Acta of Bioengineering and Biomechanics
Vol. 16, No. 1, 2014

Original paper
DOI: 10.5277/abb140106

Postural stability disorders in patients with osteoarthritis of the hip

ALEKSANDRA TRUSZCZYŃSKA[1,2,3]*, KAZIMIERZ RĄPAŁA[1,2,5], ELŻBIETA GMITRZYKOWSKA[1], ZBIGNIEW TRZASKOMA[3], JUSTYNA DRZAŁ-GRABIEC[4]

[1] Professor A. Gruca Independent Public Research Hospital, Otwock Department of Orthopaedic Surgery, Centre of Postgraduate Medical Education, Otwock, Poland.
[2] Faculty of Physical Education and Sport in Biała Podlaska, Józef Piłsudski University of Physical Education in Warsaw, Biała Podlaska, Poland.
[3] Faculty of Rehabilitation, Józef Piłsudski University of Physical Education in Warsaw, Warsaw, Poland.
[4] Institute of Physiotherapy, University of Rzeszów, Poland.
[5] Social Academy of Science, Physiotherapy, Warsaw, Poland.

The osteoarthritis of the hip dominant symptom is pain that leads to disability and to postural and gait disorders. The aim of this study was to analyze postural stability and its impact on disability and pain. The study population consisted of 60 patients and control group of 30. Group 1 (n = 30) included patients with unilateral coxarthrosis, aged 56.2 (±12.3) years, BMI 25.17 (±2.87) kg/m^2. There were 16 men (53.3%). The mean age of patients in group 2 (n = 30) with bilateral coxarthrosis was 62.3 (±12.1) years; the mean BMI was 24.87 (±2.06) kg/m^2. There were 15 men in this group (50%). The patients were evaluated using the WOMAC, the Harris Hip Score, VAS and the Biodex Balance System. Both study groups had stability index results different than the control group. There was a significant correlation between the stability indexes and BMI. VAS correlated with the M-L plane variance. In group 2, there were significant differences related to disability for the disability scales for all measured parameters. Balance disorder is a basic parameter found in coxathrosis. There is a statistically significant correlation between balance disorders and BMI, VAS and functional scales.

Key words: *postural stability, Biodex, coxarthrosis, Harris Hip Score, WOMAC*

1. Introduction

Osteoarthritis of the hip is one of the most common disorders of the human locomotor system. Regarding its etiopathogenesis, the condition may be primary, of unknown etiology, or secondary, of known etiology [1].

Tylman et al. [2] have provided a broad definition of coxarthrosis with known etiology. This is a condition in which the etiology may be varied, but with similar clinical and anatomical evidence. It leads to the destruction and degeneration of the tissues that form the joint [2]. The most common causes are dysplasia, injuries, inflammation, femoral-acetabular conflict syndrome, exfoliation of the femoral head, Perthes' disease, protrusion acetabuli and femoral head necrosis.

The most dominant symptom of such condition is pain. This pain leads to disability of various degrees and to postural and gait disorders. The range of movement of the hip becomes limited, the hip muscles atrophy and the flexion and adduction contracture of the hip leads to the functional shortening of the limb, an angled position of the pelvis, and an increase in lumbar lordosis [3]. These changes usually correlate with patient's postural stability disorders of various degrees.

In considering the above, it is important to determine whether proprioception has been retained. Proprioception is responsible for the joint position sense (JPS) and the joint motion sense (JMS). The functional effects of unimpaired proprioception are the ability to move, maintain posture and balance, and to walk correctly [4], [5].

* Corresponding author: Aleksandra Truszczyńska, Józef Piłsudski University of Physical Education in Warsaw, Faculty of Rehabilitation, ul. Marymoncka 34, 00-968 Warsaw, Poland. Tel: +48 22 8341777, e-mail: aleksandra.rapala@wp.pl
Received: February 22th, 2013
Accepted for publication: July 4th, 2013

The aim of this study was to analyze postural stability and its impact on the degree of disability and pain intensity in patients with osteoarthritis of the hip.

