Injury, Int. J. Care Injured xxx (2019) xxx–xxx

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

The use of knee mega-prosthesis for the management of distal femoral fractures: A systematic review

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ARTICLE INFO

Article history:
Received 2 July 2019
Accepted 10 August 2019

Keywords:
Distal femoral fractures
Knee replacement
Megaprothesis
Non oncological fractures
Knee fractures

ABSTRACT

Introduction: Distal femur fractures (DFFs) are unusual and difficult to deal, especially in elderly patients. A consensus about a gold-standard treatment has not been reached yet. Available options include both conservative and surgical management. In elderly patients a prosthetic replacement could be a valid treatment option. Literature is lacking about the use of mega-prosthesis in this type of fractures. The purpose of the present systematic review is to examine which fracture, both acute and chronic, involving distal femur should be treated by using a mega-prosthesis.

Materials and Methods: Studies were identified by searching electronic databases. All studies that enrolled people of any age affected by a DFFs treated by using a megaprosthesis were included. Primary outcomes of the present reviews were: ROM, functional assessment and complications. Two review authors independently selected eligible trials. Disagreements at any stage were resolved by consensus or a third party adjudication. Descriptive statics was used to summarize the data.

Results: Thirteen article were finally included in the review. One hundred-four patients were treated with knee megaprosthesis. Three categories of patients were identified: 29 patients were affected by supracondylar femur fracture; 51 patients occurred with a periprosthetic fracture; 24 patients suffered a non-union of a previous supracondylar fracture. The follow-up varied between 6 months to 58 months. All studies showed good results in terms of improving quality of life, resuming activities of daily living (ADLs), early mobilization, ROM, shorter hospital stay. Although not frequent, the only reported complications were infection and aseptic loosening.

Discussion: The present review showed that the use of knee megaprosthetic implants could represent a valid treatment option aiming to reduce patients' immobilitazion and hospital stay. Good clinical outcomes with low rate of complications were reported by all included studies. Literature is lacking about long-term outcomes and complications. Moreover studies comparing knee prostheses and other types of surgical treatment (intramedullary nails, plate fixation system) are needed.

Conclusions: Megaprosthesis represent a viable treatment option in patients affected by DFFs (either acute, periprostethic or non-union) because they allow immediate weight-bearing, shorter hospital stay, a fast recovery of knee function and ADLs.

Introduction

Distal femur fractures (DFFs) are unusual and difficult to deal. Their incidence range from 0.3 to 2.5% and are prevalent in female gender with a ratio of M:F = 1:3. Young as well as elderly patients can undergo a distal femur fracture by different mechanisms. An high energy trauma is usually the leading cause in the young population, whereas direct or indirect low energy traumatic mechanisms are the main responsible of this type of fractures in elderly [1]. Main risk factors are: female gender, rheumatoid arthritis, presence of large osteolytic lesions, osteoporosis, previous surgical treatments of that bone segment [2], as for example a hip or knee prosthesis. The most frequent types of DFFs are supracondylar fractures [3], followed by nonunion fractures of DFFs and periprosthetic fractures (Fig. 1A,B). Currently a consensus about a gold-standard treatment has not been reached yet. Available options include both conservative and surgical management. Surgical options range from plates, plates and allograft, intramedullary nails, replacement prosthesis up to arthrodesis. In young patients best treatment are open reduction and internal fixation by using a plate or intramedullary nail fixation. In elderly patients a prosthetic replacement is surely a valid treatment

