# TREATMENT OF VERTEBRAL BODY COMPRESSION FRACTURES IN CHILDREN IN THE EARLY POST-INJURY PERIOD

**Shtutin A.A.[1], Chuiko A.V.[2], Zhilitsyn E.V.[3] (Russian Federation)**

*[1]Shtutin Alexey Anatolyevich - Doctor of Medical Sciences, Professor.*
*DEPARTMENT OF TRAUMATOLOGY, ORTHOPEDICS, AND MILITARY FIELD SURGERY,*
*MAXIM GORKY DONETSK STATE MEDICAL UNIVERSITY, DONETSK*
*[2]Chuiko Alexander Valentinovich - Candidate of Medical Sciences.*
*TRAUMATOLOGIST-ORTHOPEDIST AT THE EMERGENCY TRAUMATOLOGY AND ORTHOPEDICS OFFICE, POLYCLINIC № 2 OF THE STATE HEALTHCARE INSTITUTION OF THE MOSCOW REGION "MYTISHCHI REGIONAL CLINICAL HOSPITAL", MYTISHCHI*
*[3]Zhilitsyn Evgeny Vladimirovich - Candidate of Medical Sciences, Head of the Pediatric Department,*
*STATE HEALTHCARE INSTITUTION OF THE DONETSK PEOPLE'S REPUBLIC "REPUBLICAN CENTER FOR TRAUMATOLOGY, ORTHOPEDICS AND NEUROSURGERY", DONETSK*

***Abstract:*** *this study analyzed the effectiveness of a modified conservative treatment approach for children with uncomplicated vertebral compression fractures. A multimodal assessment of pain intensity and muscle endurance was shown to objectively reflect functional recovery. The use of custom-designed reclination and hyperextension-distraction devices significantly reduced bed rest and hospitalization time, enabling earlier mobilization and faster rehabilitation.*
***Keywords:*** *vertebral compression fracture, children, conservative treatment, muscle endurance, pain assessment, early mobilization, rehabilitation, orthopedic devices.*

# ЛЕЧЕНИЕ КОМПРЕССИОННЫХ ПЕРЕЛОМОВ ТЕЛ ПОЗВОНКОВ У ДЕТЕЙ В РАННИЙ ПЕРИОД ПОСЛЕ ТРАВМЫ

**Штутин А.А.[1], Чуйко А.В.[2], Жилицын Е.В.[3] (Российская Федерация)**

*[1]Штутин Алексей Анатольевич – доктор медицинских наук, профессор.*
*кафедра травматологии, ортопедии и военно-полевой хирургии,*
*Донецкий государственный медицинский университет им. М. Горького, Донецк*
*[2]Чуйко Александр Валентинович – кандидат медицинских наук, врач-травматолог-ортопед кабинета неотложной травматологии и ортопедии поликлиники*
*№2 ГБУЗ Московской области «Мытищинская областная клиническая больница», г. Мытищи*
*[3]Жилицын Евгений Владимирович – кандидат медицинских наук, заведующий детским отделением*
*ГБУ ДНР «Республиканский центр травматологии, ортопедии и нейрохирургии», г. Донецк*

***Аннотация:*** *проведен анализ эффективности модифицированной методики лечения детей с неосложнёнными компрессионными переломами тел позвонков. Установлено, что полимодальная оценка боли и силовой выносливости мышц объективно отражает динамику восстановления. Применение оригинальных устройств позволяет сократить сроки постельного режима и стационарного лечения, обеспечивая раннюю активизацию и ускоренную реабилитацию пациентов.*
***Ключевые слова:*** *компрессионный перелом позвонков, дети, консервативное лечение, мышечная выносливость, оценка боли, ранняя мобилизация, реабилитация, ортопедические устройства.*

**Introduction**

In recent decades, there has been a growing trend in the number of vertebral body compression fractures (VBCFs) in children and adolescents [1–3]. According to various researchers, these injuries account for 5.1% to 7.3% of all skeletal trauma in childhood [1, 2]. The majority of such fractures are low-energy in nature and are not accompanied by neurological deficits [3, 4]. The primary treatment method for VBCFs in children is conservative management [3–6]. Most domestic researchers employ the functional method proposed by V.V. Gorinevskaya and E.F. Dreving in 1933 [7]. This approach involves a prolonged hospital stay aimed at the gradual development of a "muscular corset" that helps compensate for impaired static and dynamic spinal functions during the recovery period [3, 6, 8, 9].

