Doi: 10.4274/jus.galenos.2023.2023.0005
J Urol Surg 2024;11(1):1-6

Factors Affecting Stone-freeness in the Initial Session of RIRS in Childhood Kidney Stones

Onur Kaygısız, Yavuz Mert Aydın, Levent Turan, Burhan Coşkun

Bursa Uludağ University Faculty of Medicine, Department of Urology, Bursa, Turkiye

What's known on the subject? and What does the study add?

The Stone-Kidney index was described as a straightforward method for predicting the success of pediatric percutaneous nephrolithotomy. In this study, we examined the Stone-Kidney index in pediatric retrograde intrarenal surgery for the first time to the best of our knowledge. The identified threshold value for a successful outcome was 1.96.

Abstract

Objective: To determine, the factors affecting stone-freeness in children after one session of retrograde intrarenal surgery (RIRS).

Materials and Methods: The data of 102 children who applied RIRS in our clinic between February 2012-January 2022 were retrospectively evaluated. Eleven children were excluded. Ninety-one children were divided into two groups according to stone-free status in the first session. Factors affecting stone freeness were analyzed with univariate and multivariate analyses. The stone-kidney index was calculated using the stone size/kidney long muscle formula, and receiver operating characteristic (ROC) analysis was performed to determine the cut-off point of the presence of residue stone.

Results: Forty-seven (51.6%) children were girls. The median age, stone size, and stone-kidney index were 7 (1-17), 11 mm (4-30), and 1.4 (0.24-3.6), respectively. Stone-free status was achieved in 74 patients (group 1) and residual stones were present in 17 patients (group 2). There was a significant difference between the two groups in terms of stone localization, stone size, stone-kidney index, power of the laser device, and operation time. According to multivariate analysis, multiple calyces' stones [p=0.015, odds ratio (OR): 6.37] and stone size ≥2 cm (p=0.006, OR: 16.96) were factors that predicted residual stones. ROC analysis showed that the stone-kidney index at values above 1.96 was significantly associated with an increased risk of residual stone.

Conclusion: Stone size ≥2 cm, and multiple calyx stones were risk factors for residual stones after one session of RIRS in children. Stone-kidney index values higher than 1.96 are associated with lower stone-free rates.

Keywords: RIRS, laser lithotripsy, pediatric kidney stone, stone-freeness

Introduction

The more frequent recurrence rate of stone disease in children and the differences in anatomical features from adults make stone treatment more challenging in pediatric patients (1). For this reason, the recommendations for treating kidney stones are different between children and adults in the guidelines. In the European Association of Urology/European Society for Pediatric Urology (EAU/ESPU) guidelines, shock wave lithotripsy (SWL) is recommended as the first-line treatment for stones smaller than 2 cm, except including the lower pole (2). However, SWL has limitations such as high retreatment rates, requiring anesthesia in each session, and decreased success in hard and multiple stones (2-4). In the adult guidelines, retrograde intrarenal surgery (RIRS) is recommended as the first-line treatment for stones smaller than 2 cm; however, pediatric RIRS is not recommended for this type of stone due to the lack of data in the literature (5). On the other hand, laser lithotripsy applied with

Correspondence: Onur Kaygısız MD, Bursa Uludağ University Faculty of Medicine, Department of Urology, Bursa, Turkiye
Phone: +90 224 295 30 21 **E-mail:** onurkygsz@yahoo.com **ORCID-ID:** orcid.org/0000-0002-9790-7295
Received: 12.01.2023 **Accepted:** 09.03.2023

Cite this article as: Kaygısız O, Aydın YM, Turan L, Coşkun B. Factors Affecting Stone-freeness in the Initial Session of RIRS in Childhood Kidney Stones. J Urol Surg 2024;11(1):1-6.

RIRS is used in children with high efficacy and low complication rates (3,6-9). There is still a conflict about this issue. For this reason, we shared our 10-year single-center pediatric RIRS data and to determine the factors affecting stone-free (SF) status in a single session in this study.

Materials and Methods

Study Population and Design

The data of 102 pediatric patients who underwent RIRS between February 2012 and January 2022 were retrospectively evaluated. Eleven patients with renal anomaly (n=7), skeletal deformity (n=2), and SF status that could not be evaluated due to nephrocalcinosis (n=2) were excluded from the study. A total of 91 patients (47 girls and 44 boys) were included in the study. Children whose SF status was achieved after the first session of RIRS were defined as group 1, and those with residual stones as group 2 (Figure 1).

