Joint Diseases and Related Surgery

Jt Dis Relat Surg
2023;34(2):381-388

ORIGINAL ARTICLE

A comparison of two immobilization methods in the conservative treatment of pediatric distal forearm fractures: Long arm cast versus single sugar-tong splint

Ali Engin Daştan, MD[1], Arman Vahabi, MD[1], Omar Aljasim, MD[2], Bünyamin Kılıçlı, MD[1], Levent Küçük, MD[3], Erhan Coşkunol, MD[1]

[1]Department of Orthopedics and Traumatology, Medicine Faculty of Ege University, Izmir, Türkiye
[2] Department of Orthopedics and Traumatology, Medical Park Gebze Hospital, Izmit, Türkiye
[3] Department of Orthopedics and Traumatology, Medicana International Hospital, Izmir, Türkiye

ABSTRACT

Objectives: The aim of this study was to compare the results of single sugar-tong splint (SSTS) and long arm cast (LAC) as an immobilization method in pediatric distal forearm fractures.

Patients and methods: Between January 2016 and December 2019, a total of 186 pediatric patients (143 males, 43 females; mean age: 10.3±3 years; range, 4 to 15 years) with distal forearm fractures were retrospectively analyzed. The patients were divided into two groups according to the immobilization method: SSTS group (n=74) and LAC group (n=112). All patients were evaluated at the time of admission, immediately after the reduction, and at one, two, and four weeks. Sagittal and coronal plane angulations and translation percentages of the radius at each visit were calculated. Alterations in coronal angle, sagittal angle, sagittal translation and coronal translation were calculated by subtracting the measurements after reduction from the measurements at four weeks.

Results: Both groups were comparable in terms of demographic characteristics, fracture localization, and side of injured extremity. There was a statistically significant difference only in the sagittal angulations in the first (LAC: 4.7; SSTS: 6.5; p=0.009) and second week (LAC: 5.3; SSTS: 6.8; p=0.024). The rest of radiological measurements were comparable. In the LAC group, seven patients had re-intervention (three manipulations, four surgeries) and in the SSTS group, three patients had re-intervention (two manipulations, one surgery) (p=0.657).

Conclusion: Our study results suggest that SSTS and LAC are comparable in terms of radiological results and need for re-intervention as an immobilization method of pediatric distal forearm fractures.

Keywords: Long arm cast, pediatric distal forearm fracture, sugar-tong splint.

Forearm fractures are quite common in the pediatric population.[1-3] Although parents and physicians avoid residual deformities, they are mostly treated conservatively due to the high remodeling capacity at these ages.[3-6] There are different immobilization methods to maintain reduction in the conservative treatment of forearm fractures, such as short arm casts (SACs), long arm casts (LACs), single sugar-tong splints (SSTS) or double sugar-tong splints (DSTS).[7] Although the traditional immobilization method for pediatric distal forearm fractures is LAC, SAC and sugar-tong splints (STS) have shown satisfactory results in recent years.[4,7-9]

After the reduction of these fractures, edema may occur in the extremity. Particularly in circular casts, edema may lead to an increase in soft tissue pressure.

Received: December 13, 2022
Accepted: February 28, 2023
Published online: April 26, 2023

Correspondence: Ali Engin Daştan, MD. Ege Üniversitesi Tıp Fakültesi Ortopedi ve Travmatoloji Anabilim Dalı, 35100 Bornova, İzmir, Türkiye.

E-mail: aengind@gmail.com

Doi: 10.52312/jdrs.2023.981

Citation: Daştan AE, Vahabi A, Aljasim O, Kılıçlı B, Küçük L, Coşkunol E. A comparison of two immobilization methods in the conservative treatment of pediatric distal forearm fractures: Long arm cast versus single sugar-tong splint. Jt Dis Relat Surg 2023;34(2):381-388. doi: 10.52312/jdrs.2023.981.

As a result of the increased pressure, skin problems, neurovascular injuries and even compartment syndrome may develop.[10] To prevent these complications, it is possible to reduce the pressure on the soft tissue with techniques such as splitting the cast.[11] Although splitting the circular cast does not increase the risk of fracture displacement, it may lead to complications related to the saw and also lead to loss of time and increased costs.[11,12] Recent studies have reported that STS are as successful as traditional circular casting in the treatment of these fractures.[7,8,13] Moreover, there is no need for splitting, and it prevents saw-related complications and loss of time.

