Russian Journal of Biomechanics, Vol. 3, № 4: **-**, 1999

STABILOMETRIC STUDY OF THE STATIC INSTABILITY IN PATIENTS WITH ANKYLOSIS OF THE MALPOSITIONED HIP

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Abstract: Stabilometric study of 12 patients with ankylosis of the hip joint was conducted preoperatively and at short-term (to one year) follow-up using the ORTHO-SYSTEM orthopaedic computer complex ('Bioimitator', St. Petersburg, Russia). It was found out that this group of patients had the range of variations of the total centre of mass (TCM) in the coordinate plane occupying preoperatively the area five times more than normal one. Orientation of the 'displacement vector' depends on the expressiveness of the malpositioned limb and its length discrepancy. The TCM was observed to project within physiologically acceptable limits in 58% cases after operative treatment. In case of preserved former stereotype of the body position despite of the eliminated excessive flexion of the hip the body's TCM is observed to be displaced backwards that disturbs the system of the passive stabilisation of the knee in statics and is helpful for permanent active muscular correction of the spinal muscles and anterior femoral muscle group.

Key words: ankylosis, treatment with the Ilizarov frame, stabilometric study of static stability

Introduction

Severe irreversible degenerative-dystrophic changes in the hip joint result in ankylosis of the hip leading to malpositioned fusion of the femur and pelvis bones or insufficient union after arthrodising hip procedures. In this case the limb is usually flexed and adducted. Anatomical peculiarities of the hip joint and functional weight-bearing account for this position. Primarily myogenic flexion and adduction contracture develop at coxitis which transfers to arthrogenic contracture with time followed by ankylosis of the hip. In cases of insufficient union at the site of arthrodesis the adduction and flexion position of the limb is caused by a complex relationship between muscles and weight-bearing [1]. Femoral abductors, being more delayed phylogenetically, mostly suffer from the previous disease and absence of motion leading to muscular imbalance between abductors and adductors in favour of the latter and inadequate muscular response to functioning muscles at any work.

The purpose of the study was to objectivise biomechanical changes and investigate position of the total centre of mass (TCM) of the body and its deviations in patients with hip ankylosis at different stages of treatment and rehabilitation in particular.

Materials and methods of study

Stabilometric study of 12 patients with ankylosis of the hip joint was conducted preoperatively and at short-term (to one year) follow-up using the ORTHO-SYSTEM orthopaedic computer complex ('Bioimitator', St. Petersburg, Russia). In addition a group of 38 healthy individuals of the same age was examined to compare the results [2]. Supports' responses of the involved and intact limbs were recorded using special insoles with mechanical receptors. Information from each pair of insoles was screened in the computer IBM-PC/AT 386 in the form of graphic image of the foot contours, biplane coordinate system

with measuring conventional units from 0 to 100. Horizontal (OX) and vertical (OY) axes intersected in point N (x_N=50, y_N=50). Projection of the patient's centre of gravity was represented in this coordinate system in the form of the shaded part of area. Changes in the position of the TCM in time were presented separately at each of two planes.

To more completely imagine the degree of the displacement of the patient's centre of gravity a notion of a 'displacement vector' was introduced that is a vector directing from point N to point T (T bisects the TCM displacement area) which was assessed by coordinates x_T, y_T and the vector's length. The total area of the TCM displacement and the vector's length were measured in conventional units (c.u.) when axes OX and OY were recorded on the paper considering the coordinate scale.

The patients were examined preoperatively and at six-month and twelve-month follow-up.

An admission all the patients complained of limb length discrepancy, limping, malpositioned limb, pains in the knee and hip joints of the ankylosised limb, sacrum, low back pain, undue fatiguability. Absence of motion in the hip joint and fixed malpositioned limb were pathognomonic symptoms. No motion in the hip was observed in the group under study, and the leg was displaced from functionally favourable position from 10° to 20°.