However, under current conditions, this method places an excessive burden on the healthcare system and requires significant modification [4, 5, 8, 10]. Furthermore, several studies have shown that prolonged bed rest in children leads to a range of adverse effects and complications [8, 9]. All of this highlights the relevance of developing methods for earlier verticalization of patients, based on a combination of individualized orthotic support and modified programs of therapeutic exercises, physical therapy, and physiotherapy [3, 5, 8, 10].

It is evident that the effectiveness of such modified treatment approaches largely depends on the severity of the pain syndrome and its impact on the functional state of the patient's muscular system. The available literature offers limited data on the dynamics of pain syndrome and its correlation with changes in muscle function during the treatment of VBCFs in children. This gap in knowledge motivated us to conduct the present study.

**Objective of the Study**

The aim of this study was to analyze the dynamics of pain syndrome and the functional state of the trunk and lower limb muscles in children with uncomplicated vertebral body compression fractures, depending on the conservative treatment strategy used during the early post-injury period.

**Materials and Methods**

We analyzed the examination and treatment data of 74 children aged 10 to 17 years (mean age – 13.5 ± 1.4) with uncomplicated vertebral body compression fractures (see Table 1). The group included 41 boys (55.4%) and 33 girls (44.6%). Isolated fractures were observed in 18 patients (24.3%), while multiple fractures occurred in 56 cases (75.7%). In 61 patients (82.4%), the fractures were located in the thoracic spine. The diagnosis was confirmed through standard clinical and radiological examinations, as well as magnetic resonance imaging (MRI).

Depending on the nature of the treatment and rehabilitation measures, the patients were retrospectively divided into two groups. The first (control) group (n = 41) included patients treated according to the standard protocol of functional therapy. The second (experimental) group included 33 patients who received a modified treatment protocol developed by us in the early post-injury period. This included the use of an original reclination device [11], followed by individualized orthotic treatment with a distraction-hyperextension brace developed by our team [12].

The groups were comparable in terms of injury causes and mechanisms. Domestic injuries due to falls from standing height were observed in 27 patients (65.8%) in the control group and 26 (78.8%) in the experimental group ($p > 0.05$). The second most common cause was sports-related trauma – 11 patients (24.9%) and 6 patients (18.2%), respectively. Road traffic accidents occurred in 3 patients (7.3%) in the first group and 1 patient (3.0%) in the second group. All patients sought medical help within 1 to 3 days of the injury. Those who presented later were not included in the study. The majority of fractures in both groups were located in the thoracic spine – 72.4% in the first group and 83.7% in the second.

We developed a modified conservative orthopedic treatment method for children with uncomplicated vertebral body compression fractures in the early post-injury period. The method includes the following stages:

- **Early hospital stage** – from day 1 to day 10 after injury. The patient remains on strict bed rest with gradual, controlled reclination of the spine using the reclination device we developed (priority certificate for the patent “Device for Reclination of Vertebral Bodies” No. U202104101 dated July 14, 2021) [11].
- **Early verticalization stage** – from day 11 to day 18. The goal of this stage is to train the patient to maintain an upright position, use the brace, and develop safe walking skills. Individual orthotic support is provided using our custom distraction-hyperextension brace (Ukrainian Patent No. 148716, published in Bulletin No. 36 on September 8, 2021) [12].
- **Early rehabilitation stage** – from day 18 to 3 months post-injury. This stage aims for maximum motor-functional rehabilitation under conditions that exclude a sitting position. It includes controlled increases in walking time and progressive therapeutic physical activity. Exercises for the lower limbs (squats, lunges, stretches) in the brace are permitted. Courses of electrical muscle stimulation and therapeutic massage continue. Swimming is recommended. During this stage, children engage in remote learning and gradually return to their normal social environment.

A multimodal assessment of the nature and intensity of the pain syndrome was conducted using the Visual Analog Scale (VAS) in millimeter increments during the acute phase (days 1–3 after hospitalization), on day 14, before discharge (days 18–28), and at 3 and 6 months post-injury. Pain was evaluated both at rest and during movement (provoked pain), as well as maximum and minimum pain levels during a 24-hour period.

The functional state of the muscles was assessed by examining the strength endurance of the neck, trunk, and calf muscles on days 1–3, 12–14, and 18–21, and at 90 days post-injury. The following tests were used:

**Muscle endurance of the neck muscles (MENM)** was assessed by measuring the time the patient could maintain head flexion while lying on their back with arms crossed over the chest, until the onset of fatigue.

**Muscle endurance of the back extensors (MEBE)** was evaluated by the ability to maintain the upper half of the torso elevated at a 30° angle in the prone position without arm support.

**Muscle endurance of the abdominal muscles (MEAM)** was assessed by measuring the time the patient could keep their lower limbs elevated at a 30° angle in a supine position without arm support.

