, Yuasa Y, Mita M, Shimada Y. Simultaneous total knee arthroplasty and ankle arthrodesis for Charcot neuroarthropathy. Case Rep Orthop. 2019;2019:6136409–8.
26. Karageorgos A, Papadopoulos AX, Gelalis ID, Matzaroglou C. Bilateral total knee arthroplasty for Charcot arthropathy after cauda equine syndrome: a case report. J Med Cases. 2020;11:49–53.
27. Yoshikawa R, Kitagawa A, Inokuchi T, Shima N, Hashimoto Y. Staged bilateral total knee arthroplasty in a patient with Charcot knees: a case report. J Orthop Case Rep. 2020;10:9–12.
28. Alghamdi MS, Reda B, Albukhari SN, Qoqandi MA. Arthroplasty of a Charcot knee in a patient with congenital insensitivity to pain. Cureus. 2022;14:e24116.