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https://doi.org/10.1016/j.injury.2019.08.011
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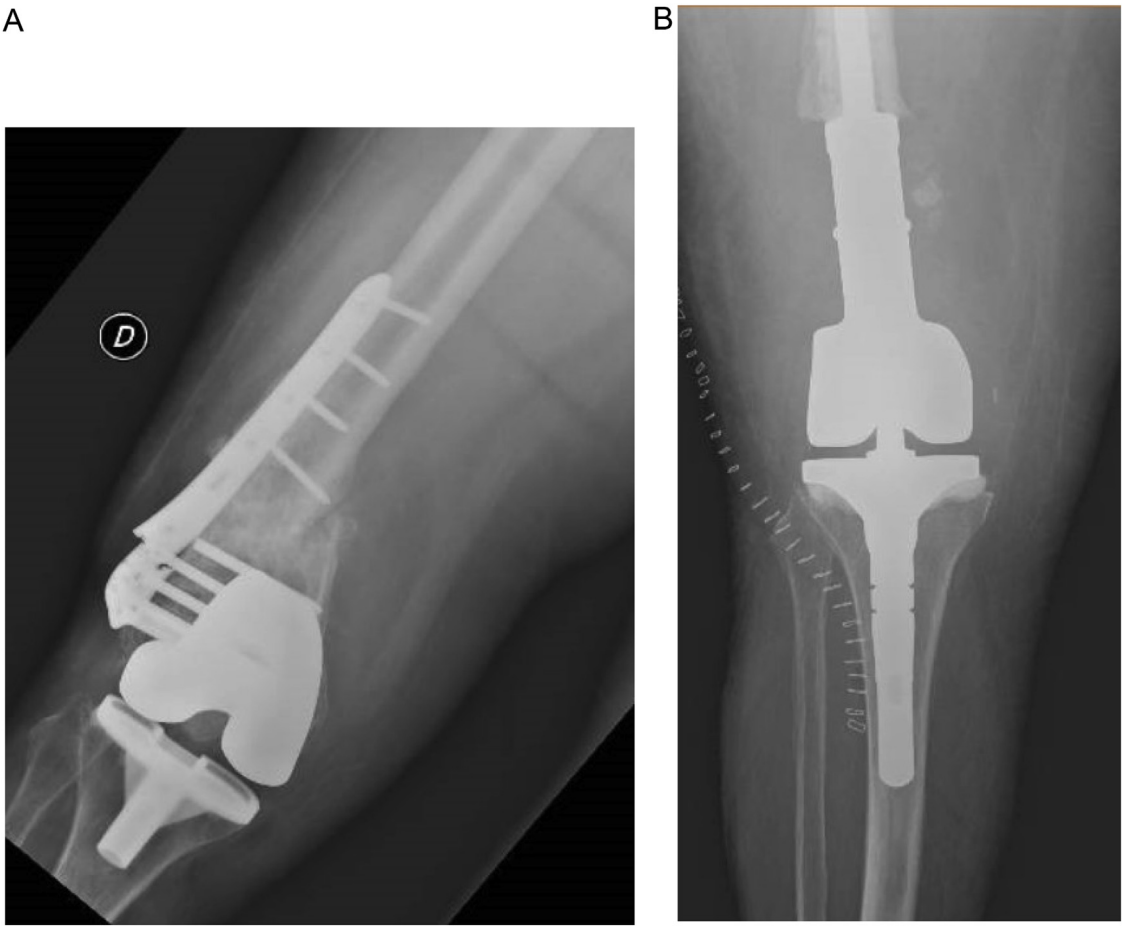

Fig. 1. A) X-rays AP view: non union of periprosthetic fractures previously treated by plate fixation. B) x-rays AP view: megaprosthesis.

option, because it allows early mobilization by decreasing complications related to immobilization, bone healing and non-weightbearing, as well as meeting the low functional requirements of some patients [4]. Several types of knee replacements are currently available, ranging from primary implants to hinge prosthetic implants. Mega-prosthetic implants were first introduced in the oncological orthopedic surgery, in order to treat primary or secondary tumor lesions that require massive bone resections [5–7]. Literature is lacking about the use of mega-prosthesis in case of distal femur fractures (Fig. 3A,B).

The purpose of the present systematic review is to examine which fracture, both acute and chronic, involving distal femur should be treated by using a mega-prosthesis.

Materials and methods

This systematic review was conducted following the PRISMA guideline [8].

All studies that enrolled people of any age affected by a DFFs treated by using a megaprosthesis were included. Only published data on peer review journals were considered.

Exclusion criteria were reviews, expert opinions, editorial pieces, and studies enrolling oncologic patients or patients treated conservatively or by using different total knee replacements or fixation techniques, such as plate or intramedullary nails.

The diagnosis of DFFs was based on clinical or radiological evaluation.

Primary outcomes of the present reviews were: ROM, functional assessment and complications. Secondary outcomes were any other outcome measurements reported by each included study.

Studies were identified by searching electronic databases. There were no restrictions on the date of publication or the language. This search was applied to MEDLINE through OVID (1946 to March, 20th 2019), and adapted for the Cochrane Library. See Appendix for the MEDLINE search strategy.

