

The Validity of ESIN Method of Osteosynthesis Compared to other Active Surgical Methods of Treatment of Diaphyseal Fractures of Long Bones in Children and Adolescents

Nado Bukvić¹, Ante Kvesić², Zdrinko Brekalo², Željko Martinović³, Velimir Valjan³, Suzana Jonovska¹, Robet Karlo¹, Grga Martinović¹ and Šime Vučkov²

¹ University of Rijeka, Rijeka University Hospital Center, Department of Pediatric Surgery, Rijeka, Croatia

² University of Mostar, Mostar University Clinical Hospital, Department of Pediatric Surgery, Mostar, Bosnia and Herzegovina

³ »Dr. fra Mato Nikolić« Franciscan Hospital, Nova Bila, Bosnia and Herzegovina

ABSTRACT

We investigated the relationship of efficiency in the application of the ESIN method of intramedullary osteosynthesis and other active surgical methods in the treatment of diaphyseal fractures of long bones in children and adolescents. The study comprised 100 subjects treated by elastic stable intramedullary osteosynthesis (ESIN – group A) and 50 subjects in whom other active surgical methods were applied (group B). The following criteria of efficiency of treatment were applied: 1. length of perioperative hospitalization, 2. time elapsed since the operation until the beginning of loading of the traumatized extremity, 3. time elapsed since the operation until the full loading of the extremity, i.e. until the recovery of the fracture, 4. incidence of complications, 5. number of post-operative outpatient clinical visits until the recovery of the fracture and 6. overall number of X-ray images of the fractured bone since the accident until the coalescence of the fracture. The results obtained in both groups were compared. 1. The length of perioperative hospitalization is shorter in patients in whom ESIN method was applied. The difference between arithmetic means was 4.45 days and is statistically significant ($p < 0.001$). 2. The time between the operation until the beginning of loading of the extremity is shorter in patients subjected to ESIN method of osteosynthesis, the difference of mean values being 23.49 days and is statistically significant ($p < 0.001$). 3. The time between the operation until the full loading of the extremity is shorter in patients subjected to ESIN method of osteosynthesis, the difference being 16.6 days and is statistically significant ($p < 0.001$). 4. The number of complications in patients treated by the ESIN method of osteosynthesis is not statistically different from that in group B ($\chi^2 = 0.25$, $p = 0.62$). 5. In postoperative period there were fewer outpatient controls in patients to whom ESIN method of osteosynthesis was applied, and the difference is statistically significant ($Z = 7.69$, $p < 0.001$). 6. Likewise, the overall number of X-ray controls was lesser ($Z = 8.06$, $p < 0.001$). The results of examining the above parameters point to a greater efficiency of treating diaphyseal fractures of long bones in children and adolescents by the ESIN method of osteosynthesis, compared to other active surgical methods.

Key words: bone fractures, treatment, ESIN method of osteosynthesis, other surgical methods

Introduction

There has been a recent rethinking of the treatment of bone fractures in organisms in which growth is not completed (children and adolescents). In this population, even when applying various methods of osteosynthesis, the traumatologist is confronted with different postu-

lates than those in the treatment of bone fractures of the adult¹⁻³. There are three important factors which determine the therapist's choice of method and means of its application in bone fractures in children and adolescents: 1. the zone of bone growth, 2. possibility of subsequent

remodelling and correction of the bone axis in the traumatized patient, with early post-traumatic angulation, which is more frequent, and 3. the possibility of subsequent angulation in patients with preserved bone axis immediately upon reposition, which is less frequent.

Even recently, in some medical centres therapists are more prone to conservative views in the treatment of fractures in children and adolescents, although such views are retreating confronted with active surgical treatment^{4–10}. After reviewing the development of treatment of bone traumas in overall population we can say that almost every method found its application in the treatment of fractures in children and adolescents, from the most conservative to the most active surgical methods¹¹. However, the influence of earlier authors who only seldom accepted an active surgical approach in the treatment of bone fractures in children and adolescents, is felt even today^{12–14}. Today, in this field of treatment, the therapist is faced with some other demands apart from achieving an anatomical and functional restitution of the traumatized extremity. A greater stress is placed upon the shortening and a greater economy of treatment, return of the injured to everyday life, of children into their families and schools, and likewise the creation of conditions for a more tolerable and acceptable life for the patients, and an easier keeping of hygiene during the treatment period.

