

Comparative characteristics of radiographic classifications of the consequences of septic coxitis in children

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Introduction Septic coxitis is sustained in the early childhood and has a devastating effect on the musculoskeletal system. Systematization of the acquired defects and deformities is of great importance for treatment planning and outcome prediction. A radiographic classification based on the features of the deformities in the proximal femur and acetabulum as well as on their mutual orientation was proposed at the Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics. Purpose To study the reliability of the mentioned classification and to compare it with other classifications. **Material and Methods** Six orthopedic surgeons divided into two groups according to their specialization evaluated 23 X-rays of the hips using the classification systems of I.H. Choi, O.A. Sokolovsky, E. Forlin, and RISC for RTO. Two orthopedic surgeons re-evaluated them two weeks later. Intra-rater and inter-rater agreement was determined using kappa value calculations. **Results** The number of inter-rater and intra-rater consensus depended on the specialization of experts, and it was higher in the first group. The highest proportion of the coincidences of three expert conclusions was observed when the classification systems of Forlin and RISC for RTO were used. The values of intra-rater and inter-rater reliability of the RISC for RTO classification were 0.542-0.641 and 0.436-0.738. **Conclusion** Taking into account a sufficient level of reliability, the RISC RTO classification can be used as a working system by planning surgical treatment and for prediction of its outcome in children with consequences of septic coxitis.

Keywords Consequences of septic coxitis, classification

INTRODUCTION

Consequences of septic coxitis in children are a variety of disorders that have a serious impact on the condition of the musculoskeletal system. They include a premature closure or destruction of growth plates, damage to the bone and cartilage structures of the hip, and disorders in the joint relationships [1, 10, 16] that result in the joint mobility impairment, limb shortening, pain and create conditions for an early progression of arthritis. The aim of surgical treatment is to improve the joint function and limb weight-bearing. The variety of pathologies present makes it difficult to choose a technique of the intervention on the joint. Therefore, the systematization of the features of this pathology is of great importance [5, 14]. The classification should help an orthopaedic surgeon characterize the main pathologies, define an optimal variant of rehabilitation measures for the condition encountered, and potential outcomes. A joint data base that registers the outcomes obtained with the use of different techniques will allow for objective comparison of treatment results accumulated by

medical establishments [11]. The classification must be reliable and validated. In case the validity of the classification system is very difficult to assess, then the reliability should be determined by the agreement of the conclusions made by a number of specialists as well as by one specialist in a repeated study [11].

The issues of the systematization of septic coxitis sequelae were reported in the studies of several authors [5]. Hip joint classification is frequently based on the anatomical features of the joint that include the deformity and destruction grade of the proximal femur and acetabulum, head dislocation and the mechanism of its development [2, 3, 5, 16]. The scientists of the RISC for RTO have proposed a classification of the consequences of septic coxitis in children [4].

The purpose of the study was to assess the reliability of the proposed classification and compare it with the existing classification systems.

MATERIALS AND METHODS

Radiographs of 23 patients in the age between two and 12 years that had sequelae of septic coxitis were studied and analyzed. The study group included only the patients that had suffered septic coxitis during the first year of their life. Exclusion criteria were consequences of tuberculosis arthritis, osteomyelitis that developed after one year of age or due to injuries of the hip. There were 15 boys and 8 girls. Anteroposterior radiographic views were examined. The reliability of four classification systems developed by

I.H. Choi [16], O.A. Sokolovsky [5], E. Forlin [14], and RISC for RTO [4] was studied.

I.H Choi's classification has 4 groups and 8 subgroups:

Ia – no deformity;

Ib – coxa magna;

IIa – femoral neck shortening with deformity of the head;

IIb – damage to the growth zone, coxa vara, coxa valga;

IIIa – damage to the femoral neck, coxa vara, coxa valga associated with a severe antetorsion and retrotorsion;

IIIb – pseudarthrosis of the femoral neck;

IVa – complete loss of the femoral head, partial loss of the neck;

IVb – femoral neck and head defect.