Two review authors independently selected eligible trials from title and abstract. Subsequently, they analysed the full text to confirm the inclusion in the study and extracted the data using a piloted form. Titles of journals, names of authors or supporting institutions were not masked at any stage. No attempt was made to contact trialists regarding trial methodology and findings. Disagreements at any stage of the review process were resolved by consensus or a third party adjudication. If possible, the data were pooled. Otherwise a descriptive statics was used to summarize the data.

Results

Thirteen article were finally included in the review (Fig. 2). Level of evidence was IV in 12 of them and V in one study. One hundred-four patients were treated with knee megaprosthesis. Three categories of patients were identified: 29 patients were affected by supracondylar femur fracture; 51 patients occurred with a periprosthetic fracture; 24 patients suffered a non-union of a previous supracondylar fracture (Table 1). In the included studies 23 patients were females, 8 patients were males. In 73 cases patients sex was not specified. The patients average age in the

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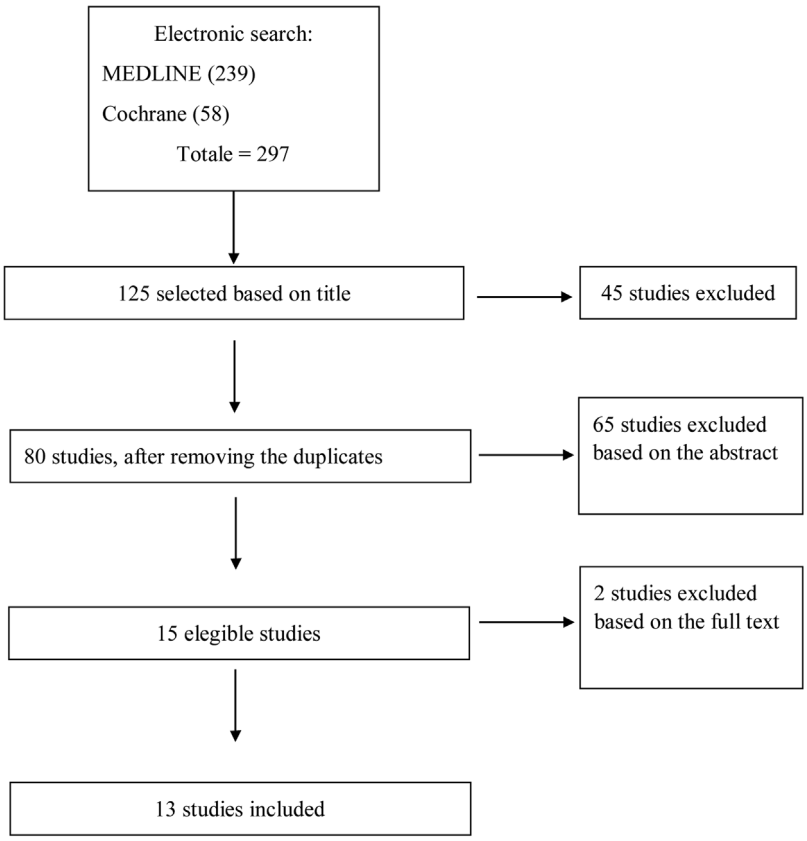

Fig. 2. PRISMA flowchart.

Table 1
The table shows literature analysis, studies level of evidence (LOE) and kind of fractures treated.

Authors	Year	LOE	Fracture Type
Madsen [21]	1989	IV	Periprosthetic
Berend [16]	1999	IV	Periprosthetic Supracondylar Non-union
J. Keenan [13]	2000	IV	Periprosthetic
Springer [15]	2001	IV	Periprosthetic Supracondylar Non-union of supracondylar fracture
Springer [14]	2004	IV	Non-union of periprosthetic fracture Non-union of supracondylar fracture Acute periprosthetic fracture
Pearse [4]	2005	IV	Supracondylar
Harrison [17]	2006	V	Periprosthetic
Vaishya [18]	2011	IV	Non-union of supracondylar femur fracture
Wakabayashi [9]	2011	IV	Supracondylar
Saidi [12]	2014	IV	Periprosthetic
Clayton C. Bettin [19]	2016	IV	Supracondylar
Hyung-Suk Choi [10]	2016	IV	Periprosthetic
Gan [11]	2018	IV	Periprosthetic

included studies is 74, 2 (range 46–94) years. AO classification system [8] was used by 3 studies [4,9] and mostly identified type C fractures, even though also fractures A and B were collected. Rorabeck classification [10] for classification of periprosthetic fractures were used in 2 studies [10,11] use, while only one [12] used the Backstein classification [13]. Seven studies [13–18] did not remind to any specific classification: fractures were only defined as "supracondylar".