There are two types of STS, mainly SSTS and DSTS. The former starts from the just proximal to palmar crease, continues around elbow and ends at the dorsal metacarpophalangeal joint level. The latter contains a proximal sugar-tong part which starts from anterior proximal humerus level, continues around the elbow and ends at the distal of the axilla in addition to SSTS. The DSTS is more rigid to limit elbow motion. A randomized-controlled study reported similar results with SAC in treatment of the distal third of the forearm compared to LAC.[13] Regarding these, we changed our immobilization method from traditional LAC to STS to avoid time consuming in the emergency department (ED), saw, and cast-related complications. We preferred SSTS instead of DSTS, as even SAC provides sufficient elbow immobilization.

In the present study, we hypothesized that SSTS was as successful as LAC in distal forearm fractures. We, therefore, aimed to compare the results of SSTS as an immobilization method in pediatric distal forearm fractures, which could be easier in terms of application and treatment management.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Medicine Faculty of Ege University, Department of Orthopedics and Traumatology between January 2016 and December 2019. Earlier, in our clinic, in the conservative follow-up procedure for distal forearm fractures, a LAC was applied after reduction, followed by bivalve release. After casting, we waited for the cast to dry for about 3 h before the valve was opened. Considering that this situation caused a loss of time for both the physician and the patient, it was decided to treat these fractures with SSTS after March 2018. The patients consulted at our clinic in the ED were reviewed using the electronic archive of our hospital. Patients between the ages of 4 and 15 years with a radius or forearm both bone fracture distal to the distal radius metaphysis-diaphyseal junction who required reduction, had an open physes, had successful closed reduction and had at least four weeks of X-ray follow-up were included in the study. Fractures that did not require reduction, open fractures, torus fractures, green stick fractures, Salter-Harris type 3 and type 4 injuries and patients with metabolic disease were excluded from the study. Finally, a total of 186 patients (143 males, 43 females; mean age: 10.3±3 years; range, 4 to 15 years) were included. The patients were divided into two groups according to the immobilization method: SSTS group (n=74) and LAC group (n=112).

Treatment methods

Closed reduction of all cases was performed immediately under sedation in the ED by a junior orthopedic resident under the supervision of a senior orthopedic resident. The sedation protocol was managed by ED physicians. The cases with acceptable reduction were followed conservatively. Surgical treatment was planned and simple splinting was applied to the patients who could not be reduced.

Circumferential cotton undercast padding was used before both LAC and SSTS application. Totally, 5, 7.5 or 10 cm plaster rolls were used depending on the size of the limb. Length of the SSTS was measured before preparation. The SSTS were made of 10 to 15 layers of plaster. Forearm was placed neutral rotation during SSTS application. After circumferential cotton padding, SSTS was applied starting from the just proximal to palmar crease, extending dorsally around the elbow and ending at the dorsal metacarpophalangeal joint level. The wrist was splinted in slight flexion or extension depending on the apex direction of the fracture (apex volar fractures splinted in flexion position, apex dorsal fractures splinted in extension position). An elastic wrap was applied to fix SSTS (Figure 1).[4,14,15]

After cotton padding, plaster was applied with three- or four-layer depending on the size of the patient for the LAC. Apex volar fractures were casted in slight flexion and pronation, while apex dorsal fractures were casted in slight extension and supination position.

The patients in the LAC group were discharged after splitting the cast by waiting for the cast to dry. The patients in the SSTS group were discharged immediately. Before being discharged, the family

