

Risk factors and complications in hip reconstruction for nonambulatory patients with cerebral palsy

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Abstract

Background Hip dysplasia is prevalent in nonambulatory children with cerebral palsy, and may contribute to a decreased quality of life (Lonstein in J Pediatr Orthop 6:521–526, 1). Reconstructive procedures such as a femoral varus derotation osteotomy with or without a pelvic osteotomy are commonly employed with the goal of achieving and maintaining well reduced hips.

Purposes The goals of this study are both to characterize the complications of reconstructive procedures and to identify risk factors that may contribute to these complications.

Patients and methods A retrospective analysis was conducted among 61 nonambulatory children (93 hips) with cerebral palsy who underwent a femoral varus derotation osteotomy, with or without an open reduction and/or pelvic osteotomy, from 1992 through 2008 at our institution. The average patient age was 8.1 years (2.6–14.7) and the mean follow-up time was 5.9 years (2.1–15.9).

Results The cumulative complication rate per patient including failures to cure was 47.6 %. Spica casting was found to be a risk factor for all complications ($P = 0.023$); whereas patients younger than 6 years old ($P = 0.013$) and children with a tracheostomy ($P = 0.004$) were found to be risk factors for resubluxation following surgery.

Conclusions Although reported complication rates of hip reconstructive procedures performed upon children with cerebral palsy have varied considerably, those with more severe disease have experienced more complications. We report our tertiary referral center's complication rate and our institutional experiences with risk factors for complications and failures to cure.

Level of evidence IV, Retrospective case series.

Keywords Cerebral palsy · Nonambulatory · Complications · Hip surgery

Introduction

Hip dysplasia is identified in up to 57 % [1] of nonambulatory patients with spastic quadriplegic cerebral palsy (CP). Reconstructive procedures are commonly performed to treat hip subluxation or dislocation, most commonly soft tissue releases and a femoral varus derotation osteotomy (VDRO) with or without an open reduction and/or pelvic osteotomy. The goal of these procedures is to retain located, mobile, and painless hips [2, 3].

While the reported complication rates for hip reconstructive surgery in patients with CP have varied considerably (0–81 %), [4–17] it is difficult if not impossible to compare studies since all but one [18] are based upon mixed populations of ambulators and nonambulators with no uniformity in defining a complication. Severity of disease, as indicated by limited ambulatory ability, the presence of a tracheostomy or gastrostomy, and Gross Motor Function Classification System (GMFCS), has been shown to be an important determinant for both the incidence of hip displacement and the risk of complications [16]. These previous studies have reported perioperative complications,

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Table 1 Modified Clavien-Dindo Classification according to Sink et al

Modified Clavien–Dindo classification according to Sink et al.	
I	Any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic, and radiological interventions. Allowed therapeutic regimens are: drugs as antiemetics, antipyretics, analgesics, diuretics, electrolytes, and physiotherapy. This grade also includes wound infections opened at the bedside.
II	Requiring pharmacological treatment with drugs other than such allowed for grade I complications. Blood transfusions and total parenteral nutrition are also included.
III	Requiring surgical, endoscopic or radiological intervention IIIa: Intervention not under general anesthesia IIIb: Intervention under general anesthesia
IV	Life-threatening complication (pulmonary embolus, admission to intensive care unit) or complication with the potential to result in permanent dysfunction/long term orthopaedic disability (permanent nerve injury, osteonecrosis)
V	Death

For this study we define subluxation or dislocation (RMI >60 % at latest follow-up) as a Grade IIIb complication (Failure to cure)

but have not considered longer term problems such as re-subluxation or redislocation as a complication. Our impression is that those patients with a dislocation, and those with subluxation in whom the natural history would result in dislocation, can be viewed as “failures to cure”, a long term complication.

With the goal of achieving better consistency in defining and categorizing complications, adaptations of the Clavien classification [19] have been reported, including the Clavien–Dindo [20]. The Clavien–Dindo scheme was adapted by Sink et al. [21] for use in orthopaedics (Table 1).

The goals of this retrospective review are to (1) document the spectrum of complications following reconstructive hip procedures in nonambulatory patients with spastic quadriplegia (GMFCS 4,5) while these complications according to Sink’s modification of the Clavien–Dindo scheme, and (2) identify risk factors for these complications.

Methods

After obtaining approval from our Institutional Review Board, we performed a retrospective chart review of patients with spastic quadriplegic CP (GMFCS 4,5) treated with reconstructive hip surgery (soft tissue release and femoral varus derotational osteotomy with or without a pelvic osteotomy) for progressive subluxation or dislocation of the hip between 1/1/1992 and 12/31/2008, and a minimum follow-up of 2 years. Patients were identified

Table 2 Variables collected for each VDRO performed

Data collection	
Preoperative variables	Age Gender CP Physiologic classification CP Geographic classification Ambulatory status Side of involvement Presence of tracheostomy Presence of gastrostomy tube Medical comorbidities (GERD, MR, epilepsy, heart defects, cardiac arrhythmias, asthma, CF, hematologic conditions)
Operative data	Procedure performed & complications (see Table 3)
Postoperative data	Type and length of immobilization Need for additional procedures Complications during admission and through latest followup (see Table 3)
Radiographic data (preop, postop, followup)	Neck shaft angle (NSA) Acetabular index (AI) Type of acetabulum (I, II) Migration index (RMI): (Normal = <30 %, mild subluxation = 30–60 %, Severe subluxation = 60–90 %, Dislocation = >90 %)

GERD gastroesophageal reflux disease, MR mental retardation, CF cystic fibrosis, ASA American Society of Anesthesiologists

through CPT codes (27258, 27259, 27165, 27146, 27147, 27151, 27156, and 27001).

The information collected for each patient is shown in Table 2, and the peri-operative, post-operative, and long term complications documented are shown in Table 3. With regard to the radiographic evaluation, the migration index of Reimer (RMI) was used to evaluate hip outcomes because of its reproducibility and its relationship to prognosis [22]. We defined a normal hip as having a RMI $\leq 30\%$, mildly subluxated as $30\% < \text{RMI} < 60\%$, severely subluxated as $60\% \leq \text{RMI} < 90\%$, and dislocated as $\text{RMI} \geq 90\%$. Severely subluxated hips with an unfavorable prognosis based on migration index ($>60\%$) were considered failures to cure, since we would predict that all of these would become dislocated over the long term [23].