2. Materials and methods

The study population consisted of 60 patients with osteoarthritis of the hip, who were qualified for hip arthroplasty by a surgeon experienced in the hip surgery. The surgeon was not aware of the aim of the study. The patients were divided into two groups. Group 1 consisted of 30 patients with unilateral disorders and group 2 consisted of 30 patients with bilateral disorders. All patients were hospitalized due to hip arthrosis in Orthopaedic Department of Medical Centre of Postgraduate Education. The consent of the Ethical Board at the Józef Piłsudski University of Physical Education in Warsaw was obtained to perform this study between January and June 2012.

The mean age of patients in group 1 with unilateral coxarthrosis was 56.2 (±12.3) years; the mean BMI was 25.17 (±2.87) kg/m^2. There were 14 women (46.7%) and 16 men (53.3%) in this group. The mean age of patients in group 2 with bilateral coxarthrosis was 62.3 (±12.1) years; the mean BMI was 24.87 (±2.06) kg/m^2. There were 15 women and 15 men in this group (50% each).

The criteria for qualification for the study were the following: degeneration of the hip confirmed by radiography, pain while walking, night pain, positive Duchenne's sign and positive Trendelenburg's sign. The criteria for excluding patients were: lack of patient's consent to participate in the study and other pathological abnormalities of the hip or prior hip surgery. The patients were also evaluated using the subjective scales of WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index), the Harris Hip Score and the Visual Analog Scale (VAS).

All the patients were qualified for total hip arthroplasty and evaluated prior surgery.

After obtaining patient's consent, they were tested on the Biodex Balance System (Balance System SD). This test is an indicator of dynamic body control and allows accurate measurements of the subject's ability to control their center of gravity and balance using visual feedback via LCD screen. All tests were conducted by the same well-trained person. The goal of the test was to hold the unstable platform in a level position for the duration of the test through anterior-posterior and medial-lateral movement of the feet and ankles. The patients were told to stand still in an upright position with the eyes open and the feet placed parallel at hip distance away from each other. A screen was positioned at the level of the eyes, so patients could easily follow their movement and to prevent them from assuming a proper posture. The screen depicted the area of the platform represented by four concentric zones labeled A, B, C, D and four parts marked I, II, III and IV. The postural stability test consisted of three measurements. Each measurement was taken at the level 12 of platform stability (1 = least stable, 12 = most stable) and had intervals: 20 seconds of testing, 10 seconds break. Three stability indexes were calculated as follows: anterio-posterior stability index (APSI) – represented the variance of platform displacement in degrees, from level, for motion in the sagittal plane; medio-lateral stability index (MLSI) – represented the variance of platform displacement in degrees, from level, in the frontal plane; overall stability index (OSI), as a sum of the first two, was defined as the variance of the platform displacement from level, in all motions during the test, measured in degrees, where a greater value indicates greater displacement and lesser balance stability. These three scores are the standard output of the dynamic balance test. The higher the variance, the higher the score indicating more severe problems in maintaining balance. It was the angular deflection of the patient's center of pressure. All tasks were conducted three times in order to ensure reliability and the best result was analyzed.

The clinical control group consisted of 30 people with no locomotor system disorders. Their mean age was 24.7 (±7.6) years and their mean BMI was 20.57 (±1.75) kg/m^2. There were 16 women (53.3%) and 14 men (46.7%) in this group.

Statistical analysis

In the cases where the independent (explanatory) variables were dichotomous, Student's *t*-test was applied for independent trials, while the equality of variance was controlled with the use of Levene's test. In the cases of independent variables measured on at least the rank level, correlation was established by the Kendall's tau-*b* rank correlation coefficient. In both cases, bilateral statistical significance was the basis.

3. Results

In group 1, the Harris Hip Score was 82.5 (±5.37), the WOMAC Index was 86.8 (±6.29) and the VAS score was 5.5 (±1.46) points.

Table 1. Postural stability data (mean and SD) – values of stability indexes (deg): overall (OSI), anterior-posterior (APSI) and medio-lateral (MLSI) in groups: 0 – control, 1 – with unilateral coxarthrosis, 2 – with bilateral coxarthrosis

Variable		*N*	Mean	±SD	Standard error
OSI	0	30	.64	.416	.0759
	1	30	1.85	2.528	.4616
	2	30	1.79	1.456	.2658
APSI	0	30	.46	.332	.0605
	1	30	1.25	1.344	.2455
	2	30	1.47	1.831	.3344
MLSI	0	30	.32	.222	.0405
	1	30	1.07	1.956	.3571
	2	30	.80	.622	.1136

score was 5.6 (±1.33) points. These differences were not statistically significant.