The follow-up varied between 6 months to 58 months. Several types of prosthesis were used (Table 2). All studies showed good results by using megaprosthetic implants in terms of improving quality of life, resuming activities of daily living (ADLs), early mobilization, ROM, shorter hospital stay.

Pain evaluation was considered in only 5 studies [9,11,13,14,16]: patients referred a better pain control, but none of the authors used a specific pain scale. In order to quantify ROM and knee function improvement, different scales have been used: 8 studies [9,15,16,18,19] reported the American Knee Society Score [20], 2 studies the HSS Knee Rating Scale [8–11,13,14,16,18]. In addition, Bristol [13] and Oxford Knee Score [22] were used each in one study [4,15], while no knee functional scores were reported in one study [17]. Seven studies reported the complications related to this kind of surgery. The most frequent complication noticed in these studies [9,10,15,18,19] was deep infection. Out of 61 patients, 18 patients (29%) developed deep implant infection. One of them was due to a previous positioning of a skeletal pin traction [13]. Wound complications were also noticed in 12 patients out of 61 [10,13,15,19]. Implant loosening was reported in 9 patients [15], however only one cases required revision for aseptic loosening. A strict clinical and radiographical follow up was carried out for the remaining cases.

Discussion

Comminute DFFs, periprosthetic fractures and supracondylar fracture non-unions still represent a challenge for the orthopaedic surgeon. Elederly patients are particularly exposed to this type of fracture, even in case of low-energy traumas (Fig. 3A,B). Taking this into consideration, the present review showed that the use of knee megaprosthetic implants could represent a valid treatment option aiming to reduce patients' immobilitazion and hospital stay (Fig. 4A,B). Good clinical outcomes with low rate of complications were reported by all included studies [9,10,12,19]. Moreover, ROM

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Table 2
The table shows literature analysis; for each study mean age, kind of megaprosthesis, range of motion (ROM), functional outcomes and FU (follow-up) are reported.

Authors	Patients	Mean AGE	Megaprosthesis	ROM	Functional evaluation tool	Score	FU
Madsen (1989) [21]	4	61-78	LINK	0-100°	HSS Knee Rating Scale	78,25	3 y
Berend 1999) [16]	15	52-91	Orthopaedic Salvage System (OSSTM; Biomet)	0-106°	American Knee Society Score	87	2 y
J. Keenan (2000) [13]	7	69-87	PFC Johnson and Johnson	0-90°	Bristol Knee Score	75-89	1 y
Springer (2001) [15]	15	46-89	Kinematic Rotating Hinged (KRH) knee	5-125°	American Knee Society Score	77	–
Springer (2004) [14]	13	47-92	Modular Segmental Kinematic Rotating Hinge (Howmedica)	0-90°	American Knee Society Score	75	58 m
Pearse (2005) [4]	6	>75	Stanmore Knee replacement	60-100°	Oxford Knee Score	60-12	6 m
Harrison (2006) [17]	2	66-72	–	3-92°	American Knee Society Score	85 Function 45	19 m
Vaishya (2011) [18]	8	68-85	Modular Resection System (Stryker, Howmedica)	3-102°	American Knee Society Score	84-92	4 y
Wakabayashi (2011) [9]	1	77	Kyocera limb salvage (KLS) tumor endoprosthesis.	0-135°	American Knee Society Score	95 Function 65	2 y
Saidi (2014) [12]	7	70-90	Stryker GMRS System	80° flexion	American Knee Society Score	72-92	6 m
Clayton C. Bettin (2016) [19]	18	62-94	LPS Limb Preservation System Depuy	1-99°	American Knee Society Score	87,5 Function 35	30 m
Hyung-Suk Choi (2016) [10]	1	70	Mutars IMPLANTCAST	0-95°	HSS Knee Rating Scale	86	2 y
Gan (2018) [11]	7	59-86	NCB Distal Femur System (Zimmer)	–	–	–	44 m

Fig. 3. DFFs in a osteoporosis woman: A) X-rays AP view, B) X-rays lateral view.

