Supracondylar femoral dome extension osteotomy in treatment of knee flexion deformity

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Background
Flexion contracture of the knee can happen by different etiologies such as burns and scars, inflammatory conditions such as juvenile rheumatoid arthritis, and neuromuscular disorders such as cerebral palsy, poliomyelitis, and many others. Supracondylar femoral extension osteotomy is widely used in treatment of such type of deformities with good results. Dome osteotomy is a circular-shaped osteotomy. The authors conducted this study to assess the effectiveness of supracondylar femoral dome extension osteotomy (SCDEO) in management of sagital plane deformity in the form of fixed-flexion deformity of the knee.
Patients and methods
Seven patients (11 knees) with knee flexion deformity underwent SCDEO fixed by anatomical locked plate and screws, three patients had a bilateral deformity as sequelae of juvenile rheumatoid arthritis, while four patients as sequelae of poliomyelitis, and three of them had unilateral deformity, while only one patient had bilateral deformity. The knee flexion deformity angle ranged from 20 to 50° with a mean of 32°. Patients were followed up every 2 weeks with monthly radiographies done till full union of the osteotomy, full weight bearing was started at 4 weeks postoperatively, in bilateral cases, the other side was operated after full osteotomy union, and all patients were followed up for 12 months with radiographies to assess the knee flexion deformity angle.
Results
All osteotomies eventually united in the period ranging from 10 to 14 weeks (average 12 weeks), no postoperative infection, nonunion, neurological, or vascular compromise occurred. All of the patients were satisfied regarding improved gait and posture, the total range of knee motion at 12 months postoperatively ranged from 60 to 100° (average 85°). Knee flexion deformity angle measured at 12 months postoperatively ranged from 8 to 15° with an average of 11°. Only one patient with juvenile rheumatoid arthritis showed significant recurrence of the deformity at 12 months of follow-up postoperatively, with flexion deformity angles of 20 and 25° in the right and left knee, respectively, whereas the preoperative flexion deformity angle in this patient was 30 and 35° in the right and left knee, respectively.
Conclusion
SCDEO fixed by anatomical locked plate and screws is an effective means of management of knee fixed-flexion deformity.

Keywords:
anatomical locked plate distal femur, knee flexion deformity, poliomyelitis, juvenile rheumatoid arthritis, supracondylar femoral dome extension osteotomy

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Introduction

A flexion deformity of the knee is the inability to fully straighten the knee. In most cases, flexion deformities occur bilaterally. Two types of knee flexion contracture can be seen: that associated with joint destruction and that in which joint anatomy is preserved. In the first one, the aim of treatment is to get an ankylosed knee in a functional position, and in the second type, deformity correction and motion preservation [1,2].

Flexion contracture of the knee can happen by different etiologies such as burns, scars, congenital immobilization, intra-articular fractures, and septic arthritis, inflammatory conditions such as juvenile rheumatoid arthritis, and neuromuscular disorders such as cerebral palsy, poliomyelitis, and many others [3].

Various treatment types are available, including exercise, casting, an orthosis, soft-tissue procedures, and osteotomies, alone or in combination [4–7].

Supracondylar femoral extension osteotomy is widely used in treatment of such type of deformities with good results. Treatment of the more severe deformities is associated with serious complications such as insufficient correction, skin necrosis, leg-length discrepancy, fractures of the tibia or femur, neurovascular problems, and recurrence of deformity [8].

Dome osteotomy (DO) is a circular-shaped osteotomy. In contrast to opening- and closing-wedge osteotomies that do not preserve the limb length, DO preserves the length of the limb [9,10].

Supracondylar femoral dome extension osteotomy (SCDEO) was used in management of coronal plane deformities in the knee [11]. Our hypothesis was that it also can correct the saggital plane deformities. So we conducted our study to assess the effectiveness of SCDEO in management of saggital plane deformity in the form of fixed-flexion deformity of the knee.

Patients and methods

We conducted our study in Ain Shams University hospitals from 2014 to 2016; we selected seven patients with knee flexion deformity, four of the patients were females and three were males, age at the time of operation ranged from 16 to 19 years with a mean of 17.8 years. The study was approved by the institutional ethics committee in the Orthopedic Department of Orthopaedic Surgery, Ain Shams University, Cairo, Egypt. Three patients had a bilateral deformity as sequelae of juvenile rheumatoid arthritis, while four patients as sequelae of poliomyelitis, three of them had unilateral deformity, while only one patient had bilateral deformity. All patients were ambulatory. Only one patient with bilateral deformity as a sequelae of poliomyelitis underwent fractional hamstring lengthening 6 years prior to our procedure, no other patients underwent any previous interventions. All patients were informed about the procedure and an informed consent was taken.