To assess **muscle endurance of the calf muscles (MECM)**, we used tests measuring the ability to maintain maximal dorsiflexion and plantar flexion of the foot while lying on the back with the straightened lower limb elevated at a 30° angle. Considering the dominance of the flexor muscle group, an average of both tests was calculated. Test results were ranked using a **5-point scale** in accordance with the criteria listed in Table 2.

The **integral muscular potential (IMP)**, reflecting the patient’s ability to maintain vertical posture, standing, and walking, was calculated as a weighted average of test results using anthropometric correction coefficients (CN – neck: 0.2; CB – back: 0.5; CA – abdomen: 0.3; CC – calf: 0.1). To avoid decimal values and simplify calculations, we used a 10-fold multiplication of the point scores. IMP was calculated using the following formula:

$$\mathbf{IMP = (CN \cdot MENM + CB \cdot MEBE + CA \cdot MEAM + CC \cdot MECM) \cdot 10}$$

Thus, the **maximum IMP score** is 55 points, and the **minimum** is 11 points.

All diagnostic and therapeutic procedures, as well as the possibility of publishing the results for scientific purposes, were discussed with and confirmed by **written informed consent** from the patients’ parents. The study was approved by the **institutional bioethics committee**. Data were processed using the **Statistica 6.0 software package** applying **nonparametric statistical tests**, with a significance level set at $p < 0.05$.

**Results and Discussion**

The dynamics of pain syndrome indicators are presented in Table 3. Analysis of the data shows no significant intergroup differences across all modalities of pain syndrome during the first two weeks of inpatient treatment. This can be attributed to the comparable composition of the study groups in terms of fracture severity and localization. A progressive decrease in pain intensity was observed—from moderate at admission to mild by discharge. Notably, a statistically significant difference in provoked pain intensity emerged between the groups beginning in the third week post-injury (18.6 ± 4.5 in Group 1 vs. 11.2 ± 2.3 in Group 2, $p < 0.05$). In our view, this may be due to more intensive recovery of the "muscle corset" when employing the modified treatment strategy.

The most pronounced differences in pain intensity were observed between 3 and 6 months after the injury. These differences were particularly significant in the provoked and maximum pain indicators, which are directly related to the level of activity of the back, abdominal, and lower limb muscles.

The restoration of physical activity levels after discharge imposes increased demands on the tone of the muscular corset, despite incomplete fracture consolidation. Discrepancy between the compensatory capabilities of back muscles and the load on the vertebral column inevitably leads to pain. This is reflected in the persistence of pain syndrome for up to three months after injury, with some exacerbation during movement compared to the end of inpatient treatment. It should be noted that by six months post-injury, post-traumatic changes in intervertebral discs may develop—particularly in cases involving endplate fractures—which also provoke pain [4–6].

Quantitative analysis of clinical muscle endurance testing results in children with vertebral compression fractures (VCF) during treatment in both control and experimental groups is presented in Table 4.

The most notable differences were observed in the **MEBE (muscle endurance of the back extensors)**. In the first three days after injury, this indicator was about 28% of the age norm. Children were either unable to perform the test or could maintain the position for no more than 30 seconds due to pain in the compressed vertebrae. By the end of the second week, with a significant reduction in pain intensity, MEBE in both groups reached approximately 50% of the age norm, correlating with our algometric data. The use of early active mobilization in Group 2 led to a significantly higher MEBE by days 18–21, with significant differences in movement-related pain intensity (19.4 ± 0.7 in Group 2 vs. 13.7 ± 0.6 in Group 1, $p < 0.05$). This trend persisted at the three-month follow-up, with MEBE in the experimental group nearly reaching age norms.

The dynamics of **MEAM (muscle endurance of the abdominal muscles)** showed a similar trend. In the first 2–3 days post-injury, this indicator averaged 32% of the age norm. Following the trend in pain syndrome, it approached 80% by the end of the second week, with no statistically significant differences between groups. A notable feature was a slight decline in MEAM by the end of the third week in the control group, resulting in a significant difference compared to the experimental group, which reached 93% ($p < 0.05$). This likely reflects the prolonged bed rest in the control group, as opposed to early mobilization in the modified treatment strategy. By the end of the observation period, MEAM was comparable in both groups.

The dynamics of **MECM (muscle endurance of the calf muscles)** followed a similar pattern to other muscle endurance indicators. A statistically significant intergroup difference was observed at the end of the third week, likely due to early mobilization in Group 2.