Statistical methods

Comparison of complication rates was performed by using Chi square analysis in cases where variables were dichotomous and there were >5 events per cell. In cases where

Table 3 Complications sought

Complications following reconstructive hip surgery	
Perioperative (intraoperative and during early postoperative period prior to discharge)	Infection
	Nerve injury
	Artery injury
	Wound (dehiscence)
	Pressure sore
	Medical Pulmonary Atelectasis
	Pneumonia
	Respiratory failure
	Gastrointestinal (Ileus)
	Deep vein thrombosis
Urinary tract infection	
Postoperative (after discharge, within 1 month of procedure)	Infection
	Fracture Away from Implant
	Adjacent to Implant
	Wound (dehiscence)
	Implant (loss of correction or fixation)
	Cast related (sores, skin breakdown)
	Neurologic deficit
	Vascular
Long term complications (more than 1 month following discharge)	Heterotopic ossification
	Avascular necrosis
	Nonunion
	Implant related Fracture (adjacent to implant)
	Prominent/painful
	Loss of fixation
	Failure to cure Hip subluxation with poor prognosis (migration percentage >60%)
Hip dislocation (migration percentage >90%)	

there were <5 events per cell, a Fisher’s exact test was used. Survival was plotted via Kaplan–Meier analysis as survival to redisplacement. A *p* value of <0.05 was considered to be statistically significant. Each hip was considered a separate point of analysis for the purposes of statistical analysis except where specified as number of patients. Statistics were calculated with the SPSS processor version 19.0. (SPSS Inc, Chicago, IL).

Results

Our initial search of CPT codes identified 156 surgical procedures (VDRO ± pelvic osteotomy) in 124 patients.

Sixty-three patients were excluded because they were ambulatory (30), lost to follow-up (19), had inadequate follow-up (8), or were treated by a salvage procedure such as valgus osteotomy or proximal femoral resection (6). Our final study group therefore included 93 hips in 61 patients (Fig. 1).

The average age at surgery was 8.1 years (range 2.6–14.7). 31 patients (51 %) were male and 30 (49 %) were female. Twenty-eight patients (45.9 %) had bilateral surgery and a pelvic osteotomy was performed on 38 hips (40 %). The average follow-up was 5.9 years (range 2.1–15.9). A summary of findings is provided in Appendix 1. The surgeries were performed at our institution by one of five attending surgeons.

Of the 61 patients (with a total of 93 hips) who underwent a unilateral or bilateral VRDO ± a Dega osteotomy, 29 patients had at least one complication in the period from surgery to final follow-up for a total complication rate of 47.6 % per patient and 32.3 % per VDRO performed. Excluding failures to cure (RMI ≥60 % at final follow-up) the total complication rate was 41 % per patient or 26.8 % per VDRO performed. Due to three patients having multiple complications each, there were 35 cumulative complications. To reduce redundancy, we report complication grades according to Sink et al’s complication grading scheme with percentages corresponding to complications per patient. There were a total of eight grade I complications (13 %) consisting of three decubitus ulcers, one case of heterotopic ossification (HO), two cases of severe pain, and two cases of atelectasis. Of the eleven grade II complications (18 %) there were eight femur fractures, one case of intraoperative malignant hyperthermia, one superficial wound infection, and one urinary tract infection. The only grade IIIa complication (2 %) was a case of respiratory failure that occurred intraoperatively. The 14 grade IIIb complications (23 %) included two re-subluxations with a RMI ≥60 % but <90 %, six redislocations with a RMI >90 %, five symptomatic implants requiring removal, and one loss of implant fixation. The lone grade IV complication (2 %) was a case of avascular necrosis (AVN).

Of the pre-, peri-, and post-operative variables collected, only post-operative immobilization with a spica cast positively correlated with future complications (*P* = 0.023). Furthermore, surgeries performed on children under the age of 6 years of age and children with tracheostomies were the only factors that predisposed to failures to cure (*P* = 0.013 and *P* = 0.004, respectively). Survival plots for time until resubluxation for the total study population, for patients with and without a tracheostomy, and for patients below and above the age of six are displayed below as Figs. 2, 3, 4, 5 and 6, respectively.

