ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN-POLONIA
VOL. LX, N1, 7 SECTIO D 2005

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Incongruence of hip joint in treated and untreated persons with DDH in the baby period. Contribution to the knowledge of the very early stage of hip arthrosis (coxarthrosis incipiens)

Developmental hip dysplasia (DDH) was and is a constant diagnostic and therapeutic problem. It was Professor Koszla, who some 30 years ago, used a term "physiologic" hip dysplasia for hip joint at newborns. German orthopaedic surgeons use a similar term "unreife Hüften" (undeveloped hips) to describe the stage of "unfinished development of hip joints".

Clinical data from the Pediatric Orthopaedic and Rehabilitation Department indicate the stage of functional and morphologic underdevelopment of hip joints in teenagers and young adults who were treated in baby period with DDH. The same situation of "imperfect" hip joints can be also observed in people whose hips were described at the baby period as "healthy" (2, 4, 5, 6, 10, 11, 14) and they were not treated. This stage of "imperfect hips" can be with time the cause of pains and dysfunctions and may lead to coxarthrosis in future (1).

On the basis of X-ray examination the authors aimed to evaluate the situation of hip joints of people who were treated and not treated with DDH in the baby period. All clinical observations in anamneses were noted. Clinical examination was compared with radiological findings.

MATERIAL AND METHODS

The research was based on X-ray pictures taken over the period 1970–2000. The retrospective analysis was conducted on the material of 100 hospital anamneses (selected at random) of newborns and babies treated in the Pediatric Orthopaedic and Rehabilitation Department with DDH and on 100 anamneses (selected at random) of people 14–24 years old who came to the Outpatients' Clinic with symptoms of fatigue and pain in the hip region. Several older patients with hip problems have been also included in the study. A detailed X-ray picture analysis included: Wiberg index, Hilgenreiner angle, antetorsion (AT), CCD (*Centum-Collum-Diaphysis* angle), Alsberg angle, character of acetabular roof and thickness and shape of acetabular bottom. The X-ray pictures were studied in accordance with the clinical and biomechanical situation of hip joint with reference to body weight, profession, way of life, sport activities, etc. (3, 13).

CLINICAL SYMPTOMS

The studied group consisted of teenagers and young adults (from 14 to 24 years) who already at that young age, showed problems with fatigue and pain during walking, sport activities. These were usually pains in hip region, even descending to lower parts of thigh. The pains were of differ-

ent character but usually they occurred suddenly, they were sharp, lasted for short periods. They occurred during walking or running or while standing up. Sometimes the pain caused falling down (rarely). Some patients informed about fatigue at the end of the day, they described feeling of tiredness in the whole extremity. The examination of range of motion in joints at these patients did not usually show any abnormalities. On the other hand, the possible reason of these clinical symptoms was observed on X-ray pictures.

PHYSICAL-MATHEMATICAL ANALYSIS OF BIOMECHANICAL SITUATION OF "IMPERFECT" HIP JOINT

In X-ray picture examination of normal hip joint it is important to note the values of CCD angle – 120^0–130^0, the angle of AT – 15^0–25^0, the Wiberg angle 45^0 or more. Even if in X-ray examination all above mentioned indexes are correct, we can observe a certain pathology which was so far undisclosed or neglected. At X-ray pictures an increase of distance between femoral head (lateralisation or expulsion) and bottom of seemingly normal acetabulum is visible (Fig. 1, 2, 3, 4, 5a-c). The lateral displacement of femoral head of such "imperfect" hips can sometimes reach 25%–75% of normal distance (example: distance head-roof 5 mm, distance head-bottom from 10 mm to 15 mm). Such positioning of femoral head causes during gait massive overstressing between femoral head and acetabular roof (15).