Tables 1 and 2 present detailed stability indexes and multiple comparisons for study groups 1 and 2 and for the clinical control group.

The following statistically significant differences were found:

1. Both study groups had stability index results different than the clinical control group. The results, however, were similar for both study groups.

2. In group 1 – patients with unilateral disorder – there was a statistically significant correlation between the overall stability index (OSI) and BMI (the correlation coefficient was 0.285*). There was

Table 2. Multiple comparisons of postural stability data of analyzed groups – stability indexes: overall (OSI), anterior-posterior (APSI) and medio-lateral (MLSI), groups: 0 – control, 1 – with unilateral coxarthrosis, 2 – with bilateral coxarthrosis

Dependent variable			Difference in mean values	Standard error	Significance	95% confidence interval	
						Lower limit	Upper limit
OSI	**0**	**1**	**–1.2033***	.4513	**.009**	–2.097	–.309
		2	**–1.1467***	.4513	**.012**	–2.041	–.253
	1	2	.0567	.4513	.900	–.837	.951
APSI	0	1	**–.7833***	.3834	**.043**	–1.543	–.024
		2	–1.0033*	.3834	**.010**	–1.763	–.244
	1	2	–.2200	.3834	.567	–.979	.539
MLSI	0	1	**–.7467***	.2746	**.008**	–1.291	–.203
		2	–.4800	.2746	**.083**	–1.024	.064
	1	2	.2667	.2746	.333	–.277	.811

* The difference in significance level is $P \leq 0.05$. Groups 1 and 2 were significantly different regarding stability indexes compared to group 0.

Table 3. Correlation (Kendall's tau-*b* coefficient) between stability indexes (overall – OSI, anterior-posterior – APSI and medio-lateral – MLSI) and BMI (kg/m^2) Harris Hip Score, WOMAC Index, VAS (points) in unilateral coxarthrosis group

		OSI	APSI	MLSI
BMI	Correlation coefficient	**.285***	**.252***	**.345****
	Significance unilateral	.018	.033	.006
	N	30	30	30
Harris Hip Score	Correlation coefficient	–.141	–.081	–.217
	Significance unilateral	.148	.275	.057
	N	30	30	30
WOMAC Index	Correlation coefficient	–.189	–.189	–.203
	Significance unilateral	.082	.084	.071
	N	30	30	30
VAS	Correlation coefficient	.205	.126	**.321***
	Significance unilateral	.073	.187	.013
	N	30	30	30

* Correlation is significant on $P \leq 0.05$ (unilateral).
** Correlation is significant on $P \leq 0.01$ (unilateral).

In group 2, the Harris Hip Score was 79.8 (±8.85), the WOMAC Index was 84.5 (±7.70) and the VAS

a statistically significant correlation between BMI and the anterior-posterior stability index – APSI

Table 4. Correlation (Kendall's tau-*b* coefficient) between stability indexes (overall – OSI, anterior-posterior – APSI and medio-lateral – MLSI) and BMI (kg/m^2) Harris Hip Score, WOMAC Index, VAS (points) in bilateral coxarthrosis group

		OSI	APSI	MLSI
BMI	Correlation coefficient	**.379****	**.269***	**.469****
	Significance unilateral	.002	.022	.000
	N	30	30	30
Harris Hip Score	Correlation coefficient	**–.365****	**–.295***	**–.425****
	Significance unilateral	.003	.012	.001
	N	30	30	30
WOMAC Index	Correlation coefficient	**–.412****	**–.358****	**–.475****
	Significance unilateral	.001	.004	.000
	N	30	30	30
VAS	Correlation coefficient	**.232***	.217	**.380****
	Significance unilateral	.048	.060	.003
	N	30	30	30

* Correlation is significant on $P \leq 0.05$ (unilateral).
** Correlation is significant on $P \leq 0.01$ (unilateral).

(0.252*) and medio-lateral stability index – MLSI (0.345*). No significant differences in disability were found in the Harris Hip Score or the WOMAC Index (Table 3).

3. In group 1, the VAS score for pain intensity correlated with the M-L plane deviation. The more intense the pain, the worse the result (details are shown in Table 3).

4. In group 2 – patients with bilateral disorder – there was a statistically significant correlation between all stability indexes and BMI.