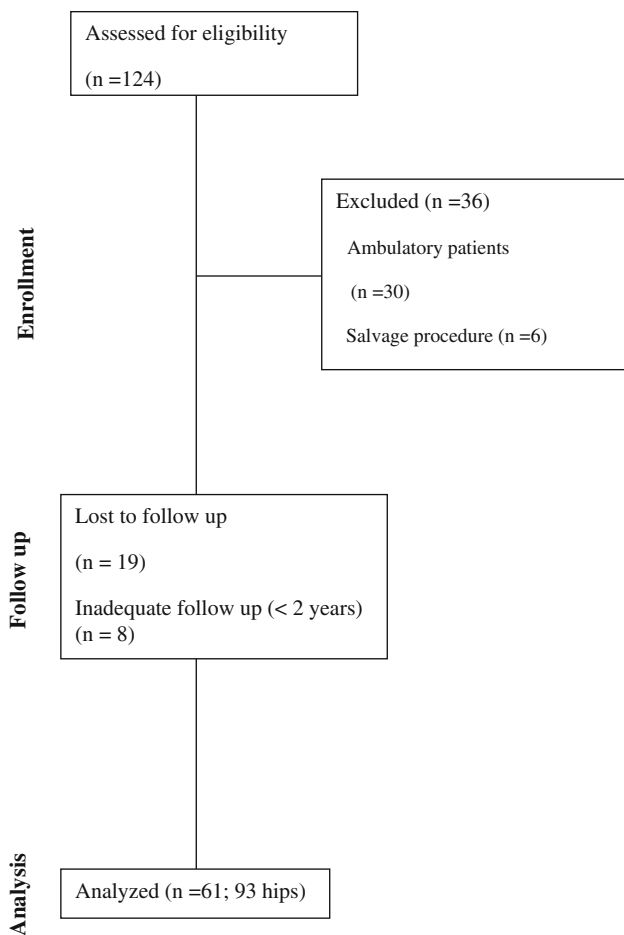


Fig. 1 CONSORT diagram outlining the determination of the final study population

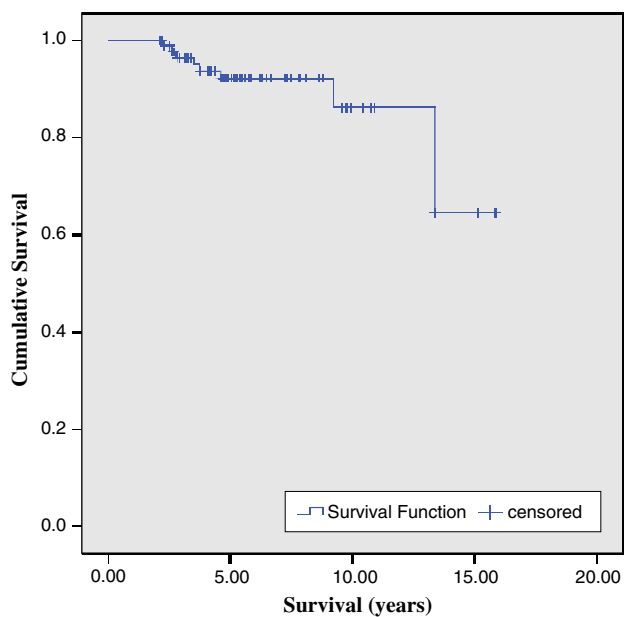


Fig. 2 Survival function for composite population

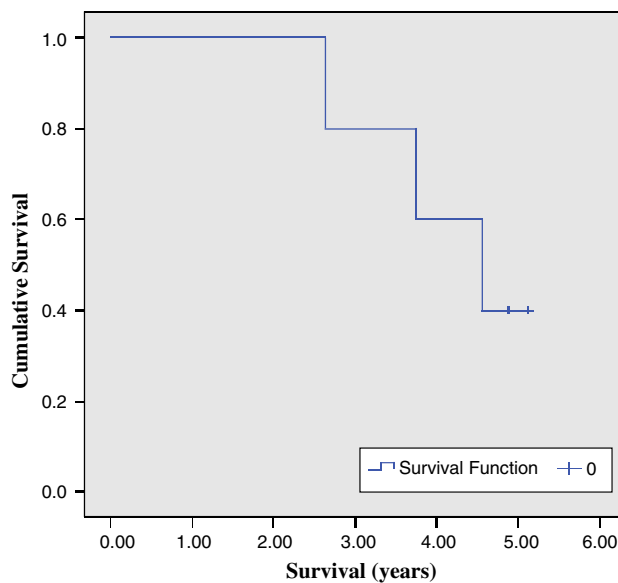


Fig. 3 Survival function for patients with a tracheostomy

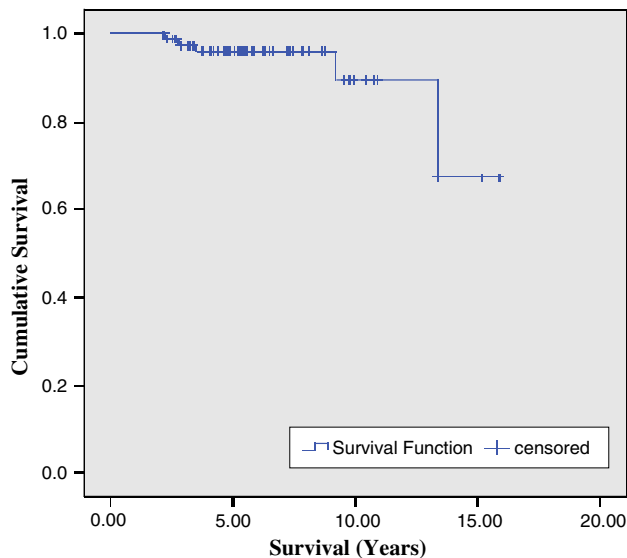


Fig. 4 Survival function for patients without a tracheostomy

Discussion

Neuromuscular hip dysplasia is common in nonambulatory patients with spastic quadriplegia, and reconstructive surgical procedures are often performed to address progressive subluxation or dislocation. Children with a greater severity of neurologic impairment have been shown to have a greater prevalence and severity of hip dysplasia [3] in addition to the highest complication rates [16].

Our first goal was to document the spectrum of complications following reconstructive surgery for neuromuscular hip dysplasia. The complication rate in this series (47.6 % per patient) falls nearly in the center of the range

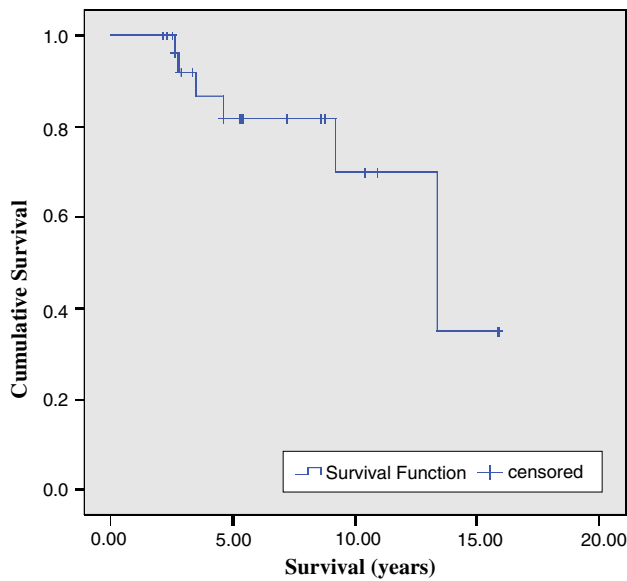


Fig. 5 Survival function for patients younger than 6 years

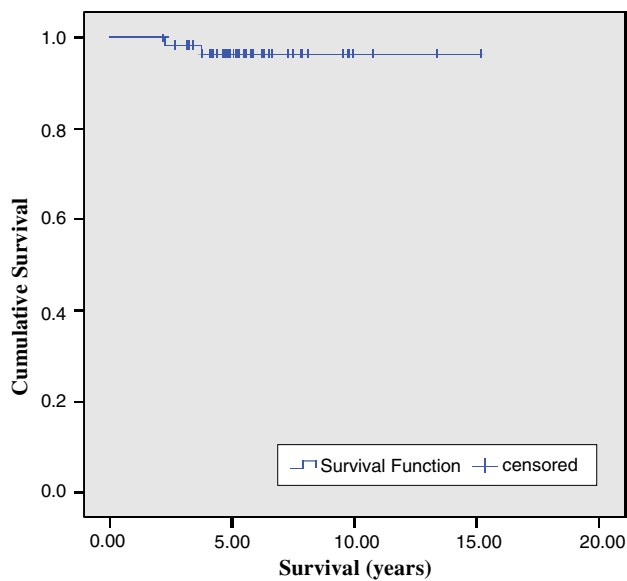


Fig. 6 Survival function for patients older than 6 years

reported in the literature (Table 4) [4–17]. Our rate may also be elevated by the choice to include the category of “failure to cure” as a complication, rather than the more common practice to review the patient’s perioperative course for complications related to the procedure.