O.A. Sokolovsky's classification distinguishes 5 groups and 10 subgroups:

Ia – normal joint;

Ib – coxa magna, partial damage to the growth zone, coxa vara, coxa valga, femur subluxation, acetabular dysplasia;

IIa – deformity of the femoral head, symmetric damage to the growth zone, shortening of the neck, coxa magna;

IIb – deformity of the femoral head, asymmetric damage to the growth zone, progressive vara, coxa valga, femur subluxation, acetabular dysplasia;

IIIa – damage to the femoral neck, coxa vara, coxa valga with expressed antetorsion and retrotorsion;

IIIb – pseudarthrosis of the femoral neck;

IVa – femur dislocation, preserved head, excessive anteversion;

IVb – femur dislocation, decrease in the femoral head size, shortened femoral neck, excessive anteversion, acetabular dysplasia;

Va – loss of the femoral head, loss of the y-shaped cartilage, deformity in the acetabulum;

Vb – loss of the femoral head and neck, loss of the y-shaped cartilage, deformity in the acetabulum.

E. Forlin's classification is presented by 2 groups and 4 subgroups:

Ia – femoral head is preserved, completely or partially, and is located in the acetabulum;

Ib – femoral head loss or the head is positioned at the acetabular level;

IIa – femoral head is preserved completely or partially but is located out of the acetabulum;

IIb – femoral head loss and the proximal femur is above the acetabulum.

RISC for RTO's classification includes 5 groups:

Ia – joint instability but the contact of the femoral head and acetabulum retained, pathological neck-to-shaft relationship, increased or reduced size of the head, increased or reduced volume of the acetabulum, underdeveloped acetabular roof;

Ib – changes similar to Ia but the contact between the femoral head and the acetabulum is absent;

IIa – deformities of the femoral head and neck of varying grades, neck-to-epiphysis disorders, hyperplasia of the greater trochanter. Acetabulum is within the age norm or there is a mild dysplasia of its roof;

IIb – changes in the proximal femur correspond to IIa subgroup, are associated with dysplasia or deformity of the acetabulum, and are associated with disorders in joint relations;

III – pseudarthrosis of the femoral neck;

IVa – defect of the femoral head but the neck is partially or completely preserved;

IVb – complete defect of the femoral neck and head;

V – rigid neoarthrosis between the pelvic and femoral bones.

Six orthopaedic surgeons were divided into 2 groups. Group 1 was three pediatric orthopaedic surgeons that specialize in hip pathology. Group 2 were experts in adult orthopaedic pathology. Each of the specialists classified 23 X-rays according to 4 classification systems named above. All the orthopedic surgeons were provided with the diagrams and description of every classification from the original source in Russian. In both groups, the number of agreement opinions was calculated for every classification.

Two orthopaedic surgeons (one from each group) reevaluated the X-rays after 2 weeks in order to determine intra-rater reliability. For defining inter-rater reliability, the results of two experts were compared in each group. The Kappa (K) value and standard Kappa error (SE(k) were calculated [11, 12]. Calculations were performed with the use of SPSS (Statistical Package for Social Science) software.

In order to assess the level of agreement, Landis [15] и Svanholm [17] criteria were used. Landis criteria: $K > 0.80$, almost excellent agreement; $K = 0.61$ up to 0.80 , significant agreement; $K = 0.41$ up to 0.60 , moderate agreement; $K = 0.21$ up to 0.40 , satisfactory agreement; $K = 0.00-0.20$, weak agreement; $K < 0.00$, poor agreement. There is an opinion that the criteria of Svanholm et al. are preferable for medical studies that are distinguished by their simple and strict parameters: $K > 0.75$ – almost excellent agreement; $K = 0.74-0.51$ – good agreement; $K < 0.50$ – poor agreement.

RESULTS AND DISCUSSION

In group 1, the rate of agreement was less than 50 % when X-rays were classified according to I.H. Choi. In Group 2 that was not the experts in hip pathology the agreement rate was lower. The agreement rate was more than 50 % only for E. Forlin's classification (**Table 1**).

Out of 184 expert assessments, disagreement in the diagnosis identified by three experts was in 32 cases.

Complete disagreement of conclusions in group 1 was detected in six cases only by the use of I.H. Choi's and O.A.Sokolovsky's classifications. Complete disagreement in the expert conclusions was revealed by the use of all classifications in group 2: I.H. Choi – 10, O.A. Sokolovsky – 9, E. Forlin – 1, RISC for RTO – 6.

Divergence of expert conclusions was seen in the

assessment of femoral head condition (41.1 %), deformity in the proximal femur (47.8 %), character of joint relations (10.1 %) (**Table 2**). The condition of the femoral head was the main cause of disagreement by the use of Forlin's classification. For the rest of the classifications, difficulties were seen in the distinguishing between the head deformity and head defect. By the use of Choi's and Sokolovsky's systems, the more common cause of disagreement was the assessment of the state of the proximal femur. Difficulties in the assessment of the disorders in joint relations were revealed by the use of O.A. Sokolovsky's classification.