All patients were assessed clinically and radiologically, the knee flexion deformity angle was measured as the angle between the femoral and tibial mid-diaphyseal axes in lateral view radiographs taken in maximum possible knee-passive extension. The knee flexion deformity angle ranged from 20 to 50° with a mean of 32°.

Surgical technique

All patients were operated in supine position under general anesthesia, the limbs were sterilized down to the feet to allow palpation of the dorsalis pedis arterial pulse intraoperatively, and no tourniquet was used. In bilateral cases only a single limb was operated at a surgical session, while the other limb was operated after full union of the osteotomy.

A lateral femoral approach was used, the supracondylar area was exposed to the medial cortex by a strictly subperiosteal dissection, a supracondylar DO was done, the line of the osteotomy was drawn in the supracondylar metaphyseal area using electrocautery as a curved line with the apex directed proximally, drill holes were done along this line, during drilling of the anterior cortex, the drill bit was directed 30 degrees cephalad, while during drilling of the posterior cortex, the drill bit was directed 30° caudally, and in three knees where the deformity angle exceeded 40°, the osteotomy was done using the same technique but at two levels with excision of a bony segment creating shortening of 2 cm to avoid vascular compromise due to acute correction of that severe flexion deformity.

After the osteotomy was complete, the knee was brought to the position of full extension, the dorsalis pedis pulse was checked, and fixation was done using anatomical locking distal femoral plate (Figs 1–3).

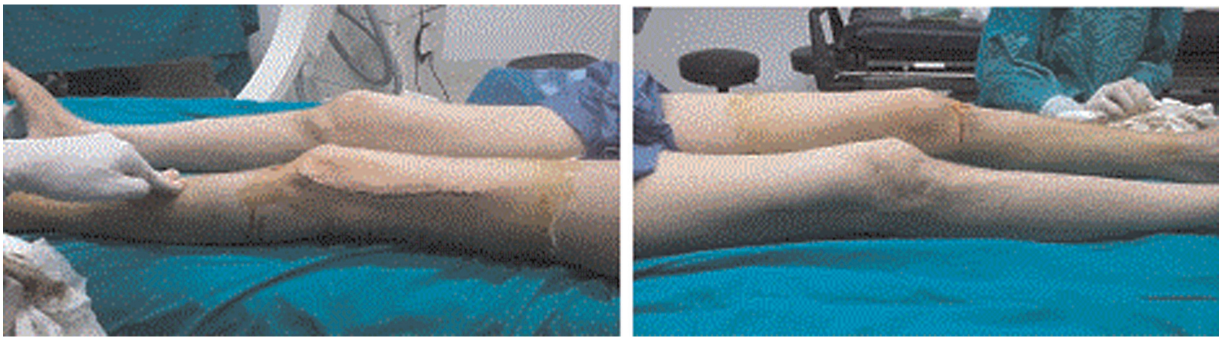
Postoperative care

Patients were allowed to mobilize using crutches with no weight bearing starting from the second postoperative day, passive knee range of motion was started with active range of motion as tolerated, patients were followed up every 2 weeks with monthly radiographies done till full union of the osteotomy, full weight bearing was started at 4 weeks postoperatively, in bilateral cases, the other side was operated after full osteotomy union, and all patients were followed up for 12 months with

Figure 1

Preoperative photo showing knee-flexion deformity.

Figure 2



Immediate postoperative photo after performing extension osteotomy in a patient with bilateral flexion deformity performed in two stages.

Figure 3

Intraoperative photo of a patient with unilateral flexion deformity before and after osteotomy.

Figure 4

Preoperative radiography of a patient with bilateral flexion deformity.

radiographies to assess the knee flexion deformity angle (Figs 4 and 5).

Results

All osteotomies eventually united in the period ranging from 10 to 14 weeks (average 12 weeks), no postoperative infection, nonunion, neurological, or vascular compromise occurred. All of the patients were satisfied regarding improved gait and posture, the total range of knee motion at 12 months postoperatively ranged from 60 to 100° (average 85°). Knee flexion deformity angle measured at 12 months postoperatively ranged from 8 to 15° with an average of 11°. Only one patient with juvenile rheumatoid arthritis showed significant recurrence of the deformity at 12 months of follow-up postoperatively, with flexion deformity angles of 20 and 25° in the right and left knee, respectively, whereas the preoperative flexion deformity angle in this patient was 30 and 35° in the right and left knee, respectively (Table 1, Figs 6 and 7).

