WRITING ABILITY IN CHILDREN SUFFERING FROM CEREBRAL PALSY AFTER PHASED FIBEROTOMY: CASE REPORT

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SUMMARY

Writing is a complex ability which includes a series of different abilities and activities which have to interact during writing. Successful writing is achieved only if all of these abilities and processes function and if, during the learning phase, their full interactivity is achieved. Cerebral palsy doesn't have a single typical clinical manifestation. It is specific to each individual in relation to: the etiology of brain damage, localization and size of defects, and the period in which the damage occurred. Given these facts, the assessment of a child with cerebral palsy should be based on the potential estimate model and through profiles of achievements in certain areas, and the qualitative and quantitative interpretation. The aim of this study is to assess the writing skills of a boy who had undergone surgery of phased fiberotomy. For the assessment of writing, through qualitative analysis, we used the "Scale for assessment of handwriting dysgraphia" (Ažiriagera, Ozias), according to Cordic and Bojanin (1997).

KEY WORDS: cerebral palsy, graphomotor ability, writing, phased fiberotomy
Cerebral palsy is a set of permanent, but variable disorders of movement and / or posture and of motor functions caused by non-progressive disorder or damage to an immature brain and / or developing brain. Motor disorders in cerebral palsy are often associated with disorders of perception, cognition, communication, behavior, epilepsy and secondary musculoskeletal disorders (Bax et al., 2005). Cerebral palsy does not have a typical clinical image, but it is specific to each individual in relation to: the etiology of brain damage, the location and size of defects, and the period in which the damage occurred. Given these facts, the assessment of a child with cerebral palsy should be based on the potential estimate model and through profiles of achievements in certain areas, and the qualitative and quantitative interpretation. So what a child can do and to what extent should be diagnosed (Horvatić, 2008).

Writing is a complex ability which includes a series of different abilities and activities which have to interact during writing. Successful writing is achieved only if all of these abilities and processes function and if, during the learning phase, their full interactivity is achieved. In the process of writing, very complex elements of motor, manipulative, kinesthetic, visual and auditory activities, cognitive ability, and the ability to use linguistic and non-linguistic knowledge are involved. Writing, as the most complex form of speech and language skills, contains in itself almost all brain functions. So the ability to write manifests multidimensional, and the interferences in writing are also multi-conditioned. A multidimensional approach to the assessment of writing skills includes the neurological, neuropsychological, psycholinguistic and speech therapy approach, but also the knowledge of the development standards of this ability.

<table>
<thead>
<tr>
<th>Age</th>
<th>Skills Description</th>
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</thead>
<tbody>
<tr>
<td>10-18 months</td>
<td>Draws patterns on paper; Holds the pencil with the palm and fingers.</td>
</tr>
<tr>
<td>2 years</td>
<td>Draws patterns, on paper, makes horizontal, vertical lines and circles</td>
</tr>
<tr>
<td>3 years</td>
<td>Draws over horizontal and vertical lines and circles; Holds the pencil with three fingers.</td>
</tr>
<tr>
<td>4-5 years</td>
<td>Draws over crosses, squares, some letters and numbers; Holds the pencil as an adult.</td>
</tr>
<tr>
<td>5-6 years</td>
<td>Draws over triangles, writes his own name, copies letters</td>
</tr>
</tbody>
</table>

Writing begins with a planning phase in which thoughts are organized and the lexical-grammatical sketch is prepared. The next stage involves the awareness of linguistic and social conventions that govern those who write during the written form of language expression. At this level,
a person who writes thinks about the letter system which he uses, handwriting readability, the rules of graphic expression, spelling rules and the use of punctuation marks. The next stage in the writing process involves motor control and visuospatial orientation. This stage involves the use of a number of factors such as holding pens correctly, a developed visual perception, good spatial orientation, developed motor skills of the arms, hands and fingers, coordinated movements of the hand and fingers and well co-ordinated eye-hand connection. So, writing begins with an idea and formatting a message in the brain, which requires appropriate graphical symbols, and ends with a psychomotor act.