Significant or good level of inter-rater agreement was seen in Group 1 for all classifications using both evaluation

systems (**Table 3**). Moderate level of reliability was seen in Group 2 for E. Forlin's and RISC for RTO systems. The degree of agreement when other classifications were used was evaluated as fair (Landis) or poor (Svanholm).

The results of intra-rater reliability (**Table 4**) showed that the agreement level in Group 1 was moderate only by the use of I.H. Choi's system. A significant level of reliability was stated for other classifications. According to the Svanholm criteria, agreement was good in all the cases. The highest Kappa value was calculated by the use of the Sokolovsky's system. In Group 2, Kappa values were lower for all the classifications. However, they corresponded to the moderate (Landis) or good (Svanholm) levels of reliability.

Table 1

Agreement by groups of experts for assessment of 23 hip joints

Classification	Group 1		Group 2	
	Absolute number	%	Absolute number	%
I.H. Choi	10	43.5	8	34.8
O.A. Sokolovsky	12	52.2	8	34.8
E. Forlin	17	73.9	13	56.5
RISC for RTO	14	60.9	10	43.5

Table 2

Disagreement in the expert conclusions by examination of 23 joints

	I.H. Choi		O.A. Sokolovskiy		E. Forlin		RISC for RTO		Total
	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	
Head	4	5	3	3	5	8	4	6	38
Proximal femur	9	10	5	9			5	6	44
Joint relations			3	3	1	2		1	10
Total	13	15	11	15	6	10	9	13	92

Table 3

Results of reliability coefficient calculations in inter-rater study of 23 joints

Classification	Group 1			Group 2		
	Absolute number	Kappa	SE (k)	Absolute number	Kappa	SE (k)
I.H. Choi	16	0.603	0.125	10	0.331	0.129
O.A. Sokolovsky	17	0.689	0.109	11	0.349	0.123
E. Forlin	19	0.749	0.114	16	0.577	0.128
RISC for RTO	18	0.738	0.103	13	0.436	0.120

Table 4

Results of reliability coefficient calculations in intra-rater study of 23 joints

Classification	Group 1			Group 2		
	Absolute number	Kappa	SE (k)	Absolute number	Kappa	SE (k)
I.H. Choi	15	0.589	0.131	14	0.514	0.115
O.A. Sokolovsky	18	0.72	0.104	14	0.55	0.11
E. Forlin	18	0.664	0.125	16	0.577	0.128
RISC for RTO	16	0.641	0.114	14	0.543	0.117

DISCUSSION

Sequelae of septic coxitis in children are numerous in varieties and result in significant difficulties for this pathology systematization [1]. It is confirmed by a great number of classification systems that were proposed.

The classifications consider the factor of time (acute or neglected complications) [3], mechanism of hip dislocation development (distension or destructive types) [5]. However, radiographic features of joint elements are a common base for systematization. L. Hunka's and I.H. Choi's classifications are primarily based on the character and grade of the damage to the proximal femur [10, 16]. The system of A.P. Krys-Pugach et al. is oriented mainly on the grade of joint relationship disorders [2]. The classification of O.A. Sokolovsky combines the systems of I.H. Choi and A.S. Samkov to some extent but overcomes their shortcomings and reflects in detail the anatomical and functional disorders of the joint components [5]. The classification system of RISC for RTO distinguishes by a lesser detailed characteristics of the pathological changes in the proximal femur but considers the grade and the character of the damage to the acetabulum [4].

There is an opinion that the classifications that consider detailed characteristics of the anatomical and functional disorders are rather bulky, difficult and inconvenient for use. E. Forlin et C. Milani compared the reliability of the well-known Choi's system with their own classification that is simple enough. The review of 41 radiographs using these systems showed that the rate of inter-rater agreement for the authors' classification was 61 % while it was only 17 % by using the classification of I.H. Choi [14].

We conducted a similar study in order to assess the reliability of the classification that was proposed by our Centre. Two systems that describe in detail the anatomical and structural changes [5, 16] and a simple system that distinguishes only two groups [14] were chosen for comparison.

After the analysis of the reasons of discordance, it was established that the main cause of disagreement by the use of the Forlin's system were the difficulties in differentiating whether the femoral defect is partial or complete.