Judging by reports, the method of intramedullar osteosynthesis (ESIN) is gaining ground and it appears to satisfy the stated requirements in a greater measure than other surgical methods observed in the study (osteosynthesis by Kirschner wires, screws, plates and cerclage), especially in the treatment of fractures in children and young persons^{2,4,5,10,15–18}.

It enables the achievement of a more successful anatomical restitution of the fractured bone, as well as a quicker functional restitution of the traumatized extremity, compared to other methods of treatment of fractures.

The application of ESIN method of osteosynthesis in the treatment of fractures in children, adolescent and even adults began in the Rijeka University Hospital Center and the University Clinical Hospital in Mostar more than a decade ago. Concomitantly, other active surgical

methods in the treatment of fractures in the said population were also applied. On the one hand, therefore, we have a new surgical method of treatment (ESIN) which probably has certain advantages over older surgical treatment methods, applied until now. By comparing the efficiency of the ESIN method of elastic osteosynthesis and other active surgical methods we can conclude whether and in which parameters the ESIN method of elastic osteosynthesis is more efficient than the other applied active surgical methods in the treatment of diaphyseal fractures of long bones in the observed population.

Materials and Methods

The study included 100 children and adolescents in whom in the treatment of transversal and slanted fractures of the diaphysis of long bones the ESIN method of osteosynthesis was applied. In most of the observed patients it was applied primarily, and only in 17 of them secondarily, i.e. after an attempt at a conservative method of treatment. The study also included 50 children and adolescents with the same diaphyseal fractures of long bones in whom some other surgical method was applied.

Table 1 shows the distribution of patients by age and sex, table 2 the incidence of fracture of individual bones in all studied patients and table 3 lists other applied surgical methods of treatment.

Two groups of patients were observed. In the first one, the method of elastic stable osteosynthesis (ESIN) was applied (group A) and in the second one, other active surgical methods (group B). The successfulness and effi-

TABLE 2
DISTRIBUTION OF PATIENTS BY FRACTURED BONES

Fractured Bone	ESIN (Group A)	Other methods (Group B)	Total
Humerus	3	2	5
Radius+ulna	48	14	62
Femur	21	9	30
Tibia + fibula	28	25	53
Total	100	50	150

TABLE 1
DISTRIBUTION OF PATIENTS BY AGE AND SEX

Age	ESIN (Group A)			Other methods (Group B)			Total
	N	Sex		N	Sex		
		M	F		M	F	
0–5	10	8	2	1	1	0	11
6–10	36	25	11	18	12	6	54
11–15	52	43	9	26	18	8	78
>16	2	2	0	5	5	0	7
Total	100	78	22	50	36	14	150

TABLE 3
OTHER APPLIED ACTIVE SURGICAL METHODS

Applied methods of treatment	Fractured bone				Total
	Humerus	Radius + ulna	Femur	Tibia+ fibula	
Kirschner wires	1	13	3	1	18
Screws	0	0	2	22	24
Plates	1	1	4	1	7
Cerclage	0	0	0	1	1
Total	2	14	9	25	50

ciency in the treatment of fractures in both groups were compared.

The criteria of treatment efficiency were the following:

1. Duration of perioperative hospitalization;
2. Time elapsed between the operation until the beginning of loading of the traumatized extremity;
3. Time elapsed between the operation until the full loading of the traumatized extremity (free use);
4. Incidence of complications;
5. Number of outpatient clinical visits during post-operative treatment and
6. Overall number of X-ray examinations since the first X-ray examination until the full recovery of fracture.

Results of examination of above parameters in both groups of patients were compared and statistically elaborated. We first examined the normality of distribution. As the distribution significantly differs from the normal one, we used non-parametric tests. To compare numerical data we used the non-parametric Wald-Wolfowitz test, while the χ^2 -test was used to compare the incidence of complications between groups. For the analysis and comparison of data we used the application programme Statistica version 8.0. Statistical significance was set at $p \leq 0.05$, i.e. the 95% confidence limit.

Results

Table 4 shows the duration of perioperative hospitalization expressed in days in both observed groups of patients. It is evident that it is significantly shorter in patients in whom the ESIN method of osteosynthesis was applied (Group A) than in the group in which other active surgical methods were applied (Group B). We compared the average duration of perioperative hospitalization between groups. The difference between arithmetic means of duration of perioperative hospitalization is 4.45 days and is statistically significant ($Z=7.31$, $p < 0.001$).