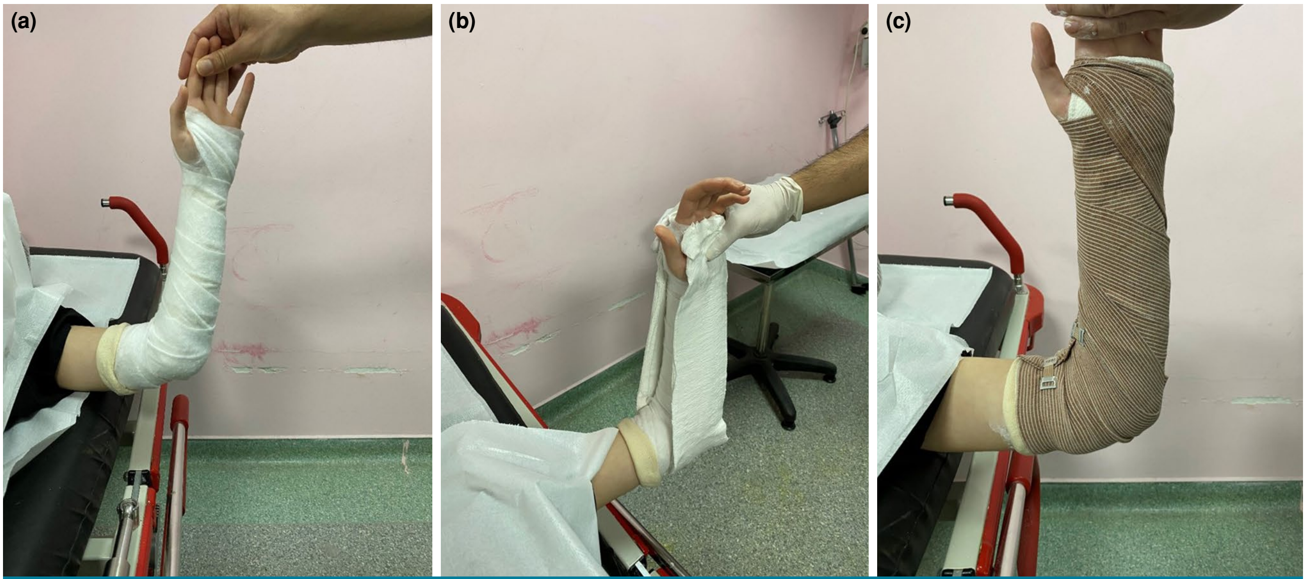

FIGURE 1. Example of a single sugar-tong splint (SSTS). **(a)** circumferential cotton undercast padding. **(b)** positioning the SSTS. **(c)** elastic wrapping.

was informed about circulatory follow-up, and they were later called for a circulatory examination. All patients had X-ray control in the first, second, and fourth weeks. In the first week, both the SSTS and LAC groups were overwrapped with plaster casts. In cases with a loss of reduction in the follow-ups, re-reduction was attempted under general anesthesia in the operating room (OR), and surgical treatment was applied to cases that could not be re-reduced. If there was no loss of reduction in the follow-ups in either the LAC or SSTS groups, the immobilization method was converted to SAC in the fourth week. In the sixth week, the cast was removed and the treatment was terminated.

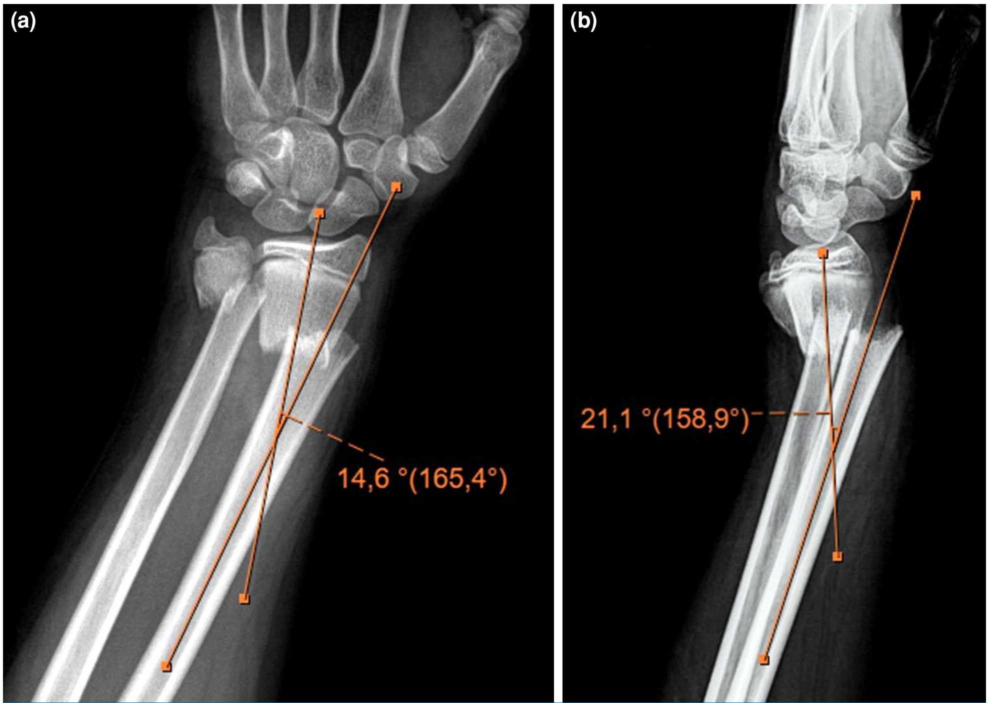

FIGURE 2. Measurement of the angulation. **(a)** Coronal angulation. **(b)** Sagittal angulation.