Changes in **IMP (integral muscular potential)** naturally reflected the overall trends described above. The initial decrease was 33.6% in both groups. Statistically significant differences emerged at 3 weeks and 2 months post-injury. In the experimental group, IMP increased significantly during the third week—from 69% to 84%—and reached 96% by the end of the observation period ($p < 0.05$). In contrast, the control group showed no IMP improvement by the third week, and only reached 85.5% at two months ($p < 0.05$).

Thus, a **polymodal assessment** of pain intensity and muscle endurance serves as an **objective criterion** reflecting the dynamics of functional recovery during the treatment of VCF in children. This approach confirms the **advantages of the modified treatment strategy** using the devices developed by our team. It enables a **shorter duration of bed rest and inpatient stay**, and **accelerates medical rehabilitation** in this patient population.

**Conclusions**

1. The dynamics of pain syndrome in children with uncomplicated vertebral body compression fractures correlate with indicators of functional muscle activity, as assessed by our modified muscle endurance testing system.
2. The spinal reclination device and the hyperextension-distraction brace we developed make it possible to modify the treatment strategy for children with vertebral compression fractures in the early post-trauma period, enabling early mobilization and active motor rehabilitation.
3. The application of the modified treatment approach results in a significant reduction in pain intensity and a faster recovery of muscle activity compared to the traditional functional treatment method.

*Table 1. General characteristics of children with vertebral body compression fractures.*

| Indicator | Group 1 (n=41) | Group 2 (n=33) | Total (n=74) |
|---|---|---|---|
| Sex (boys/girls) | 22 / 19 | 19 / 14 | 41 / 33 |
| Age (10–14 / 15–17 years) | 29 / 12 | 21 / 12 | 50 / 24 |
| Multiple / isolated fractures | 31 / 10 | 25 / 8 | 56 / 18 |

*Table 2. Evaluation criteria for muscle endurance test results (in points).*

| Points | Age 10–12 years | Age 13–17 years |
|---|---|---|
| 1 | Unable to perform due to pain | Unable to perform due to pain |
| 2 | Less than 30 seconds | Less than 60 seconds |
| 3 | Up to 60 seconds | Up to 90 seconds |
| 4 | Up to 90 seconds | Up to 120 seconds |
| 5 | More than 90 seconds | More than 120 seconds |

Tables 3 and 4. Children with Vertebral Compression Fractures

*Table 3. Pain Intensity Indicators in Children with Vertebral Compression Fractures (VAS, mm).*

| Parameter | Day 1-3 Grp. 1 | Grp. 2 | Day 14 Grp. 1 | Grp. 2 | Day 18-21 Grp. 1 | Grp. 2 | 3 months Grp. 1 | Grp. 2 | 6 months Grp. 1 | Grp. 2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Rest pain | 63.2 ±5.4 | 62.8±4.9 | 36.3±4.6 | 33.2±5.2 | 11.3±3.1 | 10.5±2.9 | 9.2±3.1 | 6.1±2.2 | 8.7±2.1* | 4.2±1.2 * |
| Pain during movement | 72.3 ±6.3 | 73.1±5.7 | 46.4±6.3 | 41.2±3.6 | 18.6±4.5 * | 11.2±2.3 * | 19.5±3.2 * | 9.2±3.1* | 16.4±3.3 * | 6.1±2.3 * |
| Maximum pain | 83.4 ±6.8 | 82.7±5.6 | 67.5±4.3 | 63.5±3.6 | 28.6±5.4 | 26.3±4.2 | 23.6±4.2 * | 11.4±2.5 * | 18.7±3.2 * | 8.2±1.4 * |
| Minimal pain | 49.4 ±6.2 | 48.7±5.8 | 28.2±3.4 | 29.2±4.1 | 18.7±6.3 | 10.2±3.1 | 8.7±2.3 | 5.3±2.1 | 7.1±2.3* | 3.1±1.2 * |
| | | | | | | | | | | |

** – statistically significant difference between groups at p < 0.05*

*Table 4. Muscle Endurance Indicators During Treatment in Children with Uncomplicated Vertebral Compression Fractures (points adjusted by anthropometric coefficient).*

| Parameter/Time | Day 1-3 | Day 12-14 | Day 18-21 | Day 90 |
|---|---|---|---|---|
| SVMS-1 | 9.2±0.5 | 9.3±0.4 | 7.8±0.31 | 9.4±0.4 |
| SVMS-2 | 9.3±0.5 | 9.1±0.5 | 9.4±0.21 | 9.7±0.3 |
| SVMRS-1 | 7.3±0.2 | 12.3±0.51 | 13.7±0.61 | 19.8±0.61 |
| SVMRS-2 | 7.4±0.3 | 13.4±0.41 | 19.4±0.71 | 24.3±0.31 |
| SVMAb-1 | 4.8±0.3 | 12.8±0.6 | 12.6±0.51 | 14.1±0.5 |
| SVMAb-2 | 4.5±0.4 | 13.2±0.5 | 14.1±0.31 | 14.4±0.3 |
| SVMGl-1 | 2.1±0.2 | 3.2±0.2 | 3.4±0.31 | 4.2±0.3 |
| SVMGl-2 | 2.2±0.3 | 3.4±0.1 | 4.1±0.21 | 4.7±0.2 |
| IMPI-1 | 18.2±0.3 | 35.6±1.2 | 35.8±1.51 | 46.9±1.71 |
| IMPI-2 | 18.7±0.5 | 37.8±1.3 | 46.1±1.31 | 53.2±1.41 |