5. In group 2, there were statistically significant differences related to disability for the Harris Hip Score and the WOMAC Index for all measured parameters.

6. In group 2, the VAS score for pain intensity correlated with the overall stability index (OSI) and medio-lateral stability index (MLSI). The more intense the pain, the worse the result (details shown in Table 4).

4. Discussion

Osteoarthritis of the hip leads to postural stability disorders that are statistically significantly different than in the clinical control group. The stability indexes do not depend on whether the disorder is uni- or bilateral. Leanetrs et al. [3] showed that improper setting of the pelvis remains after surgical hip replacement. This leads to impaired loading of the implant. Therefore, in early post-surgical physiotherapy, one should focus on stretching of the anterior and medial structures of the pelvis. One also needs to strengthen the flexors and extensors of the hip, in order to ensure normal kinematics of the pelvis and to balance the loading of the implant [3]. However, this is a challenge. Studies have shown that over 10 months after surgical hip replacement, the biomechanics of the lower limbs still do not return to normal [6]. Foucher et al. [7] also noted that asymmetry of the hip may lead to residual walking disorders that can be observed in patients after hip replacement [7]. Other long-term studies also indicate persistence of impairment and functional limitation after THA [8].

Rasch et al. [9] showed that two years after hip replacement in 20 patients, balance and walking ability had improved, although abductor muscle strength was still weakened. This is why physiotherapy should also aim to improve co-ordination within the joint [10]. Late physiotherapy should focus as well on weight-bearing exercises with hip abductor eccentric strengthening [8].

Cichy et al. [11] examined 30 patients with osteoarthritis, in whom pedobarography was applied to analyze gait parameters. The results revealed a statistically significant difference when loading both limbs under dynamic conditions. The foot pressure ground reaction results were considerably lower for the limb with coxarthrosis [11]. One month after surgery, however, they found asymmetry, caused by reduced load on the operated limb. After THA there was a slight increase in step length in both limbs, but asymmetry in step length still persisted [12]. Contrary results were presented by Calò et al. [13]. They measured balance of the standing position and the motor responses by dynamic posturography in patients treated by total hip replacement. They reported normal postural control and symmetrical responses and confirmed the absence of balance problems and fall risk [13].

Posture and balance disorders may occur in spinal or lower limb disorders. To fully characterize static and dynamic postural control disorders, complex patient examination is necessary, employing a clinical examination and a series of movement analysis techniques. In the lower limbs, postural disorders may also be related to instability of the ankle or the knee [14]–[16]. Postural stability was related also to the relative leg strength [17]

A Finnish study analyzed postural control in men with osteoarthritis. The study population consisted of 27 men aged 47–64 years. Postural control was analyzed using the sensory organization test (SOT). The results were compared to those of the clinical control group. The authors concluded that hip disorders do not influence static balance in men [18].

Postural stability and disability

No reliability comparisons of various available computer postural stability evaluation devices have so far been published in the literature. In recent years, the Biodex Balance System is often used to evaluate neuromuscular and somatosensory control and individual training to improve postural control and balance [19]. Standard deviation as a measure of postural sway, calculated in medial-lateral (M/L) and anterior-posterior (A/P) directions for the net COP (center of pressure) was used, among others by Van Emmerik et al. [20], in studies in women with multiple sclerosis. Likewise Sell [21] in a study in healthy young men and women as the primary criteria for static and dynamic stability applied standard deviation of the ground reaction forces in the anterior-posterior, medial-lateral, and vertical direction.

The results of a study on 23 healthy individuals indicate that the reliability of the Biodex Balance System is low to moderate [22]. Other authors have used this system in studies related to the impact of BMI on postural stability [23], to compare various methods of postural stability evaluation [24] or to assess the impact of knee disorders on stability [25].

In our study, which is a preliminary report, we intended to assess changes in balance disorders before THA.

Surveys regarding gait disorders among patients with THA operated by two different methods were conducted by Palieri et at. [26]. They found that gait pattern after THA was dependent on surgical access and on the extent of surgical damage. These findings also should be considered in order to correctly manage the physiotherapy after surgery [26].