It is known that the main shortcoming of I.H. Choi's and O.A. Sokolovskiy's systems is the complexity in interpreting the character of the proximal femur deformity as far as the pathology description signs are partially repeated. It was confirmed by the analysis of the reasons of the disagreement of the expert conclusions. The rate of differences in the assessment of the proximal femur was 68 % for I.H. Choi's classification and 54 % for Sokolovskiy's classification. When defining our own classification we made an attempt to simplify the assessment

criteria for evaluation of the proximal femur. However, we should acknowledge that this parameter remained the main cause of disagreement of expert opinions by the use of this classification. A number of classification systems, including the one of Sokolovsky, take into account the grade of femur dislocation [2, 3, 5]. The absence of functional views that were not provided to the experts made the differential diagnosis of femoral subluxation and dislocation difficult. It may explain the relatively high rate of disagreement (24 %) of the expert conclusions on the evaluation of the grade of joint relationship disorders when the classification of O.A. Sokolovsky was used.

According to the results obtained, the highest level of agreement was shown by the use of a simple classification independent of the expert specialization that coincides with its authors' data [14]. According to our findings, Forlin's classification is characterized by the highest degree of reliability among the systems studied. It enables to rapidly characterize the main pathological disorders. However, its possibilities in regard to a potential outcome prognosis are doubtful as far as the outcomes of a reconstructive surgery by a "preserved" or "partially preserved" femoral head differ significantly. It seems that this classification cannot be used for operative treatment planning because treatment procedures would have various aims and include the interventions that are different in their character even for the joints that are referred to one and the same type.

Surgical treatment of the sequelae of septic coxitis that are manifested by a considerable destruction of joint components is considered challenging and disputable [7]. Several specialists including E. Forlin et C. Milani believe that reconstructive operations only worsen the condition of such patients as far as they result in formation of stiff painful joints. Thus, these authors recommend to avoid any surgical intervention but have dynamic examinations of patients [9, 14, 18]. Therefore, a detailed characterization of joint components would not be required in such a case, and the classification system may be simplified.

The opposite point of view supports complex reconstructive interventions, including the staged ones, that are aimed at formation of joint components, restoration of joint relationships and provide the opportunity to improve limb supportability and function [5, 6, 8, 16]. Thus, there appears a necessity in a classification that would assess anatomical and structural disorders in the joint in detail and enable to choose an optimal surgical intervention for each patient. Three classifications that have been presented in this paper correspond to this requirement, including the RISC for RTO classification. The level of reliability of these system differed between the groups of investigators. A significant

(good) level of inter-rater and intra-rater agreement was shown in the group of orthopaedic surgeons that treat hip pathologies. In Group 2, the levels of inter-rater reliability were moderate and satisfactory.

It should be stated that reconstructive operations for septic coxitis sequelae refer to complex technologies and aggressive interventions that should be performed by the surgeons having a corresponding specialization. Therefore, classification systems should serve to the needs of this group of orthopaedic surgeons first of all. In our opinion, the level of expert agreement in the first group is of primary importance.

In general, the levels of reliability of I.H. Choi's classification were somewhat lower as compared with the other classifications. However, the agreement level by its use significantly exceeded the findings shown for E. Forlin's systematization [14].

The highest level of intra-rater reliability was shown by the use of Sokolovsky's system. The indices of inter-rater agreement by the use of the RISC for RTO classification were higher as compared with the systems of Choi and Sokolovsky.

Significant (Group 1) and moderate (Group 2) levels of inter-rater and intra-rater reliability prove a sufficient reliability of our system.

Probably, it is not able, as any of the classifications previously developed, to cover all the varieties of anatomic and structural deviations in the hip joint due to septic coxitis that require surgical correction. However, the authors believe that the system that has been presented to your attention may be used as a working classification by planning surgical treatment and for prediction of outcomes in children with different grades of damage to the hip articulation.