Different brain structures are involved in writing. When it comes to writing by dictation, it requires the involvement and activity of Heschl’s gyrus, Wernicke’s area (auditory images of words), angular (visual image of a word) and supramarginal gyrus (voice-to-letters), or areas of graphemes in the vertex lobe speech dominant hemisphere, other frontal gyri (programming the graphical output), and the vertex lobe of the non-dominant hemisphere (nonverbal visuo-spatial orientation) with the motor areas for the control of hand movement (Galic, 2009). Writing is a complex graphomotor activity which, besides linguistic knowledge, includes motor-kinesthetic, praxic, visuospatial and visuoconstructional components (Ocić, 1998). It is a complex perceptual-motor skill, which depends on the maturation and integration of a number of cognitive, perceptive and motor skills, and is developed during instruction (Hamstra-Bletz & Blot, 1993; Maeland, 1992). Writing contains several components that are necessary for the activity of writing: visuo-perceptual skills, orthographic coding, motor planning, kinesthetic feedback and visuo-motor control. This process is very complex and incorporates a variety of elements, including the linguistic content of the message, word spelling, visual and spatial organization and a number of graphic symbols, motor organization of orthographic output (Rapscak & Beeson, 2002). Visual-perceptual skills include the ability to provide accurate interpretations and to give meaning to what we see, visual discrimination (distinguishing what we see) and visual reasoning (recognizing the pattern on the basis of part of the sample). Motor planning involves the ability to plan and perform a specific motor activity, one must have an idea and a plan how to carry out an activity and the ability to coordinate motor performance with the plan. Kinesthetic feedback implies the knowledge of the position and movement of bodies in space, where the impulses of the body convey information to the brain, on the basis of which the brain adjusts the desired movements. In the deficit of these components the writing and the graphomotor abilities are disabled. Motor action begins with the idea of a motor action and the possible ways in which this action will be executed. The ideas are stored as motor engrams. In order to realize the motor behavior, we must have a picture or idea (plan) for what we want
to achieve and the ability of the motor output to match the plan (Luria, 1996).

Therefore, adequate motor planning and execution are necessary conditions for writing. Considering the often serious clinical symptoms and associated conditions in cerebral palsy on one hand, and writing being a very complex process which involves the interaction of the most complex abilities, on the other hand, it is not surprising that a large number of children with CP never acquires the ability to write, and those who write, write mostly in capital letters.

In an attempt to reduce deformities and contractures, with the aim of increasing mobility and reducing pain in certain parts of the extremities, a number of methods and techniques are implemented. One of them is a surgical method *phased fiberotomy*, developed and perfected by the Russian professor dr V. B. Ulzibat. The goal of this surgery is to increase the range of motion, improve muscle function, institute the antagonist muscle balance, and to prevent the progression of changes in the joints. Of all patients undergoing this method, 80% of patients are those with children's CP. Therapy consists of several phases, and small traumatic surgeries are performed at the same time on a 14-16 muscles in each phase. Previous studies show that the best clinical and functional results in the application of phased fiberotomy was achieved in children with medium levels of damage, with minimal changes in the joints. A good performance was achieved in 72%, fair in 20.5%, and slight in 7.5%. Satisfactory result or slight improvement was obtained in the group of children with severe paresis, who had prominent trophic disorders and joint changes. In this pathology, especially in its severe forms, the effects of phased fiberotomy was better in a younger age subgroup than in older children (most ideal time to implement the above mentioned methods is between 3 and 5 years of age). The most difficult subject to correction are changes of distal parts of the upper extremities compared to proximal.

**AIM**

The aim of this study is to assess the capability of writing and display the characteristics of graphomotorics and of a boy who underwent phased fiberotomy surgery. We decided to show this case after reaching manipulative hand skills after the second and third intervention. There was an evident improvement of the functionality of the hand and arm as a whole. There was also an improvement in the graphomotor statement. Before the intervention, the boy did not have an adequate grip, he held the pencil for writing and drawing with his fist, with the thumb in adduction. The same position of the hand was also present when using flatware, when the spoon or fork was held with the fist. After the intervention, certain improvements in functionality were achieved, such
as holding the pencil propped between the ring finger and middle finger and steadying it with the index finger. After the intervention, thumb was in the position of adduction, over the pencil and index finger. The second reason why we believe that the presentation of this case is noteworthy are the speech abilities – the boy has a good articulation, proper pronunciation, which is not often the case in children with CP.