Our review of the literature identified 16 studies reporting on 851 hips (3.3–20 years, 46–100 % nonambulators) followed for 4–16 years (Table 4). Most of these studies have reported complications during the perioperative period, have included a subset of ambulatory patients, and have varied in their definition of a complication.

Among these studies there were 534 VDRO’s and 439 VDRO’s and a pelvic osteotomy with or without open reduction of the hip. Unilateral procedures were performed for 401 hips, and bilateral in 233. The most common complication was a femur fracture (9.4 % of hips), which mirrors our experience (8.6 % of hips). Fractures have been linked to immobilization in a spica cast, although in our study both the casted and non-casted groups totaled four fractures each. Other complications included pressure sores (3.3 % of cumulative patients), infection (2 %), AVN (10 %), HO (2.3 %), arthritis from an incongruent joint (2.7 %), implant failure (0.9 %), and symptomatic implants (0.8 %). Medical complications mostly involved the pulmonary system (respiratory failure, pneumothorax, pneumonia, or atelectasis).

In our study persistent instability was identified in 9 % of cases [2 % severe subluxation (RMI >60 %), 7 % redislocation]. Most studies have not considered “failure to cure” as a complication, namely redislocation or a RMI which would predict progressive subluxation leading to dislocation. In previous studies, which have included a subset of ambulatory patients, resubluxation was reported in 76 of 678 hips (11 %, range 2–14 %, 14/16 studies), while redislocation was observed in 20/678 hips (3 %, range 0–16 %, 14/16 studies). With regard to radiographic outcomes, the average RMI at follow-up was 17 % (12/16 studies), while the acetabular index was 21.2 (10/16 studies). The neck-shaft angle was only reported in 5/16 studies, and ranged from 104 to 133 degrees at follow-up.

According to Sink’s modification of the Clavien–Dindo scheme, 19 of our 35 complications were mild (Grade I or II). Of the remaining 16 complications, 8 were failures to cure and 5 involved symptomatic implants. We found that the single grade IV complication was an asymptomatic case of avascular necrosis. AVN was reported as a complication in 64 cases (7/16 studies), 33 of which were observed in a single series (Khalife). As AVN varies in severity, and is usually asymptomatic in the nonambulatory population with cerebral palsy, it remains questionable whether AVN should be classified as a grade IV unless long term symptoms are present or would be predicted. Noonan et al. reported a complication rate of 81 % in 65 patients (92 % nonambulatory), including 15 cases of “incongruent hips”, a radiologic finding for which we did not report.

As demonstrated in Table 5, incorporating these “failures to cure” into the literature review[4–17] raises the composite complication rate from 38 % up to 54 %, while at the same time skewing the complication grades towards the more severe. The proportion of grade IIIb complications alone jumps from 24 to 43 %. We believe that this reclassification helps to better estimate the true risks associated with this intervention.

Table 4 Summary of findings of related studies

Author	Pt	Hips	Age (range)	Non-amb	Technique	Side unilateral/bilateral	Imm	FU (years)
Hoffer [6]	20	25	8.9 (4.5–15)	65 %	VDRO	15 (75 %)/5 (25 %)	2–8 weeks	11.5
Sturm [17]	21	28	19 (3.3–31)	75 %	Procedure not specified	14 (67 %)/7 (33 %)	6–12 weeks	NR
Brunner [4]	47	64	10.3 (3.4–19.4)	68 %	VDRO + OR	30 (47 %)/17 (53 %)	6 weeks	Clin (6.8) Rad (3)
Root [12]	31	35	12 (4–23)	71 %	VDRO + OR + PO (26 Salter, 5 Chiari, 3 Shelf, 1 Pen)	27 (87 %)/4 (13 %)	6 weeks	7
Gordon [5]	44	52	8.8 (4.4–16.4)	75 %	PO (Pemberton) ± VDRO (50) ± femur shortening (15) ± STR (37) ± OR (13)	36 (82 %)/8 (18 %)	6–10 weeks	4
Miller [23]	51	70	9.9 (3.3–20)	86 %	VDRO ± PO (59) ± OR (6) VDRO (11)	42 (82 %)/9 (18 %)	None	2.77
Shea [21]	15	19	7.75 (3.4–12.2)	27 %	PO (Pemberton) ± STL (9) ± VDRO (13) ± OR (3)	11 (73 %)/4 (17 %)	6 weeks	10.75
Song [15]	39	55	8.8 (3–15)	79 %	VDRO (31) VDRO + PO (24)	23 (59 %)/16 (41 %)	6 weeks	4.5
Stasikelis [16]	79	119	7.3 (2–17.8)	84 %	VDRO + STR ± PO (25)	39 (49 %)/40 (51 %) (9 staged, 31 at index)	NR	2.4
McNerney [9]	75	104	8.1 (1.1–19.2)	96 %	Index side: VDRO + STR ± OR (69) + PO Other side: VDRO (55) ± PO (2 Salter)	20 (27 %)/55 (73 %)	4–6 weeks	6.9
Noonan [11]	65	79	7.6 (3.1–16.8)	92 %	VDRO (30) VDRO + OR (49)	51 (78 %)/14 (22 %)	NR	5.2
Sankar [13]	12	14	10.6	75 %	VDRO + STR + Obt Neur + OR + PO	10 (83 %)/2 (17 %)	4–6 weeks	16.7
Al-Ghadir [18]	39	52	8.1 ± 3.6 years	100 %	A: VDRO (16) B: VDRO + PO (36)	26 (67 %)/13 (33 %)	NR	4.4
Luegmair [8]	19	19	14.6 (12–17.9)	68 %	Shelf (19) ± VDRO (5) ± STR (11) ± OR (1)	19 (100 %)/0	6 weeks	5.4
Khalife [7]	50	89	7.4 (4–15)	46 %	VDRO ± PO (40 Dega, 17 Salter) ± OR (20)	11 (22 %)/39 (78 %)	3 weeks	6
Canavese [24]	27	27	6.8 (2–15)	93 %	VDRO + STR (22) VDRO + STR + PO (5)	27 (100 %)/0	NR	2
N = 16	634	851						
Current study	61	93	8.1 (2.6–14.7)	100 %	VDRO + STR ± PO	34 (55 %)/28 (45 %)		8.9
Author	NSA (°) Preop/FU	AI (°) Preop/FU	RMI (%) Preop/FU	Complications	Compl Rate* (%)	Resubluxate/redislocate	Sink grades (% of complications)	
Hoffer [6]	155/125	28/27	NR	AVN (1), Pin drainage (4), Excessive varus angulation (3)	65	4/1	I (8, 57 %) IIIb (5, 36 %) IV (1, 7 %)	
Sturm [17]	NR	NR	NR	Fx (10)	48	NR	II (10, 100 %)	
Brunner [4]	NR	NR	NR	Fx (3), Inf (1)	47	15/3	II (4, 18 %) IIIb (18, 82 %)	