Fig. 1. 860630. Normal anatomic built of both hips. Proper roof covering. Identical distance between femoral heads and bottom and roof of acetabulum

Fig. 2. 840808. Expulsion of both femoral heads with seemingly normal roofs. Enlargement of distance between femoral heads and bottom of acetabulum. Clinical symptoms of fatigue

Fig. 3. 850812. Large expulsion of both femoral heads. Lateral displacement causes early overloading and pain in hip region

Fig. 4. 880713. Expulsion of both femoral heads, enlarged antetorsion angle (AT) imitates valgus position of femoral neck (left hip), diminishment of Wiberg angle. Occasional pains

a) b)

Fig. 5a, 5b, 5c, 5d, 5e. 870401. Series of X-ray pictures with primary subluxation of left hip and dysplasia of the right one. On first X-ray picture lateral displacement of left femoral head. On next x-rays a process of slow remodeling due to non-operative abductory splint treatment can be observed. Good result of treatment but left hip constantly worse developed. Last x-ray: expulsion of left femoral head, dysplastic roof, danger of early coxarthrosis

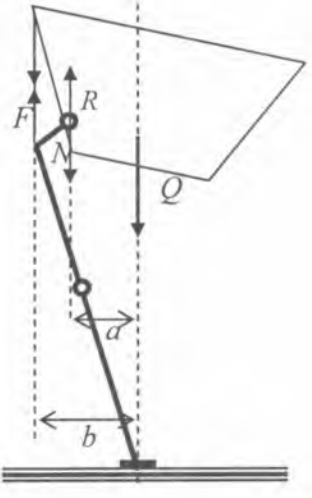

Fig. 6. Schematic presentation of forces reacting in pelvis and right leg during walking. View from the front. Detailed description in the text

An attempt was made to give an objective analysis of overstressing forces. An adequate mathematical formula was elaborated to estimate the increase of forces between femoral head and acetabular roof (Fig. 6). This anatomical and functional underdevelopment of hip joint is a cause of pains in the hip region and later may lead to coxarthrosis. Physical-mathematical analysis of biomechanical situation of "imperfect" hip joint during walking supports this statement.

During one-leg loading, the equilibrium of forces can be described as:

$$N = Q + F$$

The equilibrium of moments of forces can be described as:

$$Q \cdot a = F \cdot (b - a)$$

From these formulas we come to:

$$N = \frac{Q \cdot b}{b - a}$$

which concludes that increase of distance "a" results in increase of stress forces between acetabular roof and femoral head.

Relative increase of forces can be described:

$$\frac{\Delta N}{N} = \frac{b\Delta a - a\Delta b}{b(b - a)}$$

Example:

$a_o = 10$ cm b = const = 14 cm

$\Delta a = 1$ cm

– increase of stress forces between acetabular roof and femoral head is 25%.

With changing data resulting from biomechanics of walking, as continuous static overloading of once right and than left lower extremity, different values of "a" and "b" occur. With exemplary values:

$a_o = 10$ cm $b_o = 14$ cm

$\Delta a = 1$ cm $\Delta b = 0.5$ cm

– increase of stress forces is 16 %.

Even if we accept:

$\Delta a = \Delta b = 1$ cm

– increase of stress forces between acetabular roof and femoral head is 7%.

A teoretic clinical example:

Given values: weight of patient – 60 kg daily distance – 3 000 m

length of 1 step – 0.40 m

then, during phases of walking we observe stresses between acetabular roof and femoral head of values:

body weight number of steps 4*= 60 kg · 7,500 steps · 4 = 1,800,000 kg = 1,800 T

This is enormous overloading but it is well tolerated by a healthy hip joint (normal anatomical conditions and normal muscle activities). Even if we accept the increase of stress between acetabular roof and femoral head only by 7% of body weight (60 kg), than with daily distance of 3,000 m, the overloading in hip joint will increases by 126,000 kg = 126 T of extra loading each day. During one month this extra loading is equal to – 30 126 T = 3,780 T.

Than again, the hip which is more often overloaded is the one at which the person has a habit to stand on "at ease" – at 70% of people it is the right leg so the hip joint (7, 8).

* According to P a u w e l s calculations (11), the forces between acetabular roof and femoral head are equal to 4 times body weight during walking and 8 times during running.

The anatomic and functional "imperfect modeling" of hip joint can lead to pain and overstressing and with time to coxarthrosis. These data are supported by conducted physical-mathematical analysis.