METHODOLOGY

Subject's clinical history:

Boy, NJ, was born on April 25, 1997 in Belgrade, as a premature infant, at 30 weeks of intrauterine life. At birth, Abgar score was AS = 6 and 7, weight = 1750 g, body length = 42 cm, head circumference = 28 cm. Diagnosis at birth: Asphyxia perinatalis. After birth, he was kept in an incubator, and discharged from hospital after 45 days. On January 22, 1998, he was admitted to the Institute for Mother and Child, where he underwent MRI and the findings showed dysgenesis of the corpus collosum, ventriculomegalia and immaturity of the white brain tissue. Immediately after hospitalization, he was sent to the Special Hospital for Cerebral and Developmental Neurology, where he was diagnosed with spastic cerebral palsy. Further psychomotor development proceeded slowly. Sitting independently with a support developed at the age of two, and without support at 4. Speech developed in the third year. Average intellectual abilities. The dominant right-sided laterality of upper and lower limbs, sight and hearing. Hearing neat (as determined by ORL). Sight: strabismus in both eyes. Attends primary school with the regular curriculum, but upon mother's request, finishes sixth grade by home teaching (taken from the documentation of the child). The first meeting with the respondent was on September 20, 2005 – then he was 8 years old and he was able to stand briefly with the help of his mother, and walking was impossible due to the presence of numerous contractures and deformities, especially in the knee joint (the impossibility of motion in flexion and extension) and in the very raised foot (standing on tiptoe). During the follow up he had three phased fiberotomy operations: first on 9/22/2005, the second in 12/11/2006, and the third on 3/3/2008, after which significant progress was achieved, particularly in the ability of sitting, standing and walking. Preview of psychomotor abilities is given in Table 1.
### Table 1. Psychomotor organization

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>FUNCTIONAL ABILITIES OF THE UPPER EXTREMITIES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>visuomotor control</td>
<td>immature</td>
<td>partially good</td>
<td>adequate</td>
<td>adequate</td>
<td>adequate</td>
</tr>
<tr>
<td>grasping</td>
<td>elbow-palm grip</td>
<td>grasping with the second phalanx</td>
<td>grasping with the first phalanx</td>
<td>grasping with the first phalanx</td>
<td>immature grasping similar to pliers</td>
</tr>
<tr>
<td>manipulative right-handedness</td>
<td>bad</td>
<td>partially good</td>
<td>partially good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td><strong>COARSE MOTOR SKILLS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sitting</td>
<td>adequate without support</td>
<td>adequate without support</td>
<td>adequate without support</td>
<td>adequate without support</td>
<td>adequate without support</td>
</tr>
<tr>
<td>crawling</td>
<td>difficult (dragging the upper extremities)</td>
<td>difficult (dragging the upper extremities)</td>
<td>possible (without cross-coordination)</td>
<td>possible (without cross-coordination)</td>
<td>possible (without cross-coordination)</td>
</tr>
<tr>
<td>standing</td>
<td>standing impossible</td>
<td>difficulty standing, with help</td>
<td>difficulty standing, with help</td>
<td>with help</td>
<td>with help</td>
</tr>
<tr>
<td>walking</td>
<td>with a wheelchair</td>
<td>with a wheelchair</td>
<td>walking with the help of another person</td>
<td>walking with the help of another person</td>
<td>walking with the help of another person</td>
</tr>
<tr>
<td><strong>OVERALL PSYCHOMOTOR SKILLS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>motor control of the body</td>
<td>weak</td>
<td>weak</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>balance</td>
<td>doesn’t maintain</td>
<td>doesn’t maintain</td>
<td>doesn’t maintain</td>
<td>successfully</td>
<td>Successfully</td>
</tr>
</tbody>
</table>
**Assessment instrument**