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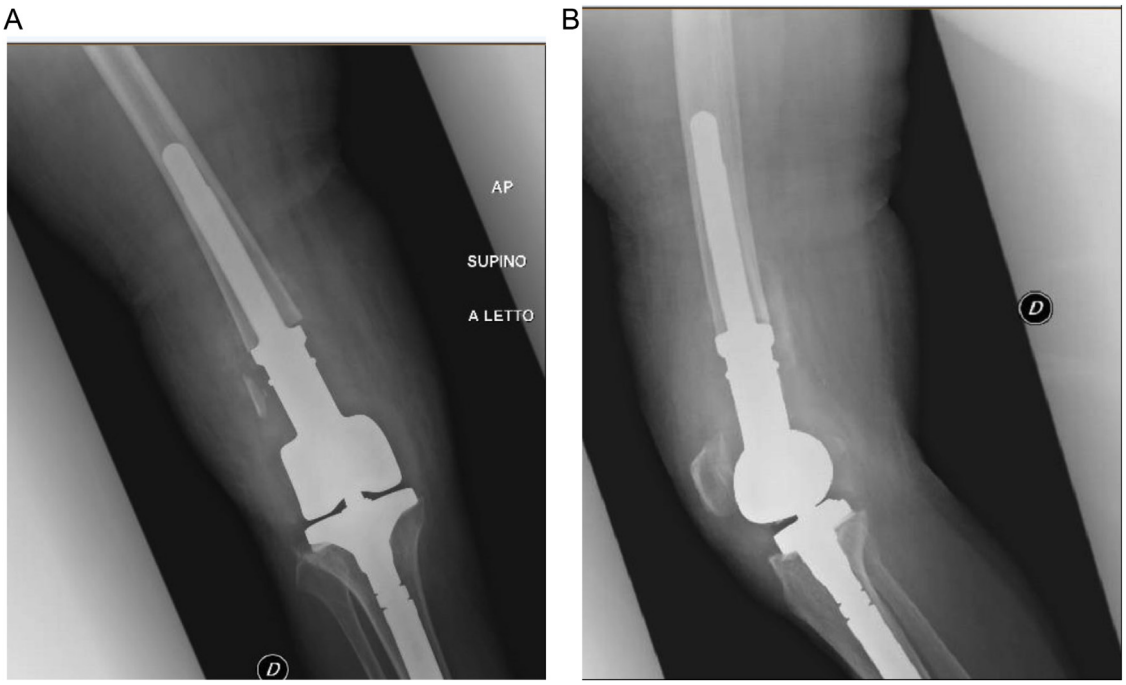

Fig. 4. Post-operative X-rays: DFFS treated by a megaprosthesis: A) AP view, B) lateral view.

restoration and a faster recovery seemed to lower costs and complication rates due to the prolonged hospital stay [4,11,12].

Three main groups of fractures could be identified. However, no differences could be detected in terms of clinical outcomes. Although complications were not reported by all studies, deep infections [9,10,13,15,19] and wound complications [10,13,15,19] were the most reported. Saidi et al. [18] did not report any complications in the DFFs group, but it must be noticed that only a six months follow-up were carried out. Therefore, long-term complications can not be excluded.

Some other reviews have been previously published on the management of DFFs. Chen et al. [19] differently from the present paper, concluded that modular implants may be suitable for comminuted intra-articular fractures, whereas extra-articular fractures could be treated with fixation techniques [23]. However, since comparative studies are lacking, it is not possible to draw a definitive conclusion. Parratte et al. [12]conducted a narrative review. The authors analysed operative times, blood loss, early mobilization and functional recovery after total knee replacement and concluded that it is a viable option in elderly patients [24]. Several recent case reports and case series have also described the use of a custom intramedullary coupling device in treating supracondylar femoral fractures [25]. Newman et al. [24] showed a case of supracondylar fracture between THA and long-stemmed TKA femoral components. This patient was treated by a long custom intramedullary intercalating component that linked the well-fixed existing THA stem to the revision TKA distal femoral component [26]. The present reviewed focused only on indications and results after using megaprosthesis implants.

The limits of the present review are mainly due to the low level of evidence of the included studies. Although several categories of diagnosis were included, there was no possible to conduct a subgroup analysis given to the low number of patients. Several kinds of megaprosthesis were used. Moreover, a data pooling was not possible either because different scales or no evaluation tools were reported. Complications were also overlooked, since some studies reported a short term follow up [4,15,18], while some others did not reported complications at all [4,10,11,16,18,21]. Finally none of the included studies reported data about patients' mortality, which is surely the most severe complication in this kind of surgery. A five-year survival rate of 79.8% has been reported [27]. Mortality rate should be considered in these studies, not only as surgical complication itself, but also as an epidemiological factor to evaluate both patient and overall implant survival.