Table 4 continued

Author	NSA (°) Preop/FU	AI (°) Preop/FU	RMI (%) Preop/ FU	Complications	Compl Rate* (%)	Resubluxate/ redislocate	Sink grades (% of complications)
Root [12]	NR	50/40	74/25	AVN (10), Technical error pelvic osteotomy (1), Fx (3), HO (2), Trochanteric bursitis (1)	68	4/0	I (14, 67 %) II (3, 14 %) IIIb (4, 19 %)
Gordon [5]	NR	NR	NR	Delayed union (2), Pneum (2), Skin ulcer (2)	14	None	I (4, 67 %) II (2, 33 %)
Miller [23]	Nonamb: 150/104 Amb: 148/115	NR	VDRO: 43/9 VDRO + PO: 74/5	Pneum (1), HO (1), PTX (1), UTI (1), Inf (3), Fx (3), Skin breakdown (6), AVN (6)	51	2/2	I (13, 50 %) II (5, 19 %) IIIa (4, 15 %) IIIb (4, 15 %)
Shea [21]	NR	28/11	55/12	None	0	None	None
Song [15]	VDRO: 157/133 VDRO + PO: 159/132	VDRO: 28/24 VDRO + PO: 29/18	VDRO: 54/27 VDRO + PO: 63/11	Fx (10), Implant failure (2), AVN (2), HO (1)	67	9/2	I (1, 4 %) II (10, 38 %) IIIb (13, 50 %) IV (2, 8 %)
Stasikelis [16]	NR	NR	NR	Death (3), Fx (25), Decub ulcers (5)	42	NR	I (5, 15 %) II (25, 76 %) V (3, 10 %)
McNemey [9]	NR	26/11	66/14	Technical error pelvic osteotomy (1), AVN (8), Wound infection (3), HO (7), Coxa vara (2), Death (1), Severe windblown hips (1)	37	5/0	I (11, 39 %) II (3, 11 %) IIIb (5, 18 %) IV (8, 29 %) V (14 %)
Noonan [11]	153/131	32/25	82/28	HO (1), Infection (2), Delayed unions (2), Pressure sore (6), Windswept hips (6), Abduction contracture (4), Fx (9), Incongruent/DJD (16), AVN (4)	81	18 (with RMI > 35 %)/3	I (29, 40 %) II (17, 24 %) IIIb (22, 31 %) IV (4, 6 %)
Sankar [13]	NR	NR	100/11	Fx (8), Arthritis (1)	75	None	I (1, 11 %) II (8, 89 %)
Al-Ghadir [18]	A: 153/120 B: 159/121	A: 24/11 B: 24/20	A: 62/10 B: 63/18	HO (1)	13	4/0	I (1, 20 %) IIIb (4, 80 %)
Luegmair [8]	NR	51/35	64/10	Hematoma (1), Stiffness (1), Graft resorption (1), Windblown hip (1), Arthritis (1)	42	0/3	I (5, 63 %) IIIb (3, 37 %)
Khalife [7]	145/130	VDRO: 30/30 VDRO + PO: 21/21	19/22	HO (1), Fx (1), AVN (33)	94	12/0	I (1, 2 %) II (1, 2 %) IIIb (12, 26 %) IV (33, 70 %)
Canavese [24]	NR	I/L: 52/44 C/L: 51/43	I/L: 48/18 C/L: 53/23	NR	NR	6/0	IIIb (6, 100 %)

N = 16

Table 4 continued

Author	NSA (°) Preop/FU	AI (°) Preop/FU	RMI (%) Preop/FU	Complications	Compl Rate* (%)	Resubluxate/redislocate	Sink grades (% of complications)
Current study	NR	NR	NR/27	Decubitus ulcers (3), HO (1), Pain (2), Atelectasis (2), Fx (8), Malignant hyperthermia (1), Inf (1), UTI (1), Respiratory failure (1), Sympt implant (5), loss of fixation (1), AVN (1)	47	2/6	I (8, 23 %) II (11, 32 %) IIIa (1, 3 %) IIIb (14, 41 %) IV (1, 3 %)

Age is reported in years

PI patient, *Imm* length of immobilization in weeks, *NSA* femoral neck shaft angle, *AI* acetabular index (angle formed by line from lateral triradiate cartilage to acetabulum edge and Hilgenreiters line), *FU* follow up, *VDRO* varus derotation osteotomy, *OR* open reduction, *PO* pelvic osteotomy, *NR* not reported, *AVN* avascular necrosis, *Fx* fracture, *HO* heterotopic ossification, *Pneum* pneumothorax, *D/D* degenerative joint disease, *Clin* clinical follow up, *Rad* radiological follow up

* Complication rate is calculated [(total complications + failures to cure)/total patients]

Table 5 Proportion of complications according to grade comparing the present series to the cumulative total from the studies represented in Table 4