In spite of individual gait of each patient all of them had common features depending on the amount of the discrepancy and position of the hip joint. At the gait the swinging of the body in frontal plane was observed in all the cases due to the functional limb shortening and difficulty in keeping balance using malpositioned limb. The patients with small angle of flexion had shorter step at the ankylosis side than one at the intact side. Patients with greater flexion angle first developed body swinging in sagittal plane. Tilting the pelvis forwards brought the femur of the involved leg closer to the vertical position and allowed to keep better rhythm of the supporting intervals. Increase of the adduction position of the limb resulted in increased pathological features of the gait. With a rotation component patients intuitively brought the knee out (flexion plane) in the direction of forward movement turning pelvis forwards or backwards depending on rotation.

Patients compensated limb length discrepancy, depending upon its amount, by tilting the pelvis sidewise or by equinus setting of the foot.

For each patient the femoral reconstruction procedure giving functionally favourable position to the limb, bringing the centre of the knee joint to position under biomechanical axis and orienting the knee fissure perpendicularly to the biomechanical axis, restoring natural orientation of the femur in frontal plane and eliminating anatomical dystopia of the TCM was made [3].

Results of the study and discussion

A healthy individual when standing on both legs has projection of the TCM close to the coordinate axes crossing point with a bit of displacement, in 44% to the right and backwards, in 30% to the left and backwards, in 20% to the right and forwards, in 16% to the left and forwards.

Table 1 shows coordinate characteristics of the position of the TCM projection and area of its deviations in patients with ankylosis of malpositioned hip joint and control group of healthy individuals.

Table 1. Preoperative coordinate characteristics of the TCM position, M±m.

Podographic index	Group under study	Normal
Number of observations	12	38
Mean statistical value of x_T (in c.u.)		55.5±2.22
- left side involved	47.7±5.1	
- right side involved	54.7±4.0	
Mean statistical value of y_T (in c.u.)		55.4±2.04
- left side involved	66.4±4.49	
- right side involved	75.8±3.8	
Mean statistical value of the displacement vector length (in c.u.)	24.8±4.35	17.4±1.58
Mean statistical meaning of changes in TCM (in c.u.)	512±390	115±39

Here M is the mean arithmetical average; m is the error in the average.

Data of Table 1 demonstrate that group of patients with ankylosis had the range of variations of the TCM in the coordinate plane occupying the area five times more than one in the healthy individuals. The TCM projection was observed to localise mostly with displacement backwards and to the side of the intact limb. Orientation of the 'displacement vector' depended on the expressiveness of the malpositioned limb and its length discrepancy and the presence of overloading on the intact limb.

If the limb length discrepancy is less than 5 cm the patients try to keep the body in correct position but stability is observed to decrease that is reflected in marked TCM variations [4] (Fig. 1). Variation coefficient made up in the average 53%.

If the limb length discrepancy is more than 5 cm the TCM projection displaced to the side of the involved limb (Fig.2).

Most probably for these patients there is no question of keeping the body in correct position. Making support on the involved leg the centre of gravity shifts to the side of the involved limb thus acquiring the stability that results in lower deviation of the TCM projection during stabilography. Otherwise they are forced to stand only on the intact leg and it markedly decreases the stability. The TCM was observed to project close to the coordinate axes crossing point within physiologically acceptable limits in 58% cases after operative

