■ HIP ARTHROPLASTY: MANAGEMENT FACTORIALS

Total hip arthroplasty in patients with neuromuscular imbalance

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Patients with neuromuscular imbalance who require total hip arthroplasty (THA) present particular technical problems due to altered anatomy, abnormal bone stock, muscular imbalance and problems of rehabilitation.

In this systematic review, we studied articles dealing with THA in patients with neuromuscular imbalance, published before April 2017. We recorded the demographics of the patients and the type of neuromuscular pathology, the indication for surgery, surgical approach, concomitant soft-tissue releases, the type of implant and bearing, pain and functional outcome as well as complications and survival.

Recent advances in THA technology allow for successful outcomes in these patients. Our review suggests excellent benefits for pain relief and good functional outcome might be expected with a modest risk of complication.

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There are two broad subgroups of patients with neuromuscular imbalance who present with an osteoarthritic hip. In the first, the disease process is of early onset leading to dysplasia of the hip and degenerative arthritis (Fig. 1). This may be seen in conditions such as cerebral palsy or myelomeningocele. In these patients, the bony anatomy is often associated with muscular imbalance. In the second group, the degenerative hip has developed independent of the neurological condition as may occur in patients with a cerebrovascular accident or Parkinson's disease. Here, the bony anatomy may be normal and the muscle imbalance is the main problem.

The muscular tone may be flaccid or spastic. In flaccidity, the tone is decreased as in poliomyelitis, Down syndrome or myelomeningocele. In case of spasticity, the tone is increased as in cerebral palsy, Parkinson's disease and following a cerebrovascular accident (CVA). There may be some imbalance, such as over-activity of the adductors and flexors of the hip. The muscular tone will influence the type of soft-tissue release to be considered at the time of surgery, as well as determine the risk of dislocation after total hip arthroplasty (THA).

For the surgeon reviewing a patient with neuromuscular compromise and end-stage osteoarthritis of the hip, three issues need to be considered: the timing of the neuromuscular event, the resultant muscular tone and the residual sensation in the limb. The expectations of the patient and family are also important, as well as the availability of resources to support a comprehensive rehabilitation program.

If the neuromuscular event preceded skeletal maturity, the size and shape of the skeleton may be affected (Fig. 2). This will influence the choice of implants and the type of fixation. On the acetabular side, the key issues will be the level of the acetabulum, its size and shape and the quality of the surrounding bone which will, for instance, be poor in patients with poliomyelitis. On the femoral side, the canal may be stenosed, deformed, anteverted, lacking in offset and osteoporotic. There may also be an associated deformity due to previous surgery, and retained hardware used for the fixation of an osteotomy (Fig. 3)

In conditions such as myelomeningocele, patients have significant loss of sensation. This is important as it influences surgical planning, rehabilitation and the survival of the components. A previous article in this journal has reviewed THA in several neuromuscular conditions and provided the expert opinion of the senior author.[1] The aim of this paper is to provide a systematic review of the currently available literature prior to April 2017 reporting the outcomes of THA in patients with neuromuscular imbalance.

Materials and Methods

We conducted a literature search on the PubMed Database (United States National

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Fig. 1

Pre-operative anteroposterior radiograph of a patient with a deformity that developed before skeletal maturity due to spina bifida. The hip is dysplatic with a high dislocation. There is poor bone stock in the acetabulum. The femur is anteverted and has a narrow canal. The patient also has a leg length discrepancy.

Fig. 3

On the femoral side, the canal may be stenosed, deformed, anteverted, lacking in offset and osteoporotic. In addition there may be superimposed deformity due to previous surgical intervention, as well as retained osteotomy fixation hardware.

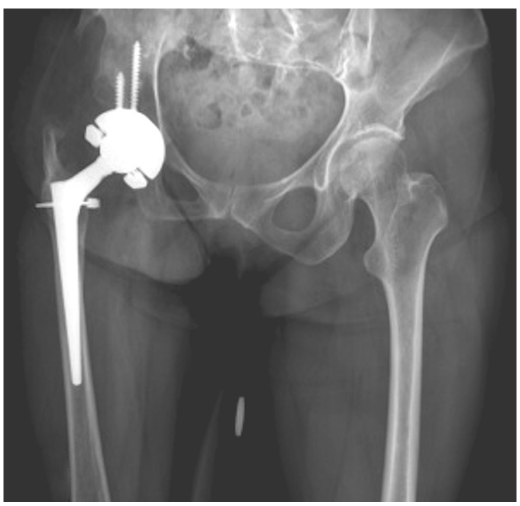

Fig. 2

Radiograph showing a total hip arthroplasty (THA) using a short non-modular tapered titanium cone stem that allows restoration of version and length with early stable fixation. A porous acetabular shell with additional screw fixation placed in the true acetabulum allows the use of a focally constrained liner, in order to decrease the risk of instability.