EASY PROPHYLACTICS AND TREATMENT METHODS

In accordance to presented physical-mathematical analysis which explains and confirms clinical observations, the authors elaborated easy prophylactic methods, which proved effective over the period of past 10 years. The principle of treatment is to change the disadvantageous stress forces in the hip joint into profitable ones. It is necessary to influence the biomechanics of hip joint so that the stress forces of acetabular roof on femoral head were of smaller value and were effecting larger surface of femoral head. A system of prophylactic exercises was introduced to prevent the hip joint from losing the full range of movement. And it is the most crucial aspect for early prophylactics of pre-arthrosis of hip joint. The therapy cares for full extension, in-rotation, abduction, which are the first to disappear in coxarthrosis. We advise in addition: hydrotermotherapy and balneotherapy, most profitable in salt-waters or geothermal waters. The changes are advised in: the way of standing, the way of walking, the way of sleeping, the way of sitting (9). These easy and simple methods are crucial for the future of the hip joint and proved beneficial in many patients in the last years.

DISCUSSION

Basing on clinical and radiological examination of hip joints four groups (I, II, III, IV) of patients have been selected:

I) hips clinically (range of movement) normal and radiologicaly (X-ray indexes) normal, with normal body built. No permanent overloading, no pains present – 10% in our material.

II) hips clinically normal and radiologicaly "imperfect", with normal body built. No permanent overloading or overloading through sport, tourism, occasional pains in hip regions – 55% in our material (mostly in older patients).

III) hips with slightly diminished range of movement and radiologicaly "imperfect", with obese body built and/or permanent hip overloading through work, frequent pains – 20% in our material.

IV) hips with visibly diminished range of movement and/or with contractures and radiologicaly "faulty", with obese body built and/or permanent hip overloading, big and constant pains – 10% in our material.

Patients from group I do not require any treatment. People from group IV are frequent patients of Orthopaedic Departments. Patients from groups II and III require early special prophylactic programs. Depending on radiological situation of hip joint decentration different range of clinical symptoms (pains, fatigue) and of pre-arthrotic and arthrotic deformities has been observed. People from groups II and III after introduction of above mentioned treatment gain better possibility for hip joint congruency and gait without pain. The longest observation is of 10 years and refers to patients who could have theoretically developed full symptoms of coxarthrosis. They show no such symptoms despite the passing time.

CONCLUSIONS

1. Every treatment of DDH should be competent – in accordance with "physiologic requirements" of the joint, long enough and effective. The treatment should lead to *restitutio ad integrum* – to obtain normal hip joint in 100%!

2. A hip joint which is not completely "cured" may cause sooner or later pains in the region of hip and with time may lead to coxarthrosis. Clinical vulnerability of "imperfect hip joint" is supported by physical-mathematical analysis.

3. People who show radiological and clinical signs of "imperfect hip joints" are endangered with coxarthrosis (groups II and III – 75% of the patients). These people require early prophylactic system and early non-operative treatment.

4. The right hip is more vulnerable, more sensible to early overloading, pains and early coxarthrosis. It is related with the habit of permanent standing position "at ease" on the right leg (75% of the examined patients). The same factor of permanent standing position "at ease" on the right leg is the main cause of development of the so-called idiopathic scoliosis in etiopathological group II and an additional factor in etiopathological group I (8).

5. Introduction of new prophylactic therapies can prolong correct functioning of hip joints and postpone the onset of coxarthrosis.