To evaluate writing, we used the "scale to assess handwriting dysgraphia" (Ažiriagera, Ozias, according to Cordic and Bojanin (1997). Given that this scale assesses standardised handwriting, and that the handwriting of our patient with CP is in capital letters, in this paper we performed only the qualitative analysis of handwriting without the possibility of quantitative treatment. The scale contains 25 items or features divided into 3 groups:

1. the spatial organization of the handwriting as a whole - 7 features,
2. performance of a series of letters - 13 marks,
3. proportions and form of letters – 5 marks.

**Process, time and place of examination**

The boy’s first task was to draw something of his own choice. The second task was to write his name, surname and a dictation (a sentence and a shorter text were dictated). The research was done in the family home, with the written approval of the mother.

**RESULTS**

In the first part we give the visual presentation of the boy’s motor expression made after each surgery, while the second part contains a table of the handwriting characteristics of our respondent in the period after one and two years after the implementation of the third intervention of the surgical methods of phased fiberotomy.

We present his first handwriting (Figs. 4 and 5), the handwriting a year after the intervention (Figure 6), graphomotor expression before and during the intervention (Figures 1, 2 and 3).

*Figure 1 (2005)*
In Figure 1 we can see the graphomotor activity of our patient immediately after the first intervention of the surgical methods of phased fiberotomy. At that time the boy only had the ability to draw back and forth across the paper, holding a pencil with the entire palm and grasping with the fingers corresponding to the typical development of a child aged 10-18 months.

Figures 2. (2007)

Figures 2 and 3 shows the graphomotor activities of our patient one year after the second intervention of the surgical methods of phased fiberotomy where we can see that compared to the previous picture, the child draws horizontal, vertical and circular shapes on paper that would be appropriate for a child of 2 years of age, and he was 10 years old in this period.
Figure 4. (2009)

Figure 5. (2009)

Figure 6. (2010)
Figure 6 shows our respondents writing ability two years after the third intervention of the surgical methods of phased fiberotomy.

**B) Display of the results of the qualitative analysis of handwriting based on the Scale for the assessment of handwriting dysgraphia (Ažiriagera, Ozias), according to Ćordić i Bojanin (1997)**

*Table 2. The spatial organization of the handwriting as a whole*

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>CHARACTERISTICS (QUALITATIVE ANALYSIS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMUDGED WHOLE</td>
<td>visibly smudged whole and the impression of poor equipment handling, clearly visible (notable drawing over and repeating moves with certain letters)</td>
</tr>
<tr>
<td>BROKEN LINE</td>
<td>multiple lines clearly broken (the line descends, then ascends suddenly)</td>
</tr>
<tr>
<td>WAVY LINE</td>
<td>all lines are wavy</td>
</tr>
<tr>
<td>DESCENDING LINES</td>
<td>lines descend at an angle larger than 6 degrees</td>
</tr>
<tr>
<td>COMPRESSED WORDS</td>
<td>There is space between words (although in some words there are compressed letters)</td>
</tr>
<tr>
<td>UNEVEN SPACE BETWEEN WORDS</td>
<td>clear unevenness (in some words, letters are compressed, and in some the space is too wide)</td>
</tr>
<tr>
<td>LACK OF MARGIN</td>
<td>unable to assess</td>
</tr>
</tbody>
</table>