Table 5 shows mean intervals between the operation and the beginning of loading of the traumatized extremity. It is evident that this interval, expressed in days, is significantly shorter in patients in whom the ESIN method of osteosynthesis has been applied (Group A), com-

pared to those subjected to other active surgical methods (Group B). The difference, according to the Wald-Wolfowitz test is 23.49 and is statistically significant ($Z=12.11$, $p < 0.001$). The right column of the table shows the mean value /days/ between the operation and the beginning of loading of the extremity in both groups.

Table 6 shows the time /days/ between the operation and the full loading (free use) of the traumatized extremity, i.e. until the full coalescence of the fracture in both

TABLE 4
DURATION OF PERIOPERATIVE HOSPITALIZATION /DAYS/
FOR BOTH GROUPS OF SUBJECTS

Duration of perioperative hospitalization /days/	ESIN (Group A)	Other surgical methods (Group B)	Total
0–1			
2–3	2 (2%)		2 (1.33%)
4–5	30 (30%)	1 (2%)	31 (20.66%)
6–7	63 (63%)	14 (28%)	77 (51.33%)
8–9	2 (2%)	18 (36%)	20 (13.32%)
10–11	2 (2%)	3 (6%)	5 (3.33%)
12–13	1 (1%)	7 (14%)	8 (5.33%)
14–15		1 (2%)	1 (0.66%)
>16		6 (10%)	6 (4.00%)
Total	100 (100%)	50 (100%)	150 (100%)

TABLE 5
AVERAGE TIME /DAYS/ BETWEEN THE OPERATION AND THE BEGINNING OF LOADING OF THE TRAUMATIZED EXTREMITY (GROUPS A AND B)

Fractured bone	Days		Mean Value for all subjects (Groups A and B)
	ESIN (Group A)	Other surgical methods (Group B)	
Humerus	5.3	20.5	11.4
Radius + ulna	5.6	26.9	10.4
Femur	6.3	33.7	14.5
Tibia+fibula	6.6	30.2	17.7
Mean Value	6.0	29.5	13.82

study groups. The difference between the two groups is evident – 16.6 days in favour of the group in which the ESIN method of osteosynthesis was applied (group A). The difference is statistically significant ($Z=8.06$, $p<0.001$). The table also shows the mean value /days/ be-

TABLE 6
AVERAGE TIME /DAYS/ BETWEEN THE OPERATION AND THE FULL LOADING OF THE TRAUMATIZED EXTREMITY (GROUPS A AND B)

Fractured Bone	Days		Mean Value of all subjects (Groups A and B)
	ESIN (Group A)	Other surgical methods (Group B)	
Humerus	26	30	27.6
Radius+ulna	29.1	39	31.3
Femur	31.4	50.2	37.1
Tibia+fibula	31.8	51.2	40.9
Mean Value	30.2	46.8	35.7

TABLE 7
COMPARISON OF INCIDENCE OF COMPLICATIONS IN TWO OBSERVED PATIENT'S GROUPS

Type of complication	Incidence of complications		Total
	ESIN (Group A)	Other surgical methods (Group B)	
Osteomyelitis	0	1	1
Pseudoarthrosis	0	1	1
Prolongation of extremity <1 cm	12	5	17
Prolongation of extremity >1 cm	2	1	3
Inflammation of soft tissue	3	3	6
Valgus	0	1	1
Valgus+ prolongation >1 cm	1	0	1
Rotation disorder	1	0	1
Total	19	12	31

TABLE 8
THE NUMBER OF OUTPATIENT CLINICAL VISITS IN THE POSTOPERATIVE PERIOD AND THE OVERALL NUMBER OF X-RAY EXAMINATIONS (GROUPS A AND B)

Fractured Bone	Groups of patients			
	ESIN (Group A)		Other surgical methods (Group B)	
	Outpatient visits (N)	X-ray controls (N)	Outpatient visits (N)	X-ray controls (N)
Humerus	3.0	3.7	3	4
Radius+ulna	2.8	3.4	3.9	5.1
Femur	2.8	3.3	4.6	5.6
Tibia+fibula	3.1	3.6	4.5	4.9
Mean Value	2.9	3.5	4.3	5.0

tween the operation and the full loading of the extremity in all patients of both groups.

The incidence of complications in both observed groups is shown on Table 7. The number of complications in patients in whom the ESIN method of osteosynthesis was applied is somewhat greater, but not significantly, than the number of complications in group B ($\chi^2=0.25$, $p=0.62$).

Table 8 shows the number of outpatient clinical visits in the observed postoperative period, as well as the overall number of X-ray controls done during the treatment. This parameter also shows that the number of outpatient postoperative controls and X-ray examinations since the moment of trauma until the last control is much smaller in patients in whom the ESIN method of treatment was applied (group A), compared to those who received other active surgical treatment methods (group B). The difference is significant, both for outpatient clinical visits ($Z=7.69$, $p<0.001$) and X-ray controls ($Z=8.06$, $p<0.001$).