Classification according to Sink modification of Clavien-Dindo		
Complication grade	Literature review	Present series (%)
I (deviation from normal postoperative course)	14 % (44/324)	23
II (requiring pharmacologic treatment)	29 % (94/324)	31
IIIa (intervention not under general anesthesia)	0.01 % (2/324)	3
IIIb (intervention under general anesthesia)	32 % (104/324)	40
IV (life threatening or long term orthopaedic dysfunction)	24 % (79/324)	3
V (death)	0.03 % (1/324)	0

Our second goal was to identify the risk factors for these complications. Only spica cast immobilization ($P = 0.023$) was linked to all-cause complications, while patients younger than 6 years old ($P = 0.013$) and children with a tracheostomy ($P = 0.004$) were linked to failures to cure. Previous studies have shown that spica immobilization is associated with an increased risk of fractures [17]. Taking a closer look at the complications associated with spica casting in our current series, the distribution of specific complications is mostly equivalent among the spica and non-spica groups (four femur fractures in each) with the exception of the CD type I complications, of which, six of eight were related to the cast: three decubitus ulcers, one case of heterotopic ossification, and two cases of severe pain with one definitely related to the cast requiring cast removal. With regard to the other risk factors, the presence of a tracheostomy indicates a greater severity of neurologic involvement, likely increasing the risk of recurrent instability. Furthermore, as progression of neuromuscular hip dysplasia is in part due to muscle imbalance within the setting of rapid growth, it seems plausible that younger patients would be at greater risk for recurrence of instability.

There are several limitations of our study, including the fact that patients were treated by a number of different surgeons over a 10 year period, and the data is retrospective. One important variable that likely relates to complications following surgical procedures in the neuromuscular population is nutritional status, which was not controlled in our study. Our current practice includes a preoperative nutritional consultation prior to reconstructive procedures for neuromuscular hip dysplasia, and while many patients are suitable candidates with oral supplementation, a more limited number have even required placement of a

gastrostomy tube to achieve appropriate nutritional parameters for these procedures.

Conclusions

While complications are frequent in nonambulatory patients with CP following reconstructive hip surgery, the vast majority are minor and do not result in permanent problems. Immobilization in a spica cast should be avoided if possible due an increased risk for cast-related complications. Furthermore, younger patients with greater levels of neurologic impairment are at the greatest risk for

a complication. We suggest that “failure to cure” be considered a long term complication. While adopting a uniform classification scheme for complications of surgical procedures is a worthy goal, our impression is that systems used in the general surgical literature must be adapted to characterize the nuances of orthopaedic complications.

Appendix

See Table 6.

Table 6 Raw patient data

Hip #	Pt #	Age at surgery (years)	Sex	Hip side	Trach/G-tube	Weight (kg)	ASA status	Procedure	Surgery total	EBL (mL)
2	2	13.9	M	R	N	42.4	2	5	2:17	150
3	2	13.4	M	L	N	38.0	3	5	4:36	200
4	3	9	F	R	N	34.0	3	4	4:52	150
5	4	5.3	M	R	Both	17.2	3	3	3:30	100
6	4	5.3	M	L	Both	17.2	3	3	3:30	100
7	5	10.4	F	R	N	16.6	3	2	2:45	100
8	6	14.6	M	R	N	32.7	2	2	2:09	100
9	7	8.8	M	R	G-tube	16.0	3	4	3:09	100
12	9	10.4	M	L	Both	36.0	3	2	2:09	150
17	14	7.9	M	R	Both	25.7	3	5	4:21	250
18	14	7.9	M	L	Both	25.7	3	5	4:21	250
21	16	7.1	M	L	Both	11.9	3	5	4:38	260
22	17	5.6	F	L	N	19.0	2	2	2:30	225
23	18	13.3	F	R	N	26.0	3	3	2:57	150
24	18	13.3	F	L	N	26.0	3	3	2:57	150
26	20	4.6	F	R	G-tube	16.6	3	3	2:53	50
27	20	4.6	F	L	G-tube	16.6	3	3	2:53	50
29	22	7.7	F	R	N	23.6	3	5	5:27	475
30	22	7.7	F	L	N	23.6	3	5	5:27	475
33	24	5.9	M	R	G-tube	10.7	3	3	3:29	100
34	24	5.9	M	L	G-tube	10.7	3	3	3:29	100
36	26	10.3	F	R	N	20.1	3	5	2:57	100
37	26	7.1	F	L	N	15.3	3	5	2:55	150
41	29	13.9	F	R	N	37.6	3	3	4:10	600
42	29	13.9	F	L	N	37.6	3	3	4:10	600
43	30	4.9	M	R	G-tube	19.0	3	2	2:33	100
46	33	6.8	M	R	N	24.3	3	5	3:28	100
47	33	8	M	L	N	31.4	3	5	2:38	100
48	34	3.8	F	R	G-tube	15.2	3	3	4:09	250
49	34	3.8	F	L	G-tube	15.2	3	3	4:09	250
51	36	6.1	F	R	G-tube	26.2	3	3	2:33	50
52	36	6.1	F	L	G-tube	26.2	3	3	2:33	50
53	37	9.7	M	R	N	18.7	3	7	3:39	150
54	37	11.5	M	L	N	20.2	3	7	4:07	200
55	38	6.7	M	L	G-tube	24.0	3	4	2:18	100
56	39	10.8	M	L	N	33.5	3	2	2:38	100
57	40	4.4	M	L	G-tube	15.1	3	4	3:31	125