*Table 3. Performing a series of letters*

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAD QUALITY LINE</td>
<td>a terrible line</td>
</tr>
<tr>
<td>TOUCHED (CORRECTED) LETTERS</td>
<td>at least two clear corrections</td>
</tr>
<tr>
<td>SCRIBBLING OVER LETTERS</td>
<td>there are a lot of such letters</td>
</tr>
<tr>
<td>CURVING THE LETTERS T, P, Š, I , U , N, NJ</td>
<td>unable to assess</td>
</tr>
<tr>
<td>ANGULAR CORNERS OF THE LETTERS T, P, Š, I , U</td>
<td>unable to assess</td>
</tr>
<tr>
<td>POINTS OF “WELDING”</td>
<td>unable to assess</td>
</tr>
<tr>
<td>UNSTICKING OF LETTERS</td>
<td>unable to assess</td>
</tr>
<tr>
<td>COLLISION OF LETTERS</td>
<td>several clear clashes</td>
</tr>
<tr>
<td>SACCADED GRAPHIC SERIES</td>
<td>graphic series not harmonic</td>
</tr>
<tr>
<td>RUSHED FINISH</td>
<td>child controls its finishing moves poorly</td>
</tr>
<tr>
<td>DISPARITY IN LETTER SIZE</td>
<td>letter size in words is variable</td>
</tr>
<tr>
<td>POOR ZONE DIFFERENTIATION</td>
<td>child doesn’t respect the three zones, writes the letters in one zone</td>
</tr>
<tr>
<td>ATROPHIC LETTERS</td>
<td>letters lacking their normal fullness</td>
</tr>
</tbody>
</table>
Table 4. Forms and proportions of the handwriting

<table>
<thead>
<tr>
<th>Features</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letters are very rigidly structured or loosely written</td>
<td>strong pressure on paper</td>
</tr>
<tr>
<td>Bad letter forms</td>
<td>some letters are very deformed</td>
</tr>
<tr>
<td>Handwriting jarringly large or small</td>
<td>large letters</td>
</tr>
<tr>
<td>Bad proportion of the handwriting zones</td>
<td>hypertrophy or atrophy of one or more zones (there are mixed forms: some parts of the letters are bigger and some smaller)</td>
</tr>
<tr>
<td>Stretched or compressed letters</td>
<td>mixed forms (some letters are very compressed while others are far away)</td>
</tr>
</tbody>
</table>

**DISCUSSION AND CONCLUSION**

Even though the methodological procedure with students begins with writing cursive script (Stošljević et al., 1997; Ćukić, 2008) the abilities of children with cerebral palsy are such that they can not learn it (Ćukić, 2008) so we can say that they are drawing letters, even the little boy we interviewed.

The characteristics of writing and handwriting that can be concluded based on this assessment are:

- Based on the overall first look of the graphemes, we can say that large printed letters are written, very poorly organized on the paper (Figures 4 and 5);
- On the basis of standard calligraphic norm of written letters, we can say that they are all in the median zone, that the proportion of letters is large and that the child generally knows and uses capital letters (Figures 4, 5 and 6);
- The boy does not fully recognize all the letters (such as : . nj, j, ć, e) which indicates that because of his state, he does not recognize the spatial organization of letters;
- In several occasions, vertical lines were drawn with multiple strokes;
- Analysis shows that the sequence of graphemes within words is distorted and that the progress from left to right is out of tune;
- The direction of letters in the word is generally horizontal, but also wavy, broken and distorted.
- The boy does not know how to limit the fullness and direction of movement which results in different shapes or sizes of letters;
- Considering that the forming of the series and learning the letters came late, the act of writing took a long time.

The reasons for most of these items can be linked with disorders related to vision, which are evidently present. All other irregularities in the handwriting we believe are present due to the lack of eye-hand coordination, and that is why the child is not able to limit the fullness and direction of motion, so the letters have different sizes and curves, but also because of the late use of the pencil.

Students with CP, because of the disorder, can seldom satisfy the basic requirements of proper writing. However, we should always strive to achieve an adequate corrective position. In teaching we should use specially designed tables and chairs and other supplies needed to immobilize the notebook. For writing, they should use pens with cartridges (of different shape and thickness) corresponding to the corrective position of hands and fingers, and which will suit the physiological position when writing and that will improve the function of the hand (Nikic, 2008).