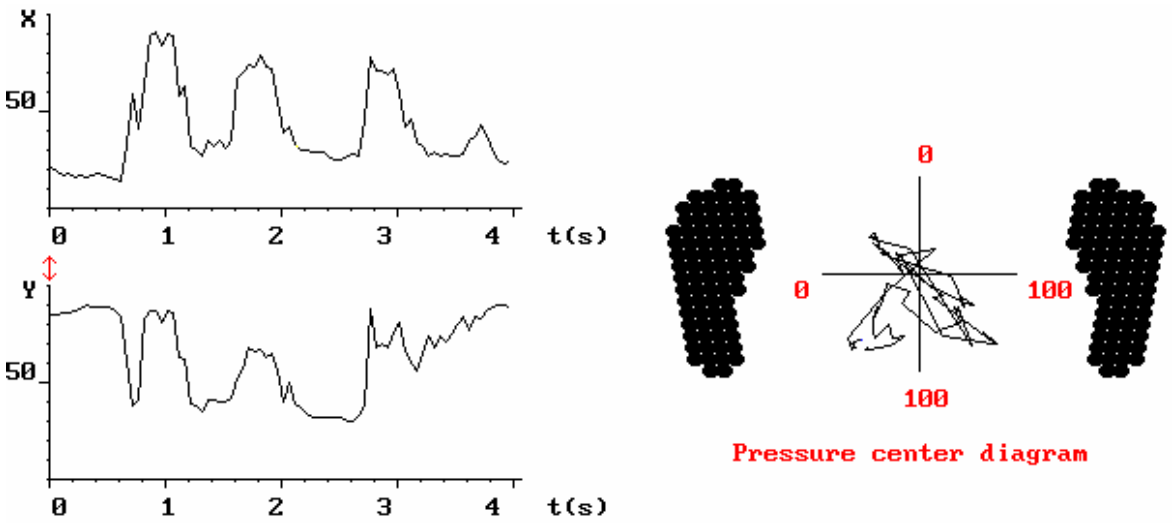

Fig. 1. Preoperative stabilogram of the patient U. (case report No. 25971) with ankylosis of the left hip with 130° flexion, 75° adduction, functional shortening is 3 cm.

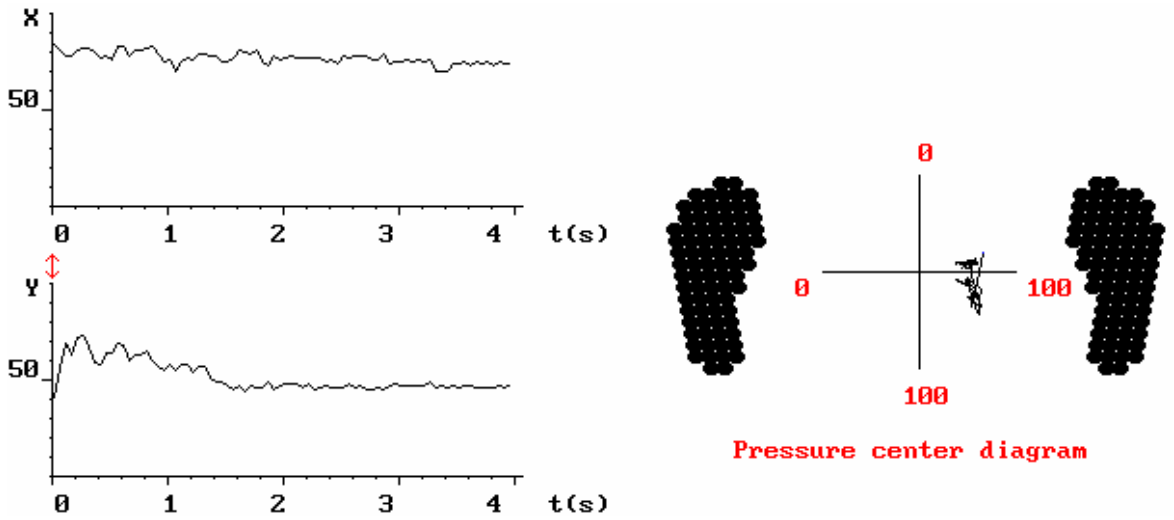

Fig. 2. Stabilogram of the patient M. (case report No. 18845) with ankylosis of the right hip with 140° flexion, 65° adduction, functional shortening is 7 cm.

treatment. Deviation area of the gravity centre projection made up in the average 108 c.u. which witnessed to high static patients' stability. And the TCM variation area was observed to decrease the average by 4 to 6 times in comparison to the similar preoperative index. Displacement vector length did not exceed 17 c.u. The vector did not show any definite orientation that is primarily typical for healthy individuals.