Figure 5

Postoperative radiography after supracondylar dome extension osteotomy.

Discussion

Severe, fixed knee contracture remains one of the most challenging deformities. Knee flexion deformity can cause marked physical disability [12]. In poliomyelitis patients with unilateral deformity and paralysis of the quadriceps, the patient needs to support his knee by putting his hand above the knee to walk. The patient is unable to walk in bilaterally severely affected knees [13]. Treatment with hamstring fractional lengthening and femoral supracondylar extension osteotomy has been successfully applied to these cases [2].

Fixed-flexion deformity of the knee joint is a common sequel of rheumatoid arthritis and carries a number of adverse consequences. Compensatory progressive hyperlordosis of the spine and hip flexion leads to patient disability, while weight bearing is made more difficult by the increased quadriceps strength required to stabilize the flexed knee. Also, if total knee replacement is done, it requires an extensive posterior release at the operation time when the deformity exceeds 30° [14–16].

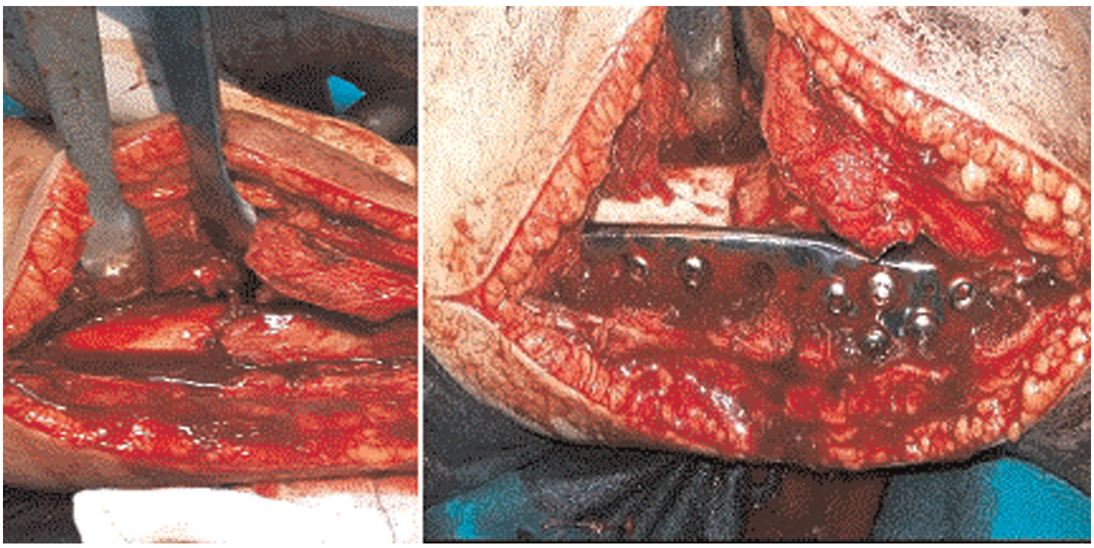
Acute correction of a major flexion knee contracture by soft-tissue release, osteotomy, or both may lead to serious complications [17].

Table 1 Summary of the results

	Age	Preoperative FDA	Postoperative FDA	Final FDA	Recurrence	Final total ROM
Series (11 knees)	17. 8	32	7	11	4	85
Polio (5)	17. 2	30	5	10	5	90
JRA (6)	18	36	10	18	8	80

FDA, flexion deformity angle; JRA, juvenile rheumatoid arthritis; polio, poliomyelitis; ROM, range of motion.

Figure 6



Intraoperative photo showing the osteotomy before and after fixation.

Figure 7

Postoperative radiography showing extension position with complete union of the osteotomy.

Various surgical procedures have been proposed to treat fixed-flexion knee deformity: lengthening of the hamstrings, epiphyseodesis of the distal femoral growth plate, posterior capsulotomy [5], femoral or tibial osteotomy [8,13], and femoral shortening [18]. These have been used alone or in combination with various degrees of success, depending on the deformity severity and etiology [19].

Although soft-tissue releases do not seem very efficient in deformity correction, and massive soft-tissue release may lead to joint instability [20], osteotomies seem to be effective but they change the joint anatomy, but the variability of the conditions for which these were used makes generalization difficult [21]. Gradual extension using external fixators has been advised by many investigators [22,23].