Library of Medicine) and Google Scholar for articles published prior to 01 April 2017. The search terms used were "hip arthroplasty", "hip replacement", "neuromuscular" and "neurological". The search was restricted to the English language to allow detailed review of the articles. All case series were included in the analysis. Further quality assessment of the articles was not undertaken as they were all of similar methodological rigour (case reports or case series).

Demographic data including the type of neuromuscular pathology, indication for surgery, surgical approach, concomitant releases, the type of implant and bearing, pain and functional outcome as well as complications and survival were extracted by one author (SK), were excluded from the studies and compiled in an Excel (Microsoft, Redmond, Washington) document.

Results

A total of 29 studies were included,[2-30] one of which analysed two different study cohorts.[20] The neuromuscular conditions reported were cerebral palsy (CP), poliomyelitis, Parkinson's disease, Charcot joint, CVAs, spinal injury, diastrophic dysplasia and myelomeningiocoele.

The age of the patient at surgery. In patients with early onset of neuromuscular abnormalites, including those with cerebral palsy, poliomyelitis and Down syndrome, the age of presentation for THA is considerably younger than that expected in general for patients with osteoarthritis.[2-6,31] The mean age was between 19 and 48 years (Table I).

Indication for surgery. Pain was the single primary indication for THA in all studies reviewed. Inability to walk was not considered a contraindication. Several authors offered the procedure to wheelchair bound patients for pain relief and to aid with assisted transfers.[6-8,17] Fracture was a common indication in patients with a CVA and Parkinson's disease.[16]

Incidence of previous non-arthroplasty operations. Many patients undergoing THA have had previous operations, such as a soft-tissue release, osteotomy, excision arthroplasty, open reduction and internal fixation and spinal fusion. The percentage of patients who had undergone previous surgery, when this was reported, was 40%,[10] 53%,[6] 56%,[5] and 60%.[8]

Surgical approach. All studies dealing with early onset neuromuscular imbalance in patients with cerebral palsy,

Table I. A summary of the studies analysing total hip arthroplasties in patients with neuromuscular compromise.