Five cases were shown to observe the gravity centre projection considerably displaced backwards and to the side of intact limb. Repeated questioning of these patients revealed general symptomocomplex: developing fatigue of the femoral muscles after a long time being on legs, feeling of discomfort, tension, fatiguability in spinal muscles. Disturbed carriage being increased in control time by Matthiassh trial by 6 to 8 times was not observed [5]. Only one case showed weakening carriage at the 4th minute (control time was 30 sec). Patients were asked to first walk correctly and gracefully, and then in a regular way they walk. In the intervals they were asked to stand in a most comfortable way. Visual control of the body position at different periods revealed changes closed to disturbed carriage, hypercompensation of the functionally favourable flexion of the limb. These patients persisted former stereotype of the body position despite of the eliminated excessive limb flexion in the hip joint. It led to the body's TCM being displaced backwards and practically excluded the system of the passive stabilisation of the knee in statics which in turn, promoted permanent active muscular correction of anterior femoral muscle group and accounted for appearance of increased fatigue of the lower limb muscles. The excessive TCM displacement backwards also led to permanent correction of its position by spinal muscles that caused their dysfunction and hence, high weariness. So, the patients were advised to conduct regular control of the body position, carriage and a complex of exercises to get normal tone and strengthen spinal muscles. At four to six month follow-up the patients observed considerable improvement of general condition, no discomfort in the spine, and much delayed fatigue of the muscles. Repeated examination of the TCM position was carried out in three of these patients. In all cases recorded projection of the total center of gravity was very close to the coordinate axes crossing point.

There is a clinical observation of a female patient G. (case report No. 27152) who was diagnosed with ankylosis of malpositioned hip joint (the left side). Left lower limb length discrepancy made up 3 cm. At admission she complained of periodical aches at the area of hip joint, lumbar spine, limping, limb length discrepancy, and malpositioned femur. Stabilography recorded the TCM projection as markedly displaced to the side of the involved

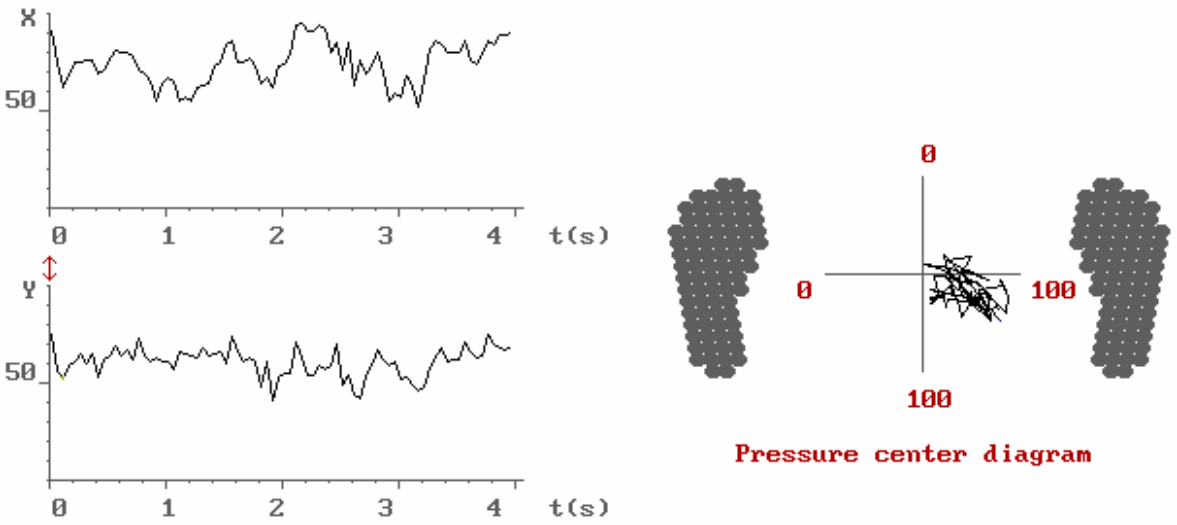

Fig. 3. Preoperative stabilogram of the patient G (case report No. 27152).