Evaluation of the radiographs

The evaluations and measurements were performed using the Sectra version 22.1 software (Sectra AB, Linköping, Sweden). Since the risk of alignment changes after the fourth week in this age group is very low, the fourth week was chosen as the endpoint for radiological measurements.[7] At the time of admission, immediately after the reduction, the first-week, second-week, and fourth-week controls were analyzed. The types of fractures were recorded. Sagittal and coronal plane angulations and translation percentages of the radius at each visit were calculated (Figures 2 and 3). The Δcoronal angle, Δsagittal angle, Δsagittal translation and Δcoronal translation values were calculated by subtracting the measurements after reduction from the measurements at the fourth week of the cases. During follow-up period, cases that required re-reduction or surgical intervention by exceeding the acceptable reduction criteria were accepted as unsuccessful treatments.

Radiographic measurements of the cases were taken by three researchers, and the average of the obtained values was used for analysis. In cases with a difference of more than 10% between the measurements, the values that were agreed upon after the face-to-face meetings between the researchers were analyzed.

Statistical analysis

Statistical analysis was performed using the SPSS for Windows version 23.0 software (IBM Corp., Armonk, NY, USA). The normality of the distribution was analyzed using the Kolmogorov-Smirnov test. An independent samples t-test was used to compare continuous variables that met parametric assumptions, while the Mann-Whitney U test was used to compare continuous variables that did not meet parametric assumptions. The chi-square test was used to compare categorical variables. A p value of <0.05 was considered statistically significant.

RESULTS

Baseline characteristics of the patients are summarized in Table I. There was no significant difference in the fracture localization and side of injured extremity between the groups.

When the radiological measurements were evaluated, there was no statistically significant difference between the angulation and translations of both groups in the sagittal and coronal planes at the time of admission to the ED. When the

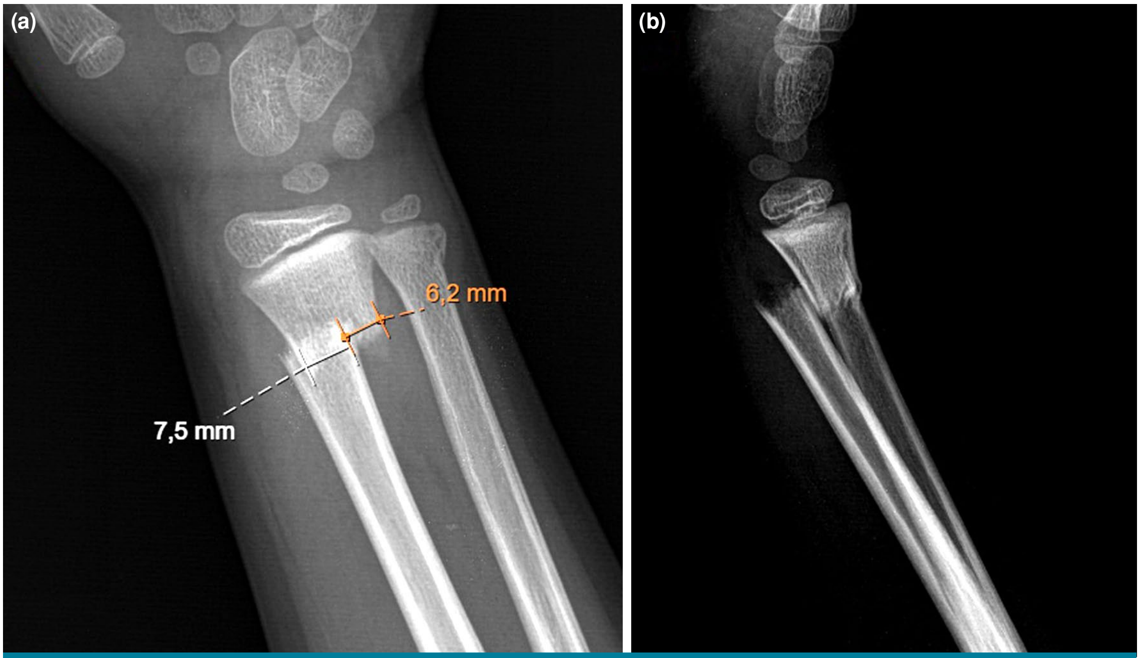

FIGURE 3. Measurement and calculation of the displacement. The percentage of the non-overlapping fracture line length in the total fracture line length was used to calculate the fracture displacement. **(a)** Example of the coronal displacement: 6.2/(6.2+7.5)×100= 45. **(b)** Example of the sagittal displacement: this fracture was considered to be 100% displaced in sagittal plane, because it has a bayonet apposition and there is no overlapping of the fracture line in the sagittal plane.