Osteotomy selection

Realignment osteotomy aims to correct limb alignment and may affect knee osteoarthritis. Some disadvantages of the wedge osteotomies are limb-length discrepancy, a mismatch of fragment cuts created by osteotomy, and the need for distal fragment translation [24]. According to Paley and Tetsworth, DO is a cylindrical osteotomy with the corresponding bone cuts, which rotate around the central axis of a circle, which allows deformity correction without introducing a length discrepancy because no bone is resected, mismatch, or need for segment translation to realign the proximal and distal axes [25,26].

Few papers have been published regarding distal femoral osteotomy (DFO), especially dome femoral osteotomy [27–29]. Good results are reported in the literature about DFO [30,31]. The main advantages of DO instead of an oblique one are the following: first, it allows combination of translation and angulation deformity correction without limb-length change; second, it is done in the metaphysis, hence it facilitates the bone union; third, it allows for simultaneous correction of valgus and varus or flexion/extension deformity; and fourth, the osteotomy shape creates a large bone contact surface area to ensure optimal healing, so no non- or delayed union or need for bone graft [24,32–34].

To our knowledge, no papers have been published on DO in correction of knee flexion deformity, which is a saggital plane deformity in contrast of its use in coronal plane deformities as the article by El Ghazaly SA and El-Moatasem HM [11].

The DO was chosen in our study. We hypothesized that DO and plate fixation in the distal femur ensures full-deformity correction without a secondary deformity and with maximal contact at the osteotomy, which allows full union without the need for bone grafting. Multiple drill holes and then a low-energy osteotomy results in small bone spikes that interdigitate at the osteotomy site after acute correction of the deformity, which can be compressed for added stability, and reducing the stress on the plate and screws. This encourages for early full weight bearing, which was started at 4 weeks postoperatively.

Osteotomy fixation

The method of fixation of DFO has a great impact on the outcome of this procedure. Metal plates are giving a rigid stable fixation, with the drawbacks of metal failure, impossible correction adjustments after surgery, and extensive soft-tissue damage. On the other side, external fixation allows for gradual correction of the deformity, also after surgery, but with the drawbacks of pin-site infection, restriction on range of motion, and patients' discomfort. Intramedullary nails are less invasive than metal plates, but a rigid fixation cannot be obtained in such metaphyseal osteotomy [3].

Mathews and colleagues described their results with 21 patients in whom they performed a DFO using different stabilization methods (plaster casts, internal fixation, or staples). The authors stated that the blade plate is associated with higher healing rates and better outcomes [35].

Seah and colleagues retrospectively evaluated 26 patients in which they performed a DFO stabilized with either fixator-assisted plating or a unilateral frame. The authors concluded that an accurate correction was obtained with both methods, so the method of fixation should be left to the surgeon's discretion [3].

In contrast to Gugenheim and Brinker [24] who fixed the osteotomy using a retrograde femoral nail, El Ghazaly *et al.* [11] fixed the osteotomy with buttress condylar plate or ""T" plate and Wang and Hsu [36] fixed the osteotomy with a 90-angled blade plate. We chose to use anatomical locked plates that are self-contoured to the anteroposterior dimensions of the distal femur region. Deformity correction was accomplished with ease, and the osteotomy-site remodeling resulted in an absence of secondary femoral deformity, which facilitates arthroplasty later if needed. Also, it is the strong plate in contrast to the weak "" plate used by El Ghazaly *et al.* [11], although they reported no implant failure that proves self-inherent stability of this type of osteotomy.

We avoided using the external fixators to avoid quadriceps tethering, pin-track infections, and the use of a cumbersome device. The use of the anatomical locked plate, in our view, is easier and requires a less-difficult after-care period.

We used the lateral approach as being more familiar, also it is safe with avoidance of the vascular structures on the medial approach.

The DO is technically demanding as performing the osteotomy as an arc needs care and precision to maintain the circular contour to ensure perfect segment rotation and bone contact and avoid inadvertent propagation. Gugenheim and Brinker [24] have described a percutaneous technique. We chose an open technique, which facilitates precision under direct vision and simpler plate fixation.

Complications

There are few reports in the literature about the complication rate after DFO, as compared with the reports on HTO. Willey and colleagues reported their complications after both HTO and DFO. They described complications as intra-articular fracture, thrombosis, infection, arthrofibrosis, deformity overcorrection, nonunion, extension loss, neurovascular injury, hardware pain, anterior knee pain, hematoma, delayed union, and tendonitis. They reported a higher complication rate for HTO, as compared with DFO [37].