In working with students with CP one should not insist on a beautiful, ideal and calligraphic handwriting, but the ability of students to write should be considered. In our case studies we can see that by using surgical methods of phased fiberotomy and adequate physiotherapeutic and defectological treatment can achieve satisfactory results in the development of writing for children with cerebral palsy. If we acknowledge the above statement, that up until the second intervention there was no graphomotor sequence (Figures 1, 2 and 3), we can say that it has been established, and that the boy has an immature and unformed handwriting, according to all the characteristics of children with cerebral palsy (Figures 4 and 5). We should note that in these students establishing coordination of eye movements and hand movements as well as coordination of fingers, hands and arms is difficult. Ćukić (2008) states that due to the damage to brain structures, weakness, convulsions and involuntary movements, the ideal of beautiful and coherent writing is rarely achieved, as in the example of the boy, our respondent. Also, damage to brain structure does not allow linking letters and cursive writing, which is often found in working with children with cerebral palsy, and most of these children can not master script, as is the case with our child. The literature states that these children write large letters, irregular, of different sizes, different spaces and distances, often with excessive elements (Ćukić, 2008) which is consistent with our findings. However, seeing as how this boy has good speaking skills, and the whole system of educational work is based on them, writing should be developed only to the extent and degree to which his motor skills allow.
In the literature we find numerous studies on the subject of graphomotor disorders in children with cerebral palsy and treatments applied for the disorder. Many authors come to the conclusion that after stimulation individual programs which have been administered to children with cerebral palsy of school age (kinesiotherapy, facilitation (Bobath, Vojta and Kabat)), led to significant improvements in the capabilities of hand movements, grip and the graphomotoric. The results provided by therapy phased fiberotomy, justifies the importance that we attach to this work and represents a foundation for further research in this treatment.

Many studies have been concerned with the factors that affect handwriting. Classification is made to external and internal factors. Examples of external factors are teaching methods and materials that are used when writing (Alston, 1985; Carlson & Cunningham, 1990; Pasternicki 1987, Rubin & Henderson, 1982; Janeiro-Bloser, 1994; Ziviani, 1987). Internal factors are the abilities of students, their visiomotor skills, visual perception, motor planning (the ability to plan a new motor behavior), hand manipulation and conscience (Beminger & Rutberg, 1992; Case-Smith & Pehoski, 1992; Laszlo & Bairstow, 1984; Maeland, 1992, Schneck, 1991; Tseng, 1991; Tseng & Murray, 1994; Weil & Amundson, 1994; Ziviani, Hayes, & Chant, 1990; Ziviani, 1995). Some authors (Brown & Donnenwirth, 1990, Chu, 1997; Exner, 1990; Exner & Henderson, 1995; Moore & Law, 1990; Naka, 1998) discussed the relationship of various aspects of cognition, attention, memory and language with the ability to write. It is alleged that the handwriting performance can be optimized when internal factors are at the appropriate developmental level, which ensures that students benefit from teaching. Pacic et al. (2011) found that in addition to the primary consequence is brain damage bad findings in this area can be explained by the empirical factor but also a lack of training in this area.

In modern societies, in many cultures today with the development of science and technological achievements and possibilities of electronic recording less and less importance is given handwriting. But writing does have a role in our lives, because it performs the integration of almost all brain structures, therefore, so it can be said to be one of the most complex human activities. Children with cerebral palsy in most cases lag behind in graphomotor skills compared to the usual standards of the normal population (Rapaic, 1996). The fact is that children with cerebral palsy present disharmonious psychomotor development which affects the activity of writing. If writing is effective, it allows us to remember, organize and process information, and if it is disturbed it causes us great inconvenience and badly affects the development of abilities important for education and learning.

It is obvious that in children with cerebral palsy, which undermines the coarse and fine motor skills, there will be interference in graphomotoric
ability. Such difficulties are visible in basic graphic skills. Children come to graphomotor activities and the drawings after a long effort. If the movement of the hand is prevented, it is necessary to support the development of limb exercises by using creative activities, where the motivation for a particular activity is also important. The application of various methods and techniques with an appropriate physical and defectological treatment is the basis for development of motor skills and as a part of it graphomotorics in this group of children.

“The authors of this study acknowledge the family Jeremic on long-term cooperation and understanding”.

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