Table 6 continued

Hip #	Pt #	Age at surgery (years)	Sex	Hip side	Trach/G-tube	Weight (kg)	ASA status	Procedure	Surgery total	EBL (mL)
58	41	12.3	M	R	N	33.8	3	4	3:36	200
60	43	11	F	R	N	38.0	2	2	2:34	100
61	44	13.4	M	L	N	61.1	3	2	2:47	200
63	46	5.7	M	R	N	16.4	3	4	2:34	50
65	48	10.9	M	L	N	35.4	2	4	3:11	150
66	49	9.4	F	L	G-tube	23.6	3	3	2:55	100
67	49	9.4	F	R	G-tube	23.6	3	3	2:55	100
70	52	5	F	R	G-tube	13.0	2	3	2:28	100
71	52	7.1	F	L	G-tube	15.3	2	3	2:09	200
72	53	12.2	F	R	N	21.0	2	7	3:35	300
73	53	11.8	F	L	N	20.5	3	7	3:59	200
76	56	10.7	F	R	N	17.2	3	2	2:12	100
77	57	9.6	F	R	N	18.1	2	3	3:31	500
78	57	9.6	F	L	N	18.1	2	3	3:31	500
81	59	8.2	M	L	N	17.7	3	4	3:45	100
82	60	6.2	F	R	G-tube	11.0	3	7	4:52	150
83	60	6.2	F	L	G-tube	11.0	3	7	4:52	150
84	61	8.9	F	R	G-tube	16.0	2	4	2:51	150
85	62	7	F	L	N	22.5	3	4	3:33	150
88	65	8.6	M	L	G-tube	17.7	3	4	3:07	100
89	66	3.1	F	R	Both	13.6	3	3	2:54	200
90	66	3.1	F	L	Both	13.6	3	3	3:54	200
91	67	12.3	F	R	N	28.0	3	3	2:53	n/a
92	67	12.3	F	L	N	28.0	3	3	2:53	n/a
97	71	4.7	F	L	G-tube	16.1	3	4	3:46	100
100	74	3.5	F	R	G-tube	10.9	3	2	3:51	250
102	76	9.3	M	R	N	46.2	3	3	3:44	250
103	76	9.3	M	L	N	46.2	3	3	3:44	250
104	77	5.3	M	R	G-tube	15.0	3	3	3:02	100
105	77	5.3	M	L	G-tube	15.0	3	3	3:02	100
106	78	7	M	R	N	21.0	3	3	3:36	300
107	78	7	M	L	N	21.0	3	3	4:36	300
110	80	8.3	F	L	N	19.0	3	4	3:51	75
116	84	9.7	M	R	N	31.2	3	5	2:05	250
117	84	9.7	M	L	N	24.9	2	5	3:11	100
127	91	7.2	F	R	G-tube	18.0	3	3	3:48	100
128	91	7.2	F	L	G-tube	18.0	3	3	3:48	100
129	92	3.3	F	R	G-tube	16.3	2	3	2:47	150
130	92	3.3	F	L	G-tube	16.3	2	3	2:47	150
131	93	7.4	M	R	G-tube	N/a	n/a	5	n/a	n/a
132	93	7.4	M	L	G-tube	n/a	n/a	5	n/a	n/a
133	94	10.8	M	R	N	25.0	3	5	2:56	150
134	94	11.6	M	L	N	25.0	3	5	2:56	150
135	95	11.1	M	R	N	24.0	2	5	4:59	300
136	95	11.1	M	L	N	24.0	2	5	5:59	300
140	98	6.1	M	L	N	18.0	3	4	3:44	250
147	103	8	F	L	N	25.0	3	4	4:38	100
150	105	4.3	M	R	N	20.1	2	3	2:28	Minimal
151	105	4.3	M	L	N	20.1	2	3	2:28	Minimal
153	107		M	R	G-tube	14.0	2	3	1:35	125
158	110	11.7	F	L	N	19.5	3	4	3:32	100
160	112	5	F	R	G-tube	11.2	2	3	4:13	30

Table 6 continued

Hip #	Pt #	Age at surgery (years)	Sex	Hip side	Trach/G-tube	Weight (kg)	ASA status	Procedure	Surgery total	EBL (mL)
161	112	5	F	L	G-tube	11.2	2	3	4:13	30
169	118	2.6	M	R	N	9.2	2	2	2:26	100
170	119	6.3	F	L	N	17.0	2	2	5:33	150
Hip #	Transfusion	Periop complications	Post-op Hgb	Immob type	Hospital complications	Length of stay CHOP (days)	Postop complications	Complication treatment	Follow-up (years)	FFU RMI
2	Y	N	7.8	abd pillow	N	8	N		5.03	0.05
3	Y	N	9.9	abd pillow	respiratory failure	7	Femur fracture	Spica cast	5.54	0.05
4	N	N	6.7	abd pillow	N	6	AVN femoral head & femur fracture	Spica cast	6.46	0.05
5	N	N	8.3	abd pillow	N	3	N		4.56	0.95
6	N	N	8.3	abd pillow	N	3	N		4.56	0.51
7	N	N	10.8	abd pillow	N	4	N		8.09	0.05
8	N	N	13	abd pillow	N	4	N		3.79	0.05
9	N	N	10.2	abd pillow	N	3	N		4.66	0.26
12	N	N	9.9	abd pillow	N	6	N		4.89	0.19
17	N	N	12.4	Spica cast	N	3	N		3.73	1.00
18	N	N	12.4	Spica cast	N	3	N		3.73	0.05
21	Y	N	11.7	Spica cast	N	5	N		5.13	0.05
22	N	N	9.6	abd pillow	N	4	N		3.33	0.59
23	N	N	8.8	Spica cast	N	6	Sacral decubitus ulcer	Wound care	7.84	0.11
24	N	N	8.8	Spica cast	N	6	Sacral decubitus ulcer	Wound care	7.84	0.27
26	N	N	10.2	abd pillow	N	4	N		2.53	0.22
27	N	N	10.2	abd pillow	N	4	N		2.53	0.24
29	Y	N	9.7	Spica cast	N	5	N		6.21	0.43
30	Y	N	9.7	Spica cast	N	5	N		6.21	0.05
33	Y	N	9.6	Spica cast	N	6	N		2.81	0.05
34	Y	N	9.6	Spica cast	N	6	Femur fracture	Spica cast	2.81	0.05
36	N	N	11	abd pillow	N	6	Femur fracture	Splint	4.11	0.27
37	N	N	13.9	abd pillow	N	3	N		7.30	0.05
41	N	N	9	Spica cast	N	2	N		3.40	0.17
42	N	N	9	Spica cast	N	2	N		3.40	0.22
43	N	N	10.3	abd pillow	N	2	Femur fracture	Spica cast	2.89	0.35
46	N	N	9.5	abd pillow	N	4	N		4.35	0.30
47	N	N	10.8	abd pillow	N	3	N		3.20	0.19
48	Y	N	10.4	Spica cast	N	3	HO		2.29	0.58
49	Y	N	10.4	Spica cast	N	3	HO		2.29	0.45
51	N	N	n/a	Spica cast	N	2	N		8.63	0.52
52	N	N	n/a	n/a	N	2	N		8.63	0.17
53	N	N	8.56	abd pillow	N	4	N		4.11	0.55
54	Y	N	7.8	abd pillow	N	6	N		2.23	0.78
55	Y	N	12.9	abd pillow	N	4	N		3.18	0.34
56	N	N	n/a	abd pillow	N	5	N		5.77	0.36
57	N	Hyperthermic intraoperatively	8.8	Spica cast	Malignant hyperthermia	3	N		3.51	0.82
58	N	N	11.6	abd pillow	N	3	N		2.70	0.28