SF status was defined as the absence of stone fragments larger than 2 mm in urinary ultrasonography and X-ray of the kidney at postoperative third-month follow-up without additional treatment. The stone-kidney index was calculated using the "the stone longest axis/kidney longest length" formula (10). The complications were recorded according to The Clavien-Dindo classification for the postoperative period and the Satava system for the perioperative period (11,12).

RIRS Procedure

Sterile urine culture was observed in all patients before surgery. Ceftriaxone prophylaxis was administered to each patient during the induction of general anesthesia. The procedure was performed in the lithotomy position, and a sensor guide (Boston Scientific nitinol guidewire with hydrophilic) and safety catheter were inserted into the renal pelvis via 6.0 F semirigid ureterorenoscope (R. Wolf™ Germany). 7.5 F Flex X2 (Flex-X2, Karl Storz, Tuttlingen, Germany) flexible ureterorenoscope (FURS) was placed in the kidney through the sensor guide. In cases where FURS did not pass through the distal ureter, active dilatation was not applied, and pre-stenting was preferred. 273 nm Ho-YAG laser probe was used. Laser device settings were 0.8-1.5 Joule (J) pulse energy, 8-15 Hertz (Hz) pulse rate on the 30-W laser system, and 0.6-0.8-J pulse energy, 8-12 Hz pulse rate on the 15-W laser system. An angiocath catheter was placed supra-pubically to drain the urine accumulated in the bladder. Before ending the process, a JJ stent was placed in all the patients. In cases where SF status was achieved, a string JJ stent was placed to prevent re-anesthetizing.

The Clinical Research Ethics Committee of the Bursa Uludağ University approved the study (approval number: 2022-20/26, date: 20.12.2022).

Statistical Analysis

Statistical analysis was performed using SPSS software (IBM Corp. IBM SPSS Statistics for Windows, version 28.0, Armonk, NY: IBM Corp.) The Shapiro-Wilk test was used to test the normality of variables. Variables that were not normally distributed have been presented as a median (minimum-maximum) and were compared using the Mann-Whitney U test. Nominal data have been presented as numbers and percentages and compared with chi-square and Fisher's Exact tests. $P<0.05$ was considered significant. Logistic regression analysis was performed to determine the factors affecting stone-freeness. Receiver operator characteristics curve (ROC) analysis was performed to determine the cut-off point of the stone-kidney index measurement to predict the presence of residue.

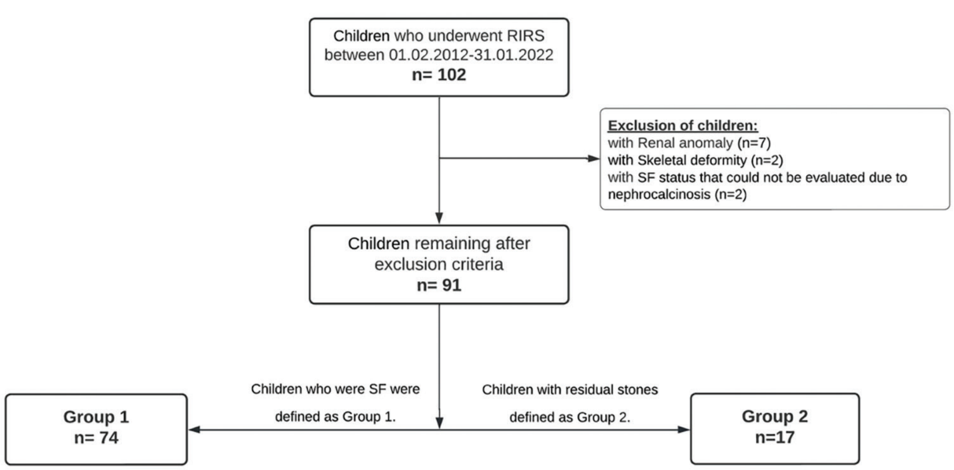

Figure 1. Study design chart

RIRS: Retrograde intrarenal surgery, SF: Stone free

Results

The median age and body mass index were 7 (1-17) years and 16.5 (11.5-39.2) kg/m², respectively. The median follow-up time was 24 (1-132) months. The mean size of the lower pole stone was 10.3 mm, and the standard deviation was 5.4 mm. The SF rate after initial RIRS was 81.3% (74 children). Fourteen of 17 children with residual stones received additional SWL or RIRS treatment, whereas three children had asymptomatic stones, and follow-up was recommended.