The most common complications following corrective osteotomies are nonunion and failure of fixation. To achieve union, good bone apposition and stable fixation are required [38]. In our series, the use of plate and screws provided the required rigid fixation and allowed full union. We found no technique-related complications or implant failures. Our series included no cases of osteotomy nonunion; we attribute this to the large bony contact surface area provided by the DO, and the rigidity of fixation provided by the anatomical locking plates.

In our series, no neurovascular complications reported as the key to avoid neurovascular compromise that appeared to be femoral bone shortening that was applied if the flexion deformity was greater than 40°.

There is no consensus in the literature about the postoperative weight bearing program after a DFO regarding the used technique. Normally, it depends on the fixation stability, until the osteotomy healing is demonstrated [39]. In our study, osteotomy is inherently stable with strong fixation that allows early weight bearing.

Review of the literature

Dasmine *et al* [22] used the Ilizarov technique for severe flexion deformity of the knee in 11 patients (13 knees), one of them was polio and one was JRA, followed for an average of 4.1 years. The deformity was corrected to a femorotibial lateral shaft angle of less than 20°. Fractures occurred in four patients and paralysis of the common peroneal nerve in another four. At the last review, all patients were able to walk on their operated leg with or without an orthosis. The average duration of the correction was 54 days, and the average fixation time 105 days. Recurrence of the deformity was seen in four patients at an average of 1.7 years after removal of the fixator.

Hosny *et al.* [12] treated 50 patients (71 knees) with flexion-knee deformity by gradual correction using Ilizarov external fixator. An osteotomy was done before distraction. The patients were followed up for a mean of 3.7 years. They concluded that treatment of flexion-knee contracture by a circular frame is an effective method to correct these deformities. Recurrence of the deformity appears to depend on the etiology and not the type of treatment in patients with bilateral deformities. However, the relatively high rate of recurrence of the deformity is still unsolved.

Patricia *et al.* [19] treated 39 patients (49 knees) with knee-flexion deformity after poliomyelitis. All were subjected to fractional hamstring lengthening with femoral supracondylar extension osteotomy in the same surgical procedure. The mean knee-flexion deformity was 65°. The mean follow-up was 15.5 years. Postoperatively, 22 knees had full extension, in 26, there was an extension lag between 1 and 10°, and in one, a lag greater than 10°. There were no neurovascular complications and all patients were fitted with long leg braces.

Zimmerman *et al.* [8] performed 32 supracondylar osteotomies of the femur in 20 patients for correction of fixed-flexion deformity of the knee, followed for an averge period of 4 years. Two-thirds of the patients had underlying paralytic disease, either meningomyelocele or polio. Although there was a significant complication rate, including fractures, infection, and recurrence, there were no permanent neurologic sequelae or nonunions. All patients eventually obtained satisfactory correction and function.

Our study included seven cases (11 knees) of femoral saggital plane deformity in the form of fixed knee-flexion deformity that underwent correction using SCDEO fixed by the anatomical locked plate and screws. The average age was with a mean of 17.8 years. Three patients had a bilateral deformity as sequelae of juvenile rheumatoid arthritis, while four patients as sequelae of poliomyelitis, followed up for 12 months. The mean preoperative flexion deformity angle was 32°. Autogenous bone graft was not used in any case, and uneventful osteotomy union was achieved at a mean of 12 weeks. There were no implant failures or reoperations. No postoperative infection, nonunion, neurological, or vascular compromise occurred. All of the patients were satisfied regarding improved gait and posture; the average of the total range of knee motion at 12 months postoperatively was 85°. The average of knee flexion deformity angle measured at 12 months postoperatively was 11°. Only one patient with juvenile rheumatoid arthritis showed significant recurrence of the deformity at 12 months of follow-up postoperatively. Only one patient underwent any previous interventions, except for one patient with bilateral deformity as a sequelae of poliomyelitis who underwent fractional hamstring lengthening 6 years prior to our procedure; the associated femoral shortening was done in three knees because the knee deformity was above 40°.

Our study has several limitations. While the deformities resulted from different causes, we tried to deal with deformities in a more or less uniform way. A small number of patients were available. The follow-up is also relatively short. Despite these limitations, this study suggests the effectiveness of SCDEO fixed by the anatomical locked plate and screws in the management of knee-flexion deformity whatever the etiology. There is no comparative cohort. Future studies involving larger numbers of cases and those comparing the use of plates with an external fixator may be useful and with other treatment modalities, with long-term follow-up.

Conclusion

SCDEO fixed by the anatomical locked plate and screws is an effective means of management of knee fixed-flexion deformity.

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Conflicts of interest

There are no conflicts of interest.

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