Table 6 continued

Hip #	Transfusion	Periop complications	Post-op Hgb	Immob type	Hospital complications	Length of stay CHOP (days)	Postop complications	Complication treatment	Follow-up (years)	FFU RMI
60	N	N	9.1	abd pillow	N	3	Severe pain	Exam under anesthesia	5.83	0.25
61	N	N	10.7	abd pillow	N	4	N		4.82	0.05
63	Y	N	9.6	abd pillow	Skin breakdown in groin area	4	N		2.13	0.24
65	N	N	9.9	abd pillow	N	4	N		5.44	0.15
66	Y	N	6	Spica cast	N	6	N		4.90	0.05
67	Y	N	6	Spica cast	N	6	n/a		4.90	0.26
70	N	N	7.3	abd pillow	N	4	N		5.43	0.54
71	N	N	8.4	abd pillow	Seizure	4	N		3.39	0.05
72	Y	N	n/a	Spica cast	Sacral decubitus ulcer	8	N		4.88	0.05
73	N	N	8.7	Spica cast	N	3	N		5.28	0.05
76	N	N	9.8	abd pillow	N	2	N		5.16	0.05
77	Y	N	6.5	Spica cast	Severe pain requiring spica change	5	N	Spica cast change	6.22	0.43
78	Y	N	6.5	Spica cast	Severe pain requiring spica change	5	N	Spica cast change	6.22	0.05
81	N	N	8.8	abd pillow	N	6	N		2.21	0.05
82	Y	N	n/a	abd pillow	N	2	N		2.66	0.47
83	Y	N	n/a	abd pillow	N	2	N		2.66	0.05
84	N	N	9.1	abd pillow	N	4	N		4.58	0.38
85	N	N	10.1	abd pillow	N	7	Symptomatic implant	Hardware removal	6.67	0.21
88	N	N	9.1	abd pillow	N	3	N		4.75	0.25
89	Y	N	7.4	abd pillow	N	8	Loss of implant fixation	Refixation	2.63	0.86
90	Y	N	7.4	abd pillow	N	8	N		2.63	0.51
91	N	N	9.8	Spica cast	N	3	N		4.83	0.08
92	N	N	9.8	Spica cast	N	3	N		4.83	0.09
97	N	N	10.2	Spica cast	N	3	Infection	PICC line placement & antibiotics	5.28	0.46
100	N	N	n/a	Spica cast	Atalectasis	3	Femur fracture	Splint	2.79	1.00
102	N	N	8.7	abd pillow	N	4	N		4.21	0.47
103	N	N	8.7	abd pillow	N	4	N		4.21	0.05
104	N	N	11.4	Spica cast	N	3	Symptomatic implant	Hardware removal	7.22	0.19
105	N	N	11.4	Spica cast	N	3	Symptomatic implant	Hardware removal	7.22	0.50
106	N	N	12.6	Spica cast	N	5	None		10.75	0.05
107	N	N	12.6	Spica cast	N	5	None		10.75	0.35
110	N	N	13	Spica cast	N	5	Femur fracture	Spica cast	7.49	0.18
116	N	N	9.1	abd pillow	N	4	Symptomatic implant	Hardware removal	7.81	0.05
117	N	N	11.1	abd pillow	N	4	None		9.56	0.05
127	N	N	13.5	Spica cast	Skin breakdown	57	None		9.91	0.05
128	N	N	13.5	Spica cast	Skin breakdown	57	None		9.91	0.05
129	N	N	10.8	Spica cast	Atalectasis	3	None		8.78	0.05
130	N	N	10.8	Spica cast	Atalectasis	3	None		8.78	0.05

Table 6 continued

Hip #	Transfusion	Periop complications	Post-op Hgb	Immob type	Hospital complications	Length of stay CHOP (days)	Postop complications	Complication treatment	Follow-up (years)	FFU RMI
131	N	N	n/a	abd pillow	N	n/a	None		7.26	0.19
132	N	N	n/a	abd pillow	N	n/a	None		7.26	0.19
133	N	N	13.6	abd pillow	N	3	None		6.27	0.39
134	N	N	13.6	abd pillow	N	3	None		5.44	0.05
135	N	N	11.7	Spica cast	UTI	5	None	Bactrim	4.65	0.05
136	N	N	11.7	Spica cast	UTI	5	None	Bactrim	4.65	0.05
140	N	N	8.5	abd pillow	N	4	None		9.21	1.00
147	N	N	14.1	Spica cast	N	7	None		9.77	0.05
150	N	N	10.3	Spica cast	N	6	None		10.42	0.05
151	N	N	10.3	Spica cast	N	6	Femur fracture	Spica cast	10.42	0.14
153	Yes	N	11.4	Spica cast	N	3	None		13.34	1.00
158	N	N	14.2	Spica cast	N	3	None		10.89	0.24
160	N	N	14.5	Spica cast	N	3	None		10.89	0.43
161	N	N	14.5	Spica cast	N	3	None		15.86	0.43
169	N	N	n/a	Spica cast	N	3	None		15.17	0.05
170	N	N	11.1	Spica cast	N	3	Symptomatic implant	Hardware removal	5.86	0.16

Pt #, patient number, Trach/g-tube, presence of tracheostomy, gastrostomy tube, or both; Procedure: 2, unilateral VDRO; 3, bilateral VDRO; 4, unilateral VDRO and unilateral pelvic osteotomy; 5, bilateral VDRO and unilateral pelvic osteotomy; 7, bilateral VDRO and bilateral pelvic osteotomy

ASA American Society of Anesthesiologists, *immob* immobilization, *abd pillow* abduction pillow

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