*Note: SV** – 1 = muscle endurance in group 1 (control); SV** – 2 = muscle endurance in group 2 (treatment); 1 – statistically significant difference between groups at p < 0.05*

### ***References / Список литературы***


1. *Baindurashvili A.G.* Pokazateli i dinamika travm kostno-myshechnoj sistemy u detej Sankt-Peterburga v sovremennyh uslovijah [Indicators and dynamics of injuries of the musculoskeletal system in children of St. Petersburg in modern conditions]. Pediatr. 2016; 7 (2): 113-120 (in Russian).
2. *Zaletina A.V., Vissarionov S.V., Baindurashvili A.G. s soavt.* Struktura povrezhdenij pozvonochnika u detej v regionah Rossijskoj Federacii [The structure of spinal injuries in children in the regions of the Russian Federation]. Hirurgija pozvonochnika. 2017; 14 (4): 52–60 (in Russian).
3. *Baindurashvili A.G. [i dr.]* Konservativnoe lechenie detej s kompressionnymi perelomami pozvonkov grudnoj i pojasnichnoj lokalizacii v Rossijskoj Federacii (obzor literatury) [Conservative treatment of children with compression fractures of the thoracic and lumbar vertebrae in the Russian Federation (literature review)]. Ortopedija, travmatologija i vosstanovitel'naja hirurgija detskogo vozrasta. 2016; 4 (1): 48–56 (in Russian).
4. *Courvoisier A. [et al.]* A New Paradigm for the Management of Thoracolumbar Pediatric Spine Traumas. Pediatr. Emerg. Care. 2017; 33 (8): e10-e14.
5. *Singer G.* The influence of brace immobilization on the remodeling potential of thoracolumbar impaction fractures in children and adolescents. Eur. Spine J. 2016; 25 (2): 607-613.
6. *Astahova N.A., Zhila N.G.* Ispol'zovanie reklinirujushhih ustrojstv v processe dispansernogo nabljudenija detej s kompressionnymi perelomami pozvonochnika [The use of reclining devices in the process of dispensary observation of children with compression fractures of the spine]. Dal'nevostochnyj medicinskij zhurnal. 2013; 1: 39-41 (in Russian).

7. *Gorinevskaja V.V., Dreving E.F.* Funkcional'noe lechenie kompressionnyh perelomov pozvonochnika [Functional treatment of compression fractures of the spine]. Sovetskaja medicina. 1933; 4-5: 13–19 (in Russian).
8. *Golovkin S.I. [i dr.]* O neobhodimosti optimizacii shem i srokov lechenija neoslozhnjonnyh kompressionnyh perelomov pozvonkov u detej [On the need to optimize the schemes and terms of treatment of uncomplicated vertebral compression fractures in children]. Mat' i Ditja v Kuzbasse. 2014; 1: 46-51 (in Russian).
9. *Golovkin S.I. [i dr.]* Osobennosti reakcii obmena na travmu i lechenie pri ogranichennom sroke vynuzhdennoj gipodinamii i gipokinezii u detej s neoslozhnennymi kompressionnymi perelomami pozvonkov [Features of the trauma metabolic reaction and treatment for a limited period of forced physical inactivity and hypokinesia in children with uncomplicated vertebral compression fractures]. Mat' i Ditja v Kuzbasse. 2015; 3: 18-24 (in Russian).
10. *Pavlov I.V.* Rannee ortezirovanie v kompleksnom lechenii detej s kompressionnymi perelomami grudnogo i pojasnichnogo otdelov pozvonochnika: dis. … kand. med. nauk [Early orthotics in the complex treatment of children with compression fractures of the thoracic and lumbar spine: Cand.med.sci.diss.abs.]. SPb; 2015. 139 (in Russian).
11. Prioritetnaja spravka na patent № U202104101; 2021 (in Russian).
12. *Zhilicyn E.V., Shtutin A.A., Chujko A.V.* Patent Ukrainy № 148716; 2021 (in Russian).