Conclusions

Megaprosthesis represent a viable treatment option in patients affected by DFFs (either acute, periprostethic or non-union) because they allow immediate weight-bearing, shorter hospital stay, a fast recovery of knee function and ADLs. Up to now, there is no diagnostic-therapeutic algorithm that correlates the type of DFFs to the use of a megaprosthetic implant and literature is lacking of high evidence level studies showing long-term outcomes in non-oncologic patients. Futures studies are needed.

References

[1] Ehlinger M, Ducrot G, Adam P, Bonnomet F. Distal femur fractures. Surgical techniques and a review of the literature. Orthop Traumatol Surg Res 2013;99:353–60, doi:http://dx.doi.org/10.1016/j.otsr.2012.10.014.
[2] Marsland D, Mears SC. A review of periprosthetic femoral fractures associated with total hip arthroplasty. Geriatr Orthop Surg Rehabil 2012;3:107–20, doi:http://dx.doi.org/10.1177/2151458512462870.
[3] Whitehouse MR, Mehendale S. Periprosthetic fractures around the knee: current concepts and advances in management. Curr Rev Musculoskelet Med 2014;7:136–44, doi:http://dx.doi.org/10.1007/s12178-014-9216-0.
[4] Pearse EO, Klass B, Bendall SP, Railton GT. Stanmore total knee replacement versus internal fixation for supracondylar fractures of the distal femur in elderly patients. Injury 2005;36:163–8, doi:http://dx.doi.org/10.1016/j.injury.2004.04.007.
[5] Reddy VG, Mootha AK. Total Knee Arthroplasty as Salvage for Non Union in Bicondylar Hoffa Fracture: a report of two cases. J Orthop Case Rep n.d.;1:3.
[6] Gautam D, Malhotra R. Megaprosthesis versus Allograft Prosthesis Composite for massive skeletal defects. J Clin Orthop Trauma 2018;9:63–80, doi:http://dx.doi.org/10.1016/j.jcot.2017.09.010.
[7] De Gori M, Scoccianti G, Frenos F, Bettini L, Familiari F, Gasparini G, et al. Modular endoprostheses for nonneoplastic conditions: midterm complications and survival. Biomed Res Int 2016;2016:1–5, doi:http://dx.doi.org/10.1155/2016/2606521.