angulations, displacement percentages and Δ values were compared in post-reduction and at the first, second and fourth weeks, a statistically significant difference was found only in sagittal angulations in the first (LAC: 4.7; SSTS: 6.5; p=0.009) and second weeks (LAC: 5.3; SSTS: 6.8; p=0.024) (Table II). In the LAC group, seven patients had re-interventions (three manipulations, four surgeries) and in the SSTS group, and three patients had re-interventions (two manipulations, one surgery). There was no statistically significant difference between the two groups in terms of the need for re-interventions (p=0.657).

DISCUSSION

In the present study, we compared the results of SSTS as an immobilization method in pediatric distal forearm fractures. The main finding of this study is that SSTS has similar outcomes with LAC in terms of radiological results and the need for re-intervention in pediatric distal forearm fractures.[16] These fractures are quite common and mostly treated conservatively. Although loss of reduction and malunion is one of the most important risk factors, these complications are tolerated well owing to favorable remodeling capacity of children.[4-6,17] Despite this remodeling capacity, loss of reduction can put clinicians in a difficult position due to the concerns of the family in the follow-up process. Therefore, clinicians are willing to perform the immobilization method with the lowest complication rate.

In the current study, a statistically significant difference in the radiological measurements was found only in sagittal angulations in the first and second weeks. This difference disappeared in the following weeks and did not indicate a clinical relevance.

Successful results of STS in childhood forearm fractures have been published in recent years.[7,9,17-20] Denes et al.[19] published the results of 53 children with distal radius fractures with SSTS and reported that 51 cases were successfully treated. We also found successful results in immobilization with SSTS, and while Denes et al.[19] did not have a control group, in our study, cases immobilized with LAC were studied as the control group with a higher number of cases. Levy et al.[17] compared LAC (n=37) and DSTS (n=34) in pediatric distal forearm fractures in their prospective, randomized-controlled study, and they concluded that DSTS was at least as effective as LAC in the treatment of these injuries. Although the number of cases was higher in our study, the study of Levy et al.[17]

TABLE I
Baseline characteristics of the patients

	LAC group (n=112)					SSTS group (n=74)					Total (n=186)					
	n	%	Mean±SD	Median	Min-Max	n	%	Mean±SD	Median	Min-Max	n	%	Mean±SD	Median	Min-Max	*p*
Age (year)			10.1±2.9	10	4-15			10.5±3	10.5	4-15			10.3±3	10	4-15	0.339
Sex																0.501
Male	88	78.6				55	74.3				143	76.9				
Female	24	21.4				19	25.7				43	23.1				
Side																0.174
Right	49	43.8				25	33.8				74	39.8				
Left	63	56.3				49	66.2				112	60.2				
Fracture type																0.191
Physeal fracture	16	14.3				16	21.6				32	17.2				
Distal radius	58	51.8				41	55.4				99	53.2				
Distal forearm both bone	38	33.9				17	23				55	29.6				
Need for repeat intervention																0.657
No	105	93.8				71	95.9				176	94.6				
Manipulation	3	2.7				2	2.7				5	2.7				
Surgery	4	3.6				1	1.4				5	2.7				

LAC: Long arm cast; SSTS: Single sugar-tong splint; SD: Standard deviation.

TABLE II
Radiographic measurements

	LAC group (n=112)	SSTS group (n=74)	*p*
Sagittal angle (degree, mean)			
Initial	21.2	21.8	0.502
Postreduction	3.6	5.7	0.032
First week	4.7	6.5	**0.009**
Second week	5.3	6.8	**0.024**
Fourth week	5	6.2	0.121
Alteration (Δ)	1.5	0.7	0.770
Sagittal displacement (percentage, mean)			
Initial	45	40.5	0.568
Postreduction	7.6	7.1	0.751
First week	10.7	9.7	0.518
Second week	10.2	10.5	0.805
Fourth week	10.3	9.5	0.843
Alteration (Δ)	3	2.4	0.868
Coronal angle (degree, mean)			
Initial	8	7.9	0.802
Postreduction	1.6	2.2	0.125
First week	2.3	3.3	0.423
Second week	2.8	4.2	0.131
Fourth week	2.5	4.4	0.112
Alteration (Δ)	1.1	2.4	0.405
Coronal displacement (percentage, mean)			
Initial	18.6	18.2	0.505
Postreduction	7	8.2	0.286
First week	6.9	8.9	0.108
Second week	7.1	9	0.061
Fourth week	7	8.1	0.070
Alteration (Δ)	0.1	0.7	0.063