REFERENCES

1. Aronson J.: Osteoarthritis of the young adult hip: Etiology and treatment, in: Anderson L.D.: Instructional Course Lectures XXXV. St Louis, Mosby, 14, 119, 1986.
2. Barlow T. G.: Early diagnosis and treatment of congenital dislocation of the hip. JBJS, 44B (2), 292, 1962.
3. Brand R. A. et al.: Contact stresses in human hip: implications for disease and treatment, Hip International, 11, 117, 2001.
4. Dega W.: Badania z dziedziny etiologii wrodzonego zwichnięcia biodra. Chir. Narz. Ruchu, 144, II, 1932.
5. Green N. E., Griffin P. P.: Hip dysplasia associated with abduction contracture of the contralateral hip. JBJS, 63-A, 1273, 1982.
6. Hensinger R. D.: Congenital dislocation of the hip: Treatment in infancy to walking age. Orthop. Clin. North. Am., 18, 597, 1987.
7. Iglic A. et al.: Computer determination of contact stress distribution and size of weight bearing area in the human hip joint, Comp. Methods Biomed. Eng. 5, 185, 2002.
8. Karski T.: Skoliozy tzw. idiopatyczne – etiologia, rozpoznawanie zagrożeń, nowe leczenie rehabilitacyjne, profilaktyka, Wydawnictwo KGM, Lublin 2002.
9. Karski T.: Gąbkowy klin odwodzący do leczenia zastarzałej dysplazji biodra. Materiały Chir. Narz. Ruchu i Ortop. Polska, LVIII, 82, 1992.
10. Karski T.: Wrodzona dysplazja stawu biodrowego. Patomorfologia wady. Leczenie operacyjne, Wydawnictwo Folium, Lublin 1999.
11. Pauwels F.: Biomechanics of the Normal and Diseased Hip. Springer-Verlag, Berlin 1976.
12. Tachdijan M. O.: Congenital Dislocation of the Hip. New York, Churchill-Livingstone 1982.
13. Vingard E.: Work, sports, overweight and osteoarthrosis of the hip: Epidemiological studies. Arbete och Halsa, 25, 1, 1991.
14. Weinstein S.: Natural history of congenital hip dislocation and hip dysplasia. Clin. Orthop., 225, 1987.
15. Żuk T., Dziak A.: Ortopedia z traumatologią narządów ruchu", PZWL, 161, Warszawa 1993.

SUMMARY

In the paper the authors analyze X-ray documentation of young and adult patients who were treated in the baby period with DDH or not treated. In the histories of these patients, treated or even sometimes classified as healthy, a morphologic anomaly of hip joints can be found on X-ray pictures. The anomaly is the enlargement of distance between femoral head and acetabular bottom (lateralisation or expulsion). Such "imperfect" hip joints can lead to early pain and dysfunctions in older age and later to coxarthrosis. The paper gives physical-mathematical analysis of biomechanical situation of "imperfect" hip joint. The authors suggest introduction of early prophylactics and non-operative treatment methods in all patients who at early age of life (14–24 years and later) show radiological signs of imperfect hips. Effectiveness of special rehabilitation treatment has been confirmed in the whole examined material.

Niezborność stawu biodrowego u osób leczonych w dzieciństwie z powodu wrodzonej dysplazji biodra i u osób nieleczonych. Przyczynek do wiedzy o wczesnych fazach koksartrozy (*coxarthrosis incipiens*)

W pracy autorzy przedstawiają analizę dokumentacji radiologicznej pacjentów, młodzieży i dorosłych, którzy w okresie dzieciństwa byli leczeni ze względu na rozwojowe (postępujące) zwichnięcie biodra lub też którzy nigdy nie byli leczeni, lecz w późniejszych latach mają problemy ze stawami biodrowymi. Pacjenci leczeni oraz ci, których stawy biodrowe zawsze oceniane były jako zdrowe, w szczegółowej analizie radiologicznej mogą ujawniać anomalię morfologiczną bioder. Polega ona na zwiększeniu odległości pomiędzy głową kości udowej a dnem panewki (lateralizacja, ekspulsja) jednocześnie przy prawidłowym dachu panewki stawu biodrowego. Taki „niedoskonały" staw biodrowy może prowadzić do wczesnych objawów bólowych, dysfunkcji w wieku późniejszym i z czasem do koksartrozy. Praca przedstawia fizyczno-matematyczne wyliczenia biomechanicznej sytuacji bioder „niedoskonałych". Autorzy podają proste metody profilaktyczne i zalecają zastosowanie nieoperacyjnych metod leczniczych u pacjentów, u których wcześnie, już w wieku 14–24 lat, ale i później, dostrzegalne są w obrazie radiologicznym cechy niedojrzałości bioder. Skuteczność specjalnych działań rehabilitacyjnych potwierdzono na całym ocenianym materiale.