SF status was achieved in 74 children (group 1), and 17 had residual stones after one session of RIRS (group 2). No significant differences were found between the groups regarding age, gender, side, stone density, JJ insertion before RIRS, and fluoroscopy time (Table 1). The median stone size [17.1 versus (vs.) 10.5 mm], stone-kidney index (2.08 vs. 1.25), and operation time (85 vs. 50 minutes) were significantly higher in group 2 than in group 1 (p<0.001, 0.001, <0.001, respectively). All children with stones in multiple localizations, except one, included the lower pole. The success rate was 89% for non-lower pole single calyx stones, 88.8% for lower pole stones, and 50% for multiple calyces. Group 1 had a higher rate of 30W laser device use (p=0.048) (Table 1).

In the multivariate analysis, multiple calyces (6.37 times higher than single calyx, p=0.015) and stone size equal to or larger than 2 cm (16.96 times higher than stones smaller than 1 cm, p=0.006) were significant independent predictors of residual stone after one session RIRS. Data on multivariate analysis are given in Table 2. ROC analysis showed that the stone-kidney index at values above 1.96 was significantly associated with an increased risk of residual stone (area under the curve: 0.75 and sensitivity 52.94%, specificity 87.84%, p<0.001) (Figure 2).

In the perioperative period, contrast extra-lumination was observed in retrograde pyelography in two children aged 2 and 5 years. JJ stent was placed in a five-year-old child, and the urethral stent was removed on the first postoperative day, no extrarenal fluid was observed at an ultrasound examination, and the child was discharged. (Satava 2a complication). In the other child, laparotomy was required due to abdominal distension during the operation, and the fluid in the abdomen was drained (Satava 3 complication). A drain was placed at the end of the laparotomy and removed on the first postoperative day. The child's urethral catheter was removed on the third postoperative day, and the child was discharged with recovery. The urinary tract infection

Table 1. Factors affecting stone-freeness in the initial RIRS

		Group 1 (n=74)	Group 2 (n=17)	p
Age		7 (1-17)	9 (2-16)	0.430
Gender (girl)		41 (55.4%)	6 (35.3%)	0.180
Side (right)		31 (41.9%)	8 (47.1%)	0.790
Stone location	Single calyx (except lower calyx) Lower calyx Multiple calyces (with lower calyx)	49 (89.1%) 16 (88.9%) 9 (50%)	6 (10.9%) 2 (11.1%) 9 (50%)	**<0.001**
Multiple stones		34.2%	58.8%	0.096
Stone size (mm, min-max)		10.5 (8-135)	17.1 (7-30)	**<0.001**
Stone size	<10 mm	26 (92.9%)	2 (7.1%)	**<0.001**
	≥10 mm, <20 mm	43 (86.0%)	7 (14%)	
	≥20 mm	5 (38.5%)	8 (61.5%)	
Stone density (HU, min-max)		908 (340-1668)	862 (378-1786)	0.863
Stone-kidney index (min-max)		1.25 (0.2-3.6)	2.08 (0.7-3.5)	**0.001**
JJ insertion before RIRS (available/none)		41/33	9/8	1
Laser power 15/30 W-30 W Rate		20/54 69%/87.1%	9/8 31%/12.9%	**0.048**
Operation time (minutes)		50 (8-135)	85 (30-120)	**<0.001**
Fluoroscopy time (seconds)		35.05±28.34	63.8±47.1	0.052
Complication Clavien 2: Urinary tract infection Satava 2a: Fornix rupture Satava 3: Fornix rupture causing abdominal distension		7 (9.5%) 6 (8.1%) 1 (1.4%) None	2 (11.8%) 1 (5.9%) None 1 (5.9%)	0.673

mm: Millimeter, min: Minimum, max: Maximum, HU: Hounsfield unit, W: Watt, RIRS: Retrograde intrarenal surgery

Table 2. Multivariate analysis of factors affecting stone-freeness							
		RC	**p**	**OR**	**Lower 95% CI**	**Upper 95% CI**
Age (years)			0.365	1.07	0.92	1.25
Laser power 15W		30 W	0.067	3.71	0.91	15.09
Stone location	Lower calyx	Single calyx	0.877	1.16	0.17	7.79
	Multiple calyces		0.015	6.37	1.44	**28.19**
Stone size (cm)	≥1 cm, <2 cm	<1 cm	0.402	2.14	0.36	12.75
	≥2 cm		0.006	16.96	2.25	**128.07**

Hosmer and Lemeshow test: p=0.577, Logistic regression model significance: p<0.001, RC: Reference category, cm: Centimeter, W: Watt, OR: Odds ratio, CI: Confidence interval