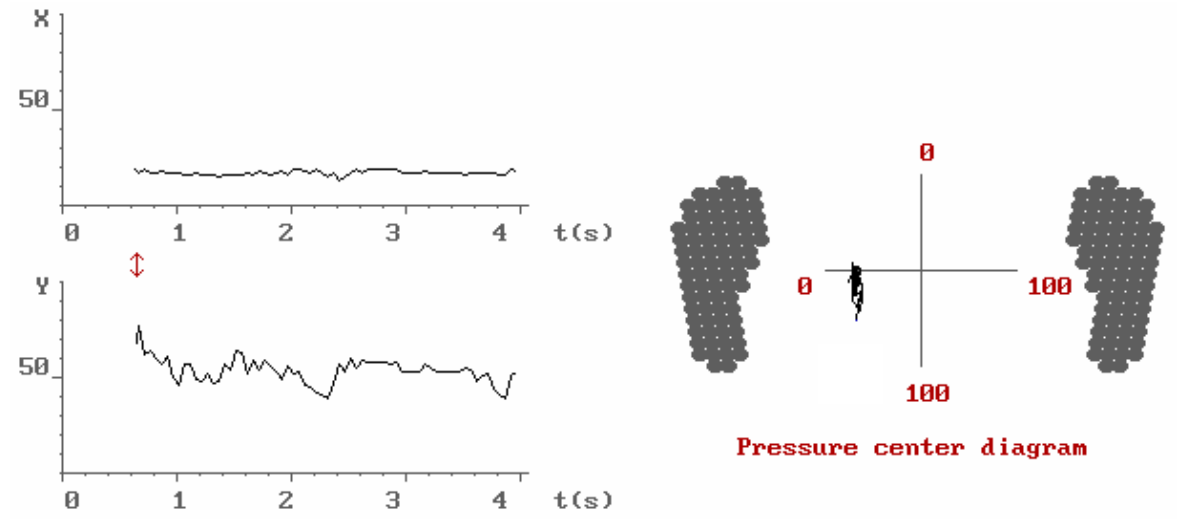

Fig. 4. Stabilogram of the patient G. (case report No. 27152) at four-month follow-up.

limb and backwards. Displacement vector was equal to 31 c.u. and deviation area made up 647 c.u. (Fig.3).

Femoral reconstruction was performed taking into consideration frontal and sagittal planes, limb lengths equalised. Total treatment period using Ilizarov frame made up 135 days. At four month follow-up the limb was shown to be in functionally favourable position, the limb lengths being equal; the patient was happy with treatment result, active and had no complaints. Stabilographic investigation recorded the TCM projection being displaced backwards to the side of the intact limb (Fig.4).

Displacement vector made up 25 c.u., and deviation area being 289 c.u. At questioning the patient noted undue fatiguability of the muscles of the femur operated on, feeling of discomfort in the lumbar spine after a long time being on foot, Matthiassh trial being negative, no disturbed carriage revealed. Visual control of the regular body position showed hypercompensation of the flexed limb position in the hip joint. The patient was advised to control the column position, to do a complex of exercises to normalise tone and strengthen spinal muscles, and to form correct gait stereotype. Four-month follow-up was performed. At eight-month follow-up the patient walked without limping. The patient developed increased