Discussion

A child is not a miniature of the grown-up, neither a man on a small scale¹⁹. It has its biology, physiology, psychology, possible pathology, and the principles of treatment. All of this can be applied in the choice of the method of treatment of fractures in a young organism¹¹. The trauma of the locomotor system in children and the young is different from those in adults in the psychological reaction of the traumatized to his/her trauma^{20,21} and in the biological response of the entire organism and bone structures to the injury. It is different in the metabolic effect which the trauma produces in the organism and in the response of the adjacent soft and bone tissue to the trauma. The biological difference lies in the capacity of the young organism to grow, to regenerate quickly and to maintain, thanks to the capacity for biological remodelling, the basic architecture of the bones, and in some circumstances to rectify possible remaining post-traumatic deformities^{22,23}. The procedures in the treatment of fractures in adults cannot be automatically applied to the organism whose growth is not yet complete, due to possible damage of the zone of bone growth, exces-

sive growth of the fractured bone and the capacity of remodelling of inadequately coalesced bone^{13,24}. All the existing methods of treatment of fractures have been applied more or less, and are being applied to date, in children and adolescents. It is stated that the aim of treatment of bone fractures in young organisms is not the achievement of a rigid internal fixation of the fragments, but the achievement of an orderly anatomic axis of the bone^{25,26}.

Anatomic and functional restitution of the traumatized extremity with fracture is being achieved by the application of conservative and active surgical methods of treatment. However, both of these methods require long-term hospital treatment, long-term immobilization of the extremities, long-term separation of children from their families and school, and, after all that, a long-term psychiatric treatment. During such treatment life is more difficult to bear, uncomfortable and unpleasant, and the treatment itself is much more expensive.

After an era of A-O osteosynthesis, more and more frequent in clinical practice is the intermedullary osteosynthesis as the most acceptable therapeutic approach in the treatment of fractures of long bones. Gradually, this approach is applied in children and adolescents too^{3,15,27–29}. The method of intramedullary osteosynthesis represented an advance in the treatment of bone trauma³⁰. At that time intramedullary osteosynthesis was seen as a method of choice^{30–32}. More recently, a child traumatologist is faced with new postulates in the treatment of bone injuries. Medical science and practice strive to achieve, along with anatomic and functional restitution of the traumatized extremity, the creation of conditions for a more comfortable life during treatment, and the return of the adults into everyday life and work place, and of children and the young into their family environment and their schools as soon as possible. Ultimately, an important aim is to reduce the costs of treatment^{1–3}.

According to numerous recent reports in medical literature and our own experience, the ESIN method of osteosynthesis, inaugurated by Metaizeau and Prévot^{33–35} conforms to the greatest degree to the stated aims in the treatment of bone injuries^{5–10,36–38}. It is also called biological osteosynthesis^{4–39}. Some authors point to the value of ESIN method in special cases in combination with external fixator⁸, others point to its limitations¹⁰, and the third to the drawbacks of its use and to possible complications^{40–42}, including a greater exposure to radiation⁴³.

The paper gives a comparison of the efficiency of treatment of the diaphyseal fracture of long bones in children and adolescents by the use of the ESIN method and other surgical methods. The study included 100 patients in whom the ESIN method was applied and 50 who were treated by other methods. The efficiency of treatment was judged by the following parameters: 1. peri-

operative duration of hospitalization, 2. duration of strict immobilization of the traumatized extremity, 3. time elapsed between the beginning of treatment and the free use of extremity, 4. the incidence of complications, 5. the frequency of outpatient control visits and 6. the number of X-ray examinations of the fractured bone.

The time elapsed since the beginning of treatment until the initial loading of the traumatized extremity is shorter in patients in whom the ESIN method is applied, compared to those who underwent other surgical methods. The difference is statistically significant ($Z=12.11$, $p<0.001$). The time elapsed since the beginning of treatment until the full loading of the extremity, i.e. until the free use is likewise shorter in patients in whom the ESIN method was applied, compared to those subjected to other methods. The difference is significant here too ($Z=8.06$, $p<0.001$). The incidence of complications is somewhat greater in the group of patients in whom the ESIN method was applied than in the other observed group, but the difference is not significant ($\chi^2=25$, $p=0.62$). Observing the frequency of outpatient clinical visits and the overall number of X-ray examinations of the fractured bones in every individual patient, a visible difference was observed between the patients treated by the ESIN method and those who underwent other methods of treatment. During postoperative treatment of traumatized persons treated by the ESIN method, the frequency of outpatient clinical visits was visibly smaller than in those in whom other methods of treatment were applied. This difference is statistically significant ($Z=7.69$, $p<0.001$). Likewise, in the group of patients treated with the ESIN method a visibly smaller number of X-ray examinations was necessary than in the other observed group. The difference is statistically significant too ($Z=8.06$, $p<0.001$).