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[8] Ebraheim NA, Kelley LH, Liu X, Thomas IS, Steiner RB, Liu J. Periprosthetic distal femur fracture after total knee arthroplasty: a systematic review. Orthop Surg 2015;7:297–305, doi:http://dx.doi.org/10.1111/os.12199.
[9] Wakabayashi H, Naito Y, Hasegawa M, Nakamura T, Sudo A. A tumor endoprosthesis is useful in elderly rheumatoid arthritis patient with acute intercondylar fracture of the distal femur. Rheumatol Int 2012;32:1411–3, doi:http://dx.doi.org/10.1007/s00296-011-1897-8.
[10] Choi H-S, Nho J-H, Kim C-H, Kwon S-W, Park J-S, Suh Y-S. Revision arthroplasty using a MUTARS® prosthesis in comminuted periprosthetic fracture of the distal femur. Yonsei Med J 2016;57:1517, doi:http://dx.doi.org/10.3349/ymj.2016.57.6.1517.
[11] Gan G, Teo YH, Kwek EBK. Comparing outcomes of tumor prosthesis revision and locking plate fixation in supracondylar femoral periprosthetic fractures. Clin Orthop Surg 2018;10:174, doi:http://dx.doi.org/10.4055/cios.2018.10.2.174.
[12] Saidi K, Ben-Lulu O, Tsuji M, Safir O, Gross AE, Backstein D. Supracondylar periprosthetic fractures of the knee in the elderly patients: a comparison of treatment using allograft-implant composites, standard revision components, distal femoral replacement prosthesis. J Arthroplasty 2014;29:110–4, doi:http://dx.doi.org/10.1016/j.arth.2013.04.012.
[13] Keenan J, Chakrabarty G, Newman JH. Treatment of supracondylar femoral fracture above total knee replacement by custom made hinged prosthesis. Knee 2000;7:165–70, doi:http://dx.doi.org/10.1016/S0968-0160(00)00041-7.
[14] Springer BD, Sim FH, Hanssen AD, Lewallen DG. The modular segmental kinematic rotating hinge for nonneoplastic limb salvage. Clin Orthop 2004;421:181–7, doi:http://dx.doi.org/10.1097/01.blo.0000126306.87452.59.
[15] Springer BD, Hanssen AD, Sim FH, Lewallen DG. The kinematic rotating hinge prosthesis for complex knee arthroplasty. Clin Orthop 2001;392:283–91, doi:http://dx.doi.org/10.1097/00003086-200111000-00037.
[16] Berend KR, Lombardi AV. Distal femoral replacement in nontumor cases with severe bone loss and instability. Clin Orthop 2009;467:485–92, doi:http://dx.doi.org/10.1007/s11999-008-0329-x.
[17] Harrison RJ, Thacker MM, Pitcher JD, Temple HT, Scully SP. Distal femur replacement is useful in complex total knee arthroplasty revisions. Clin Orthop 2006;446:113–20, doi:http://dx.doi.org/10.1097/01.blo.0000214433.64774.1b.
[18] Vaishya R, Singh AP, Hasija R, Singh AP. Treatment of resistant nonunion of supracondylar fractures femur by megaprosthesis. Knee Surg Sports Traumatol Arthrosc 2011;19:1137–40, doi:http://dx.doi.org/10.1007/s00167-011-1416-1.
[19] Bettin CC, Weinlein JC, Toy PC, Heck RK. Distal femoral replacement for acute distal femoral fractures in elderly patients. J Orthop Trauma 2016;30:503–9, doi:http://dx.doi.org/10.1097/BOT.0000000000000600.
[20] Maempel JF, Clement ND, Brenkel IJ, Walmsley PJ. Validation of a prediction model that allows direct comparison of the Oxford Knee Score and American Knee Society clinical rating system. Bone Jt J 2015;97-B:503–9, doi:http://dx.doi.org/10.1302/0301-620X.97B4.34867.
[21] Madsen F, Kjaersgaard-Andersen P, Juhl M, Sneppen O. A custom-made prosthesis for the treatment of supracondylar femoral fractures after total knee arthroplasty: report of four cases. J Orthop Trauma 1989;3:332–7.
[22] Collins NJ, Misra D, Felson DT, Crossley KM, Roos EM. Measures of knee function: international knee documentation committee (IKDC) subjective knee evaluation form, knee injury and osteoarthritis outcome score (KOOS), knee injury and osteoarthritis outcome score physical function short form (KOOS-PS), knee outcome survey activities of daily living scale (KOS-ADL), lysholm knee scoring scale, oxford knee score (OKS), Western Ontario and McMaster universities osteoarthritis index (WOMAC), activity rating scale (ARS), and Tegner activity score (TAS). Arthritis Care Res 2011;63(Suppl. 11):S208–228, doi:http://dx.doi.org/10.1002/acr.20632.
[23] Chen F, Li R, Lall A, Schwechter EM. Primary total knee arthroplasty for distal femur fractures: a systematic review of indications, implants, techniques, and results. Am J Orthop (Belle Mead NJ) 2006;9.
[24] Parratte S, Ollivier M, Argenson J-N. Primary total knee arthroplasty for acute fracture around the knee. Orthop Traumatol Surg Res 2018;104:S71–80, doi:http://dx.doi.org/10.1016/j.otsr.2017.05.029.
[25] Lachiewicz PF. Periprosthetic fracture between a constrained total knee arthroplasty and a long-stem total hip arthroplasty: treatment with a novel device. J Arthroplasty 2007;22:449–52, doi:http://dx.doi.org/10.1016/j.arth.2006.04.001.
[26] Newman ET, Hug KT, Wellman SS, Bolognesi MP, Kelley SS. Custom intramedullary intercalating device for treatment of supracondylar fracture between constrained total knee arthroplasty and well-fixed total hip arthroplasty. Knee 2014;21:594–6, doi:http://dx.doi.org/10.1016/j.knee.2012.11.007.
[27] Pour AE, Parvizi J, Slenker N, Purtill JJ, Sharkey PF. Rotating hinged total knee replacement: use with caution. J Bone Joint Surg Am 2007;89:1735–41, doi:http://dx.doi.org/10.2106/JBJS.F.00893.

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