REFERENCES

1. Akhtyamov I.F., Abakarov A.A., Beletskiy A.V., Bogos'yan A.B., Sokolovskiy O.A. *Zabolevaniya tazobedrennogo sustava u detey. Diagnostika i khirurgicheskoe lechenie* [Diseases of the hip in children. Diagnosis and surgical treatment]. Kazan': Tsentr Operativnoy Pechati, 2008. 456 p.
2. Krysa'-Pugach A.P., Guk Yu.N., Kutsenok Ya.B., Darovskiy A.S. Nash opyt khirurgicheskogo lecheniya ortopedicheskikh posledstviy gnoynogo koksita u detey [Our experience in surgical treatment of septic coxitis orthopedic consequences in children]. *Travma*. 2008. T. 9, N 1. pp. 66-70
3. Nikolaev A.I., Kamosko M.M. Varianty rentgenoanatomicheskikh narusheniy tazobedrennogo sustava u detey s patologicheskimi vyvikhom bedra u detey [Variants of the hip roentgen-anatomical disorders in children with pathological dislocation of the hip]. *Sbornik tezisov dokladov VIII s'ezda travmatologov-ortopedov Rossii* [Abstracts of VIII Congress of Russian traumatologists-orthopedists]. Samara, 2006. Tom 2. pp. 942-943
4. Teplen'kiy M.P., D'yachkova G.V., Oleynikov E.V., D'yachkov K.A. Rentgenologicheskaya klassifikatsiya posledstviy septicheskogo koksita u detey [Roentgenological classification of septic coxitis consequences in children]. *Mezhdunar. Zhurn. Priklad. i Fundam. Issled.* 2015. N 11-5. pp. 684-688
5. Sokolovskiy A.M., Sokolovskiy O.A. *Patologicheskii vyvikh bedra* [Pathological dislocation of the hip]. Minsk: Vysshaya shkola, 1997. 208 p.
6. Abrishami S., Karami M., Karimi A., Soufali A.P., Aslani H.R., Badizadeh K. Greater trochanteric preserving hip arthroplasty in the treatment of infantile septic arthritis: long-term results. *J. Child Orthop.* 2010. Vol. 4, N 2. pp. 137-141
7. Baghdadi T., Saberi S., Sobhani Eraghi A., Arabzadeh A., Mardookhpour S. Late sequelae of hip septic arthritis in children. *Acta Med. Iran.* 2012. Vol. 50, N 7. pp. 463-467
8. Benum P. Transposition of the apophysis of the greater trochanter for reconstruction of the femoral head after septic hip arthritis in children. *Acta Orthop.* 2011. Vol. 82, N 1. P. 64-68
9. Betz R.R., Cooperman D.R., Wopperer J.M., Sutherland R.D., White J.J. Jr., Schaaf H.W., Aschliman M.R., Choi I.H., Bowen J.R., Gillespie R. Late sequelae of septic arthritis of the hip in infancy and childhood. *J. Pediatr. Orthop.* 1990. Vol. 10, N 3. pp. 365-372
10. Hunka L., Said S.E., MacKenzie D.A., Rogala E.J., Cruess R.L. Classification and surgical management of the severe sequelae of septic hips in children. *Clin. Orthop. Relat. Res.* 1982. N 171. pp. 30-36
11. Garbuz D.S., Masri B.A., Esdaile J., Duncan C.P. Classification systems in orthopaedics. *J. Am. Acad. Orthop. Surg.* 2002. Vol. 10, N 4. pp. 291-297
12. Cohen J. A coefficient of agreement for nominal scales. *Educational and Psychological Measurement* 1960. Vol. XX, N 1. pp. 37-46
13. Dobbs M.B., Sheridan J.J., Gordon J.E., Corley C.L., Szymanski D.A., Schoenecker P.L. Septic arthritis of the hip in infancy: long-term follow-up. *J. Pediatr. Orthop.* 2003. Vol. 23, N 2. pp. 162-168
14. Forlin E., Milani C. Sequelae of septic arthritis of the hip in children: a new classification and a review of 41 hips. *J. Pediatr. Orthop.* 2008. Vol. 28, N 5. pp. 524-528
15. Landis J.R., Koch G.G. The measurement of observer agreement for categorical data. *Biometrics*. 1977. Vol. 33, N 1. pp. 159-174
16. Choi I.H., Yoo W.J., Cho T.J., Chung C.Y. Operative reconstruction for septic arthritis of the hip. *Orthop. Clin. North Am.* 2006. Vol. 37, N 2. pp. 173-183
17. Svanholm H., Starklint H., Gundersen H.J., Fabricius J., Barlebo H., Olsen S. Reproducibility of histomorphologic diagnoses with special reference to the kappa statistic. *APMIS*. 1989. Vol. 97, N 8. pp. 689-698

18. Sucato D.J., Schwend R.M., Gillespie R. Septic arthritis of the hip in children. *J. Am. Acad. Orthop. Surg.* 1997. Vol. 5, N 5. pp. 249-260

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