Study	THA (n)	Neurological condition	Mean age (yrs, range)	Follow-up (yrs)	Implant /surgical details	Complications	Outcome	Survival
Schroeder[7]	18	Cerebral palsy	42 (32 to 58)	10 (2 to 18)	Cemented and uncemented components; one constrained liner	2 component revisions for aseptic loosening; 1 component revision for recurrent dislocation; 1 hip revision for infection; 1 closed reduction of dislocation	77% pain-free; 92% improved function	4 (*22*) of 18 hips revised
Raphael[8]	65	Cerebral palsy	31 (14 to 61)	9.7 (2 to 28)	Cemented, uncemented, and hybrid components; 22 and 32 heads, no constraint	8 dislocations; 9 revisions	81% pain-free; 100% improved function	95% at 2 years; 85% at 10 years
Sanders[9]	10	Cerebral palsy	54 (43 to 61)	3.3 (1.8 to 4.7)	Dual mobility articulation	1 periprosthetic fracture from fall	90% pain reduction; 90% improvement in function; improvement in Short Form 36	N/A
Yoon[10]	5	Cerebral palsy	36 (20 to 56)	6.8 (5.8 to 8.3)	Uncemented components; ceramic-on-ceramic articulation	1 traumatic dislocation treated with closed reduction and brace	100% pain reduction; function improved in 60% of patients	No loosening, wear or fracture
Houdek[4]	39	Cerebral palsy	49 (21 to 74)	3 (0.3 to 8.0)	5 dual-mobility liners; 2 lipped liners; 4 femoral head augmentations	2 acetabular aseptic loosenings; 2 recurrent instabilities; 1 deep infection	Significant improvement in mobility and use of walking aids	92% at 2 years; 88% at 5 years; 81% at 10 years; 81% at 15 years.
Morin[6]	40	Cerebral palsy	19 (13 to 31)	5.3 (0.75 to 12.3)	Dual mobility articulation	6 revisions (2 infections, 2 osteotomy nonunions, 1 femoral loosening, 1 troch detachment, 1 osteoma, 1 femoral head dislodging from taper); 4 non-operative complications (2 proximal metaphyseal fractures, 1 acetabular loosening, 1 lateral cortex resorption)	Significant improvement in pain; minimal improvement in function; GMCFS Level V	N/A
Schörle	18	Cerebral palsy	49 (24 to 67)	4.6 (1.5 to 12.4)	N/A	1 dislocation; 1 femoral aseptic loosening; 1 periprosthetic fracture	81% pain-free; 88% improvement in function	N/A
Weber and Cabanela[12]	16	Cerebral palsy	49 (22 to 79)	9.7 (2.5 to 21.0)	12 all cemented components; 2-all uncemented components; 2 hybrid components	1 revision (aseptic loosening); 2 additional surgeries (1 avulsed trochanter, 1 adductor tenotomy)	87% good to excellent reduction in pain; 79% improvement in function	N/A
Buly[2]	19	Cerebral palsy	30 (16 to 52)	10.1 (3.1 to 16.8)	Cemented components; 12 tenotomies; hip spicas in 16 patients post-operatively	11 dislocations, 3 revisions	89% pain reduction; 94% improvement in function	95% at 10 years for aseptic loosening; 86% at 10 years for any reason
Ries[13]	11	Cerebral palsy	N/A	2 to 7	N/A	6 major complications requiring additional surgery	100% were more independent	N/A
Root[14]	15	Cerebral palsy	31 (16 to 52)	9.8 (2.5 to 12.0)	N/A	13 dislocations	93% pain free; 87% improvement in function	N/A
Blake[15]	2	Cerebral palsy	14	2	Complete pain relief; improvement in function	None	100% pain-free; 100% improvement in function	100%
Park[16]	19	11 cerebral infarctions; 4 cerebral haemorrhages; 4 cases of Parkinson's disease	72.6 (62 to 81)	17.2 (12 to 16)	2-incision approach; large diameter metal-on-metal	1 death aspiration pneumonia, 1 delirium, 1 urinary tract infection	HHS 81; WOMAC 42.9	N/A
Alosh[17]	30	12 cases of CP; 9 traumatic brain injuries; 3 cases of CVA; 2 cases of MS, 1 spinal cord injury	48.6 (29 to 75)	2.5 (2.1 to 12.0)	Uncemented press-fit; modular femur in 3 for severe dysplasia; acetabular augments/ femoral heads for support; constrained liners in 2 cases	1 intra-operative calcar fracture; 1 deep infection and resection arthroplasty; 3 superficial infections DAIR	100% improvement in mobility	N/A
Robb[18]	1	Charcot joint/tabes dorsalis	N/A	N/A	N/A	N/A	N/A	N/A
Sprenger and Foley[19]	1	Charcot joint/tabes dorsalis	61	7	N/A	None	N/A	N/A
Meek[20]	1399	CVA	N/A	N/A	N/A	0.0 to 0.3 annual dislocation rate	N/A	N/A
Meek[20]	2394	Parkinson's disease	N/A	N/A	N/A	0.0 to 0.46 annual dislocation rate	N/A	N/A
Dicaprio[21]	31	CVA	68 (43 to 84)	2 (1 to 6)	Uncemented acetabular component; cemented femoral component	11 heterotopic ossification	N/A	N/A
Kosashvili[5]	9	Down syndrome	35 (25 to 47)	10 (2 to 23)	Uncemented components; 6 constrained liners	None	Significant improvement in HHS. 41.1 (SD 15.1) to 59.1 (SD 9.7)	2 stem revisions, at 6 and 16 years
Weber[22]	3	Myelomeningocoele	45 (28 to 54)	7.6 (5 to 10)	1 all-cemented component, 1 all-uncemented component, 1 hybrid component	3 dislocations; 2 revisions	Poor pain relief	N/A
Weber[23]	107	Parkinson's disease	72 (57 to 87)	7.1 (2.0 to 21.0)	Uncemented and cemented components; 7 tenotomies	6 dislocations (all revisions); 3 cases of aseptic loosening; 28 post-operative medical complications	93% pain relief	N/A
Yoon[24]	10	Poliomyelitis	48 (32 to 59)	3 (3.4 to 13.0)	Cementless components	Anterior dislocation in 1 hip	Pain reduction; improvement in function	0 revisions at 7 years
Laguna and Barrientos[25]	1	Poliomyelitis	N/A	3.8	N/A	N/A	N/A	N/A
Spinnickie and Goodman[26]	1	Poliomyelitis	N/A	0.6	N/A	Dissociation of the femoral head and trunnion	N/A	N/A
Wicart[27]	2	Poliomyelitis	N/A	5	N/A	Anterior dislocation in 1 hip	N/A	N/A
Cabanela and Weber[28]	5	Poliomyelitis	N/A	2 to 8	N/A	None	N/A	N/A
Cameron[3]	1	Poliomyelitis	N/A	3	N/A	N/A	N/A	N/A
Helenius[29]	41	Diastrophic dysplasia	N/A	7.8 (5 to 19)	N/A	7 undisplaced femur fractures; 1 femoral nerve laceration; 1 femoral nerve paresis; 1 posterior dislocation; 5 revisions of the acetabulum for aseptic loosening	Significant improvement in HHS from 44 to 71	4 patients required revision at 9.4 yrs (range 4.1 to 15.6)
Becker[30]	6	Spinal injury	39.4 (23 to 57)	1 (0.5 to 2.0)	N/A	None	N/A	N/A