The Western Ontario and McMaster University Arthritis Index (WOMAC) is a widely used set of standardized questionnaires used by health professionals to evaluate the condition of patients with osteoarthritis of the knee and hip. It evaluates pain, stiffness and physical functioning of the joints [27], [28]. Previous studies have also confirmed the reliability of the Harris Hip Score [29]. Furthermore, Brokelman et al. [30] believe that the VAS is a reliable instrument to evaluate satisfaction in patients who have undergone hip replacement surgery.

Further research planned by the authors is needed to conduct regarding impact of different implants (short stem, classical, revision), as well as influence of different rehabilitation protocols of postural stability after THA.

Our study found a statistically significant correlation between the WOMAC Index, the Harris Hip Score and pain intensity (VAS) and postural stability disorders for the patients in group 2 with bilateral coxarthrosis. The strongest correlation concerned anterior deviation, which is probably related to the muscle weakening, and medial-lateral deviation, which is related to relieving the damaged joint.

5. Conclusions

1. Balance disorder is a basic parameter found in osteoarthritis of the hip.

2. There is a statistically significant positive correlation between balance disorders and BMI, the VAS score for pain intensity and the balance stability indexes.

References

[1] RĄPAŁA K., WALCZAK P., TRUSZCZYŃSKA A., *Etiopathogenesis of osteoarthritis of the hip*, Kwart. Ortop., 2011, Vol. 2011(4), 386–395.

[2] TYLMAN D., KOZŁOWSKI P., RĄPAŁA K., *The etiology of degenerative changes in the hip joints in radiological assessment*, Polski Przeg Radiologii i Med. Nukl., 1977, Vol. 41, 399–403.

[3] LENAERTS G., MULIER M., SPAEPEN A., VAN DER PERRE G., JONKERS I., *Aberrant pelvis and hip kinematics impair hip loading before and after total hip replacement*, Gait & Posture, 2009, Vol. 30(3), 296–302.

[4] WINTER D.A., *Human balance and posture control during standing and walking*, Gait & Posture, 1995, Vol. 3, 193–214.

[5] LEE H.J., CHOU L.S., *Detection of gait instability using the center of mass and center of pressure inclination angles*, Arch. Phys. Med. Rehabil., 2006, Vol. 87(4), 569–575.

[6] BEAULIEU M.L., LAMONTAGNE M., BEAULÉ P.E., *Lower limb biomechanics during gait do not return to normal following total hip arthroplasty*, Gait & Posture, 2010, Vol. 32(2), 269–273.

[7] FOUCHER K.C., WIMMER M.A., *Contralateral hip and knee gait biomechanics are unchanged by total hip replacement for unilateral hip osteoarthritis*, Gait & Posture 2012, Vol. 35(1), 61–65.

[8] DI MONACO M., VALLERO F., TAPPERO R., CAVANNA A., *Rehabilitation after total hip arthroplasty: a systematic review of controlled trials on physical exercise programs*, Eur. J. Phys. Rehabil. Med., 2009, Vol. 45(3), 303–317.

[9] RASCH A., DALÉN N., BERG H.E., *Muscle strength, gait, and balance in 20 patients with hip osteoarthritis followed for 2 years after THA*, Acta Orthop., 2010, Vol. 81(2), 183–188.

[10] CHIU S., LU T., CHOU L., *Altered inter-joint coordination during walking in patients with total hip arthroplasty*, Gait & Posture, 2010, Vol. 32(4), 656–660.

[11] CICHY B., WILK M., ŚLIWIŃSKI Z., *Changes in gait parameters in total hip arthroplasty patients before and after surgery*, Med. Sci. Monit., 2008, Vol. 14(3), CR159–169.

[12] CICHY B., WILK M., *Gait analysis in osteoarthritis of the hip*, Med. Sci. Monit., 2006, Vol. 12(12), CR507–513.

[13] CALÒ L., RABINI A., PICCIOTTI P.M., LAURINO S., PASSALI G.C., FERRARA P.E., MAGGI L., PIAZZINI D.B., SPECCHIA A., FRASCA G., RONCONI G., BERTOLINI C., SCARANO E., *Postural control in patients with total hip replacement*, Eur. J. Phys. Rehabil. Med., 2009, Vol. 45(3), 327–334.

[14] MISSAOUI B., PORTERO P., BENDAYA S., HANKTIE O., THOUMIE P., *Posture and equilibrium in orthopedic and rheumatologic diseases*, Neurophysiol. Clin., 2008, Vol. 38(6), 447–457.