LAC: Long arm cast; SSTS: Single sugar-tong splint; Bold values indicate level of significance at $p<0.05$. Δ: Delta.

was prospective, randomized, and controlled. In addition, while Levy et al.[17] immobilized with DSTS, we showed that successful results could be obtained with a simpler immobilization method by SSTS. Acree et al.[20] compared the results of immobilization with SAC (n=48) and SSTS (n=25) for pediatric distal forearm fractures and found that both methods were equally effective in the initial follow-up. They reported that cast application immediately after reduction was more cost-effective than splint placement with later cast conversion. Although the number of cases in our study was higher than that of Acree et al.,[20] there was an additional cost analysis in their study. In addition, while Acree et al.[20] had an SAC in the cast groups, LAC was used in our study.

Murphy et al.[7] reported in a retrospective study comparing the results of SSTS (n=50) and LAC (n=50) in pediatric forearm fractures that there was no significant difference between the two groups in terms of angulation and the need for re-intervention. The aforementioned authors retrospectively studied the fixation results with SSTS (n=51) and LAC (n=70) in pediatric forearm fractures with a larger number of patients later and reported that both methods were acceptable and equivalent methods of immobilization for these injuries.[18] Dittmer et al.[9] published the results of 168 pediatric forearm fractures immobilized with STS and reported that STS was effective in maintaining the reduction of pediatric forearm fractures, similar to published rates for casting. Of note, relative to the study of Dittmer et al.,[9] there were more cases in our study and these authors did not have a control group. Moreover, the studies of Dittmer et al.[9] and Murphy et al.[7,18] consist of all forearm fractures, while the current study includes more specific and regionally homogeneous distal forearm fractures.

It may be argued that since LAC provides more rigid immobilization of the forearm and elbow movement than SSTS, LAC has better radiological outcomes. However, in the current study, we found comparable outcomes between two methods, whereas Webb et al.[13] published that even SAC provided adequate immobilization in these fractures. Moreover, the range of motion after LAC may be lower in the early-term as a disadvantage of the more rigid fixation. Since, in the current study, there are no data about clinical scores and range of motion, we are unable to investigate this argument. Further studies may clarify difference of functional outcomes and complications between two groups.

Clinicians worry about compartment syndrome, which may develop after fracture reductions immobilized with casts due to swelling of soft tissue.[10,11,21,22] To avoid this complication, splitting the cast is recommended.[11,21] Although splitting the cast is an effective method to accommodate swelling, it is time-consuming, causes stress reaction in children and is difficult both for the medical staff and patients, particularly with wet plaster casts, around joint creases and over bony prominences.[21-23] Additionally, saw-related injuries may occur.[11,12] The current study shows that SSTS effectively immobilizes pediatric distal forearm fractures. In this way, time-consuming and saw-related complications may be avoided. To the best of our knowledge, this study consists of the largest sample size that compares the results of pediatric distal forearm fractures immobilized with SSTS and LAC.

Nonetheless, the present study has several limitations. First, our study is retrospective and data were retrieved from medical records. To overcome this limitation, we included cases with complete and exact medical records. The second limitation is that radiological measurements depended on the quality of the radiographs. To minimize mistakes due to the quality of radiographs, radiographic measurements of the cases were measured by three researchers, and the average of the obtained values was used for analysis. In cases with a difference of more than 10% between the measurements, the values that were agreed upon after the face-to-face meetings between the researchers were analyzed. The third limitation is that although reductions and interventions were optimally standardized under the supervision of a senior orthopedist, interventions were performed by different clinicians.

In conclusion, SSTS and LAC are comparable in terms of radiological results and the need for re-intervention as an immobilization method for pediatric distal forearm fractures. Moreover, SSTS does not require splitting and prevents saw-related complications and loss of time.

Ethics Committee Approval: The study protocol was approved by the Ege University Faculty of Medicine Medical Research Ethics Committee (date: 28.05.2020, no: 20-5.1T/43). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Design, analysis, writing the article: A.E.D.; Idea, design, data collection: A.V.; Idea, data collection, literature review: O.A.; Data collection, literature review: B.K.; Supervision, critical review: L.K.; Design, supervision: E.C.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The authors received no financial support for the research and/or authorship of this article.

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