THA, total hip arthroplasty; GMCFS, Gross Motor Function Classification System; HHS, Harris Hip Score; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; CVA, cerebrovascular accident; MS, multiple sclerosis; DAIR, debridement, antibiotics, and implant retention

poliomyelitis and Down syndrome reported the use of a trans-gluteal lateral or posterolateral approach.[7-9,29] Other approaches included trans-trochanteric,[8] and lateral approach with trochanteric osteotomy.[6] Park et al[16] reported the use of a minimally invasive two-incision approach. However, these authors were dealing with adult patients with CVAs or Parkinson's disease, with a mean age of 72 years (62 to 81).

Choice of components and bearing. Both cemented and cementless components have been reported with success. Some authors also reported the use of femoral head[8] **or metallic[17] acetabular augments. The choice of articulation was varied (Table I). Some authors reported selective use of constrained liners for instabilty, abductor insufficiency or hyperlaxity.[5,7,17] Yoon et al[10] reported good outcomes when using a ceramic-on-ceramic bearing. A dual mobility articulation was used by some authors to increase stability.[4,6,9]**

Intra-operative soft-tissue releases. Adductor and flexor releases were the most commonly reported soft-tissue procedures.[4,7-9,17,24] Some authors had strict indications for a soft-tissue release. Raphael et al[8] reported adductor release for abduction of < 30°. Alosh et al[17] suggested a release when there was an adduction contracture of > 15° and a flexion contracture of > 30°. They also suggested the need to consider Achilles tendon lengthening and split tibialis anterior tendon transfer pre-operatively to aid mobilisation in some patients.[17]

Post-operative bracing. Post-operative bracing was not universally described in these patients. The use of a hip spica,[8] an abduction brace[8,17,24] and a knee brace,[8,17] for between three and six weeks, was described in some patients.

Surgical outcome. Pain relief was the single significant gain (Table I). Most patients were pain free, with some reporting improvement and very few reporting persistent pain.

Function improved post-operatively in all patients (Table I). Some authors reported that mobility was regained in some wheelchair bound patients[7,17] and others used walking aids less.[5,7,8,17] Morin et al[6] reported the least gain in function but they were dealing with wheelchair bound patients who did not regain mobility.

Improvements in hip scores and health related quality of life measures were reported by some authors (Table I). A recent study[4] compared 39 patients undergoing THA with a diagnosis of cerebral palsy matched 1:2 with a group of patients undergoing THA for osteoarthritis. At a mean follow-up of seven years, there was no difference in the rate of re-operation, the survival of the components, or complications, specifically dislocation, between the groups. All patients had moderate or severe pain pre-operatively, and none had this severity of pain post-operatively. A total of 23 patients had improved independent mobility, and all pre-operative hip flexion contractures were corrected. There was also a significant improvement ($p < 0.0001$) in the mean Harris Hip Scores.[32]

Table I summarises the implant survival and complications. The rate of complications was between 0% and 24%. Dislocation was a common complication. A higher infection rate than seen with THA in patients without neuromuscular abnormalities was not observed by any of the studies reported here.