[15] WINIARSKI S., CZAMARA A., *Evaluation of gait kinematics and symmetry during the first two stages of physiotherapy after anterior cruciate ligament reconstruction*, Acta Bioeng. Biomech., 2012, Vol. 14(2), 91–100.

[16] BŁAŻKIEWICZ M., WIT A., *Comparison of sensitivity coefficients for joint angle trajectory between normal and pathological gait*, Acta Bioeng. Biomech., 2012, Vol. 14(1), 83–91.

[17] ŁAPSZO J., GIOVANIS V., PRUSIK K., PRUSIK K., *Balance control contributors – the relationships between leg strength and balance control ability in seniors*, Acta Bioeng. Biomech., 2012, Vol. 14(3), 3–8.

[18] AROKOSKI J.P., LEINONEN V., AROKOSKI M.H., AALTO H., VALTONEN H., *Postural control in male patients with hip osteoarthritis*, Gait & Posture, 2006, Vol. 23(1), 45–50.

[19] GUSI N., ADSUR J.C., CORZO H., DEL POZO-CRUZ B., OLIVARES P.R., PORRACA J.A., *Balance training reduces fear of falling and improves dynamic balance and isometric strength in institutionalised older people: a randomised trial*, J. Physiother., 2012, Vol. 58, 97–104.

[20] VAN EMMERIK R.E.A., REMELIUS J.G., JOHNSON M.B., CHUNG L.H., KENT-BRAUN J.A., *Postural control in women with multiple sclerosis: Effects of task, vision and symptomatic fatigue*, Gait & Posture, 2010, Vol. 32, 608–614.

[21] SELL T.C., *An examination, correlation, and comparison of static and dynamic measures of postural stability in healthy, physically active adults*, Phys. Ther. Sport, 2012, Vol. 13, 80–86.

[22] PICKERILL M.L., HARTER R.A., *Validity and reliability of limits-of-stability testing: a comparison of 2 postural stability evaluation devices*, J. Athl. Train, 2011, Vol. 46(6), 600–606.

[23] KU P.X., ABU OSMAN N.A., YUSOF A., WAN ABAS W.A., *Biomechanical evaluation of the relationship between postural control and body mass index*, J. Biomech., 2012, Vol. 45(9), 1638–1642.

[24] OH K.Y., KIM S.A., LEE S.Y., LEE Y.S., *Comparison of manual balance and balance board tests in healthy adults*, Ann. Rehabil. Med., 2011, Vol. 35(6), 873–879.

[25] SAMAEI A., BAKHTIARY A.H., ELHAM F., REZASOLTANI A., *Effects of genu varum deformity on postural stability*, Int. J. Sports Med., 2012, Vol. 33(6), 469–473.

[26] PALIERI G., VETRANO M., MANGONE M., CERETI M., BEMPORAD J., ROSELLI G., D'ARRIGO C., SPERANZA A., VULPIANI M.C., FERRETTI A., *Surgical access and damage extent after total hip arthroplasty influence early gait pattern and guide rehabilitation treatment*, Eur. J. Phys. Rehabil. Med., 2011, Vol. 47(1), 9–17.

[27] QUINTANA J., ESCOBAR A., BILBAO A., AZKARATE J., GOENAGA J.I., ARENAZA J.C., *Health-Related Quality of Life and Appropriateness of Knee or Hip Joint Replacement*, Arch. Intern. Med., 2006, Vol. 166, 220–226.

[28] KERSTEN P., WHITE P.J., TENNANT A., *The visual analogue WOMAC 3.0 scale-internal validity and responsiveness of the VAS version*, BMC Musculoskelet Disord., 2010, Vol. 30(11), 80.

[29] NAAL F.D., SIEVERDING M., IMPELLIZZERI F.M., VON KNOCH F., MANNION A.F., LEUNIG M., *Reliability and validity of the cross-culturally adapted German Oxford hip score*, Clin. Orthop. Relat. Res., 2009, Vol. 467(4), 952–957.

[30] BROKELMAN R.B., HAVERKAMP D., VAN LOON C., HOL A., VAN KAMPEN A., VETH R., *The validation of the visual analogue scale for patient satisfaction after total hip arthroplasty*, Eur. Orthop. Traumatol., 2012, Vol. 3(2), 101–105.