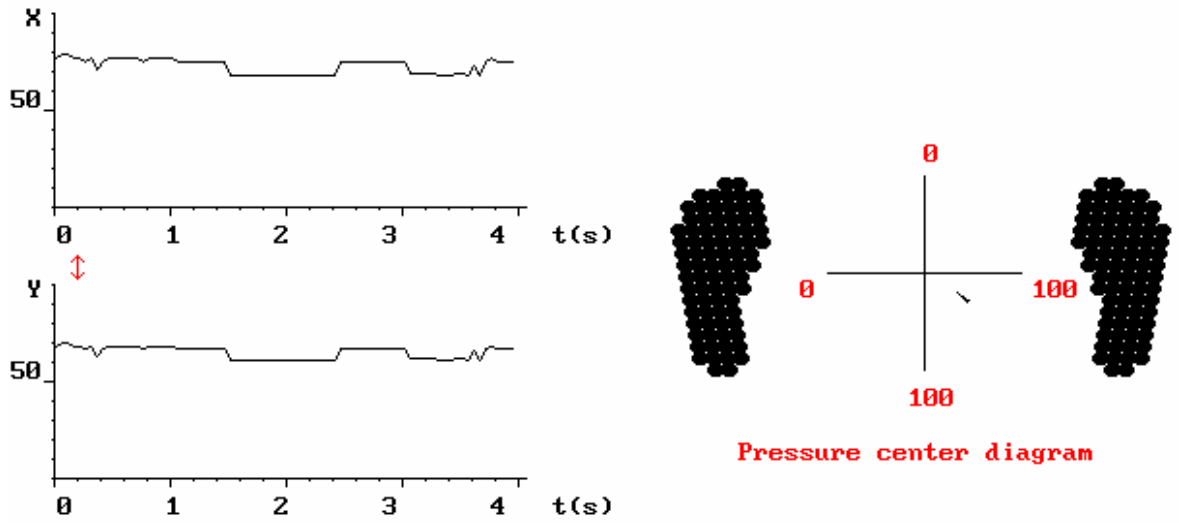

Fig. 5. Stabilogram of the patient G. (case report No. 27152) at eight-month follow-up.

motion activities, no syndrome of undue muscular fatiguability and discomfort in the spine were observed. She was satisfied with the result of treatment. Stabilographic investigation showed normal position of the TCM projection (Fig.5). Displacement vector was equal to 14 c.u., and deviation area of the TCM projection being 83 c.u.

Conclusions

1. Restoration of delicate biomechanical relationships in the ‘spine - pelvis - limb’ system does not affect on the course of short-term rehabilitation period after the frame comes off. Moreover, the realisation of the relationships needs restoration of both the supporting function of the limb and formation of a correct motion and carriage stereotype.
2. To correct hyperlordosis and optimise functional weight-bearing on the spine the conditions of the formed correct motion and carriage stereotypes are necessary.

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Russian Journal of Biomechanics, Vol. 3, № 4: **-**, 1999

СТАБИЛОМЕТРИЧЕСКОЕ ИССЛЕДОВАНИЕ СТАТИЧЕСКОЙ УСТОЙЧИВОСТИ У БОЛЬНЫХ С АНКИЛОЗОМ ТАЗОБЕДРЕННОГО СУСТАВА В ПОРОЧНОМ ПОЛОЖЕНИИ

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На ортопедическом компьютерном комплексе ORTHO-SYSTEM («Биоимитатор», Санкт-Петербург) проведено стабилометрическое исследование 12 пациентов с анкилозом тазобедренного сустава до оперативного вмешательства и в ближайшие сроки (до 1 года) после снятия аппарата. Выявлено, что у этой группы больных диапазон варьирования проекции общего центра масс на координатной плоскости до лечения в среднем занимает

площадь в 5 раз большую, чем в норме. Ориентация “вектора смещения” зависит от степени выраженности порочной установки конечности и ее укорочения.

После проведенного оперативного лечения аппаратом Илизарова в 58 % наблюдений центр тяжести тела проектируется в пределах физиологически допустимых границ. В случаях сохранения у больных прежнего стереотипа положения туловища, несмотря на устранение избыточного сгибания конечности в тазобедренном суставе, наблюдается смещение общего центра масс тела кзади, что нарушает систему пассивной стабилизации в коленном суставе в статике и способствует постоянной активной мышечной коррекции со стороны мышц спины и передней группы мышц бедра. Проведение комплекса упражнений для укрепления мышц спины сопровождалось нормализацией исследуемых параметров.

Рассмотрен ряд клинических примеров.

Ключевые слова: анкилоз, лечение аппаратом Илизарова, стабилометрическое исследование статической устойчивости

Received 16 November 1999