The results of comparative investigation described in this paper point to a greater therapeutic efficiency of the ESIN method in relation to other observed methods of treatment of diaphyseal fractures of long bones in children and adolescents. All of the observed methods of treatment of fractures result in the anatomical and functional restitution of the traumatized extremity along with – with respect to present-day treatment conditions – a minimal incidence of complications. The application of the ESIN method visibly shortens the hospital treatment and the overall treatment of the traumatized person, making life more comfortable and enabling the children to return to their family environment and school earlier. The treatment itself is several times cheaper^{1–3}. The psychological moment is an important part of the overall treatment of children, especially traumatized children²⁰. Elastic stable intermedullary osteosynthesis (ESIN) apparently assumes the features of the »gold standard« in the treatment of bone fractures, especially in children and adolescents.

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Š. Vučkov

Brdo 10, 51000 Rijeka, Croatia
e-mail: sime.vuckov1@ri.t-com.hr

VRIJEDNOST ESIN METODE OSTEOSINTEZE U USPOREDBI S DRUGIM AKTIVNIM KIRURŠKIM METODAMA LIJEČENJA PRIJELOMA DIJAFIZA DUGIH KOSTIJU U DJECE I ADOLESCENATA

SAŽETAK

Ispitivali smo odnos uspješnosti primjene ESIN metode intramedularne osteosinteze i drugih aktivnih kirurških metoda u liječenju prijeloma dijafiza dugih kostiju u djece i adolescenata. U promatranje smo uzeli 100 ispitanika liječenih primjenom intramedularne stabilne elastične osteosinteze (ESIN) (grupa »A«) te 50 onih u kojih su primijenjene druge aktivne kirurške metode (grupa »B«). Primijenjeni su slijedeći kriteriji procjene uspješnosti i efektivnosti liječenja: 1. trajanje peroperativne hospitalizacije, 2. vrijeme proteklo od operacije do početka opterećenja traumatiziranog ekstremiteta, 3. vrijeme proteklo od operacije do potpunog opterećenja ekstremiteta tj. do sanacije prijeloma, 4. incidencija komplikacija, 5. broj postoperativno izvršenih ambulantnih kontrola do sanacije prijeloma te 6. sveukupni broj učinjenih rendgenskih slika prelomljene kosti od ozljede do srastanja prijeloma. Rezultate ispitivanja u obje grupe stavili smo u međusobni odnos. 1. Trajanje peroperativne hospitalizacije kraće je u ispitanika s primijenjenom ESIN metodom liječenja. Razlika među aritmetičkim sredinama je iznosila 4,45 dana i statistički je značajna $p < 0,001$. 2. Vrijeme od operacije do početka opterećenja ekstremiteta kraće je u ispitanika s primijenjenom ESIN metodom osteosinteze, a razlika između srednjih vrijednosti iznosi 23,49 dana i statistički je značajna $p < 0,001$. 3. Vrijeme od operacije do potpunog opterećenja ekstremiteta kraće je u ispitanika s primijenjenom ESIN metodom osteosinteze, a razlika iznosi 16,6 dana i statistički je značajna $p < 0,001$. Broj komplikacija u ispitanika s primijenjenom ESIN metodom osteosinteze statistički se ne razlikuje od broja komplikacija u grupi »B« ($\chi^2 = 0,25$, $p = 0,62$). U postoperativnom je vremenu manje ambulantnih kontrola u ispitanika s primijenjenom ESIN metodom osteosinteze što je statistički značajno ($Z = 7,69$, $p < 0,001$), a isto tako je statistički značajno i manje sveukupnih rendgenskih kontrola u njih ($Z = 8,06$, $p < 0,001$). Rezultati ispitivanja navedenih parametara ukazuju na veću uspješnost i efektivnost liječenja prijeloma dijafize dugih kostiju u djece i adolescenata primjenom ESIN metode osteosinteze nego u onih s primijenjenim drugim aktivnim kirurškim metoda liječenja.