Charcot arthropathy may be seen with inadequately treated syphilis (tabes dorsalis) and other neuropathic disorders such as diabetes mellitus, syringomyelia, peripheral nerve injuries, peripheral neuritis secondary to alcoholism and vitamin deficiency, congenital absence of pain syndrome and myelodysplasia. Rapała and Obrebski[33] described two patients with Charcot arthropathy due to tabes dorsalis. One had two atraumatic dislocations post-operatively requiring eventual revision, and one atraumatic dislocation after contralateral THA. At ten years post-operatively, this patient had good function. The other patient had no complications, 9.5 years post-operatively. Earlier reports from the 1980s were also equivocal with regards to outcome in this situation. Sprenger and Foley[19] reported a successful seven-year outcome with cemented THA and a large femoral head (38 mm) and Robb et al[18] reported recurrent dislocation in their patient which ultimately resulted in an excision arthroplasty.

Discussion

This review summarises the reports of THA in patients with neuromuscular imbalance during the last two decades. Good outcomes have been reported in mobile patients and wheelchair users. The indication for THA is primarily pain followed by functional improvement. The greatest gain was in pain relief, but some improvement in function can also be expected. A modest rate of complications may be associated with THA in these patients which the surgeon and patient/carer should be aware of.

This review had limitations. Our search attempted to identify all available literature on this topic. Non-English language literature had to be excluded. Isolated case reports were added where available but had limited generalisability. One of the most important limitations is the small number of patients in each study and the heterogeneous nature of the patients in the studies. There was no uniform system of reporting post-operative outcomes. Pain scores were frequently used. Some authors reported the Harris Hip Score but this may not be relevant for most patients with neuromuscular imbalance. Function was often reported using the Gross Motor Function Classification System (GMFCS), which uses a scale of level I to V of increasing limitation of independent mobility, use of walking aids and of a wheelchair.[34] In the absence of other reliable outcome measures, an improvement in GMFCS level has been used to indicate a successful outcome. The choice of articulation, the use of a dual-mobility component or of a constrained liner was not uniform in all studies. In the absence of long-term studies, the drawbacks of constrained liners in primary THA may not be obvious. However, it may be that this is acceptable practice in patients with low functional demands and limited mobility and with a high risk of instability. We have not included another option available for treating these patients, namely hip resurfacing with or without derotation osteotomy.[35] Currently the use of resurfacing has declined and several of the smaller resurfacing femoral heads with associated dysplasia cups have been withdrawn from the market.

Little has been written about the outcome and complications of THA in patients who have suffered a cerebrovascular accident (CVA). One report found a low rate of dislocation after THA, < 0.4% in a large registry based study of over 14 000 THAs.[20] The authors hypothesised that this may be due to reduced mobility in these patients and suggested that THA should not be withheld under these circumstances and that the routine use of a constrained liner was probably unnecessary. The other consideration when performing THA in a patient who has had a CVA is the high incidence of heterotopic ossification (HO). DiCaprio et al[21] reported that HO occurred in 11 of 31 patients (36%) who underwent THA after a CVA. Surgeons may wish to consider prophylaxis using a course of oral anti-inflammatory medications in this situation.

The challenges of undertaking THA in patients with a neurological disorder include difficulties with pre-operative counselling, altered acetabular and femoral anatomy, dealing with effects of previous surgery to the hip, the need for altered post-operative rehabilitation and a high rate of complications.

Based on this review, we cannot recommend any particular approach, implant, articulation or type of fixation. Authors have reported good outcomes with their preferred techniques. The functional gain from THA in these patients is encouraging and the procedure should be offered to symptomatic patients with appropriate counselling. The surgeon should make a balanced decision taking into account all options for the management of neuromuscular imbalance such as non-surgical management, corrective osteotomies and resection arthroplasties.

In our opinion, contemporary THA with choices of fixation and constraints allows successful implantation with significant gains for the patient from pain relief and functional improvement with a modest rate of complications.

Take home message:

- Current advances in THA technology allow for successful outcomes in hip arthroplasty in patients with neuromuscular imbalance.
- Our review suggests excellent benefits for pain relief along with good functional outcome and a modest risk of complications.

Author contributions:

S. Konan: Data collection, Writing the paper.

C. P. Duncan: Conceptualised topic, Data collection, Writing the paper.

The author or one or more of the authors have received or will receive benefits for personal or professional use from a commercial party related directly or indirectly to the subject of this article. In addition, benefits have been or will be directed to a research fund, foundation, educational institution, or other non-profit organisation with which one or more of the authors are associated.

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