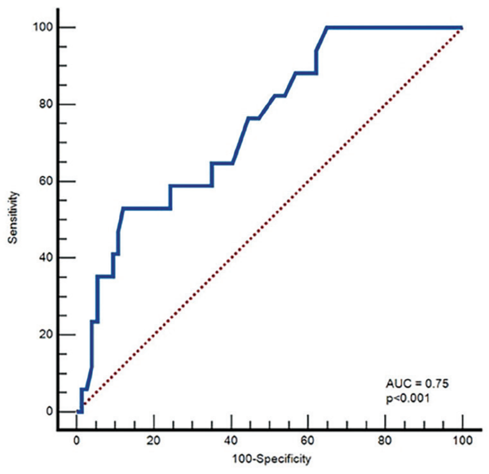

Figure 2. ROC analysis for stone-kidney index

AUC: Area under the curve, ROC: Receiver operating characteristic

(Clavien 2 complication) rate is 6 (8.1%) and one (5.9%) child in group 1 and group 2, respectively. While 5 of them received oral antibiotic treatment, 2 of them required intravenous antibiotic treatment.

Discussion

This study showed that larger stone size and multiple stone localization were related to residual stones after one session of RIRS. Additionally, the operation time was longer in children with residual stones. The children with residual stones had larger stones, including multiple calyces, so prolonged operation time could be a predicted finding. The fluoroscopy time was insignificantly higher in children with residual stones, according to children with SF status.

The current study demonstrated that stone size and localization were risk factors for residual stones after RIRS. In the current study, 19 of 20 children with multiple localization stones included the lower pole. Xiao et al. (13) showed that stone size and the presence of staghorn stones were related to the SF rate in the multivariate analysis. Moreover, in a multicenter study based on pediatric patients, stone size and multiple stones were shown to be risk factors for residual stones (14). Similar to the aforementioned study, the success of RIRS decreased in multiple calyxe stones containing the lower pole and ≥2 cm stones in our study.

The treatment of lower pole stones is more complex than other localizations in adults and children (2,15). EAU/ESPU 2022 guidelines recommend percutaneous nephrolithotomy (PNL) as the first-line treatment for lower pole stones in children (2). Stone size, presence of a lower pole, and multiple stones were found to be significant predictors of residual stone on multivariant analysis in a study including adult patients, 20% of whom were pediatric patients (16). In our study, the success rate of single non-lower pole calyx and lower pole calyx stones was similar, with 89.0% and 88.8%. Kahraman et al. (17) reported that stone localization did not affect the SF rate and suggested that it was due to the improved deflection abilities of flexible ureterorenoscopes. The high success rate of these stones may be due to the displacement of a single lower calyx stone with a small size to the appropriate position with a basket catheter. Also, the decrease in the success rate in larger stones in multiple localization, including the lower pole where a basket catheter cannot be used, supported our mentioned opinion.

Çitamak et al. (10) suggested that the stone-kidney index has a predictive value on the success of PNL. The authors reported that a stone-kidney index greater than 2.95 predicted the risk of residual stones (10). The current study showed that the stone-kidney index in the residual stone group was significantly higher than that in the SF group (2.08 vs. 1.25, p<0.001). Additionally, in our study, it was found that a stone-kidney index greater than 1.96 increases the risk of residual stones with a specificity of 87.84%. According to Çitamak et al.'s (10) results, our cut-off value seems lower; it may be due to the fact that our study is focused on RIRS. The failure of RIRS in stones larger than 2 cm in our study mainly explains the difference between the cut-off values that PNL was recommended as the first choice in these stones. To the best of our knowledge, this is the first study that evaluates the stone kidney index for pediatric RIRS cases in predicting residual stone risk.

In this study, we found that the SF rate was significantly higher at a 30W power laser device (87.1) than 15W power laser device (69%). However, we found that using 15W laser power did not predict the risk of residual stones in multivariate analysis. It has been shown that high laser-powered devices have the advantage of short operation time, but it does not significantly contribute to the single-session SF rate (18).

The success rates of the initial RIRS have been reported to be 50 to 100%. Consistent with the literature, we found the success of the initial RIRS to be 81.3% and 96.7% after additional treatment (RIRS and SWL). Tanaka et al. (19) reported a retreatment rate of 37% for 6-10 mm kidney stones and 71% for over 10 mm kidney stones. These retreatment rates were higher than that in our study. The mentioned study was one of the first studies on pediatric RIRS. Therefore, the difference might be due to the development of surgical skills and technological progress.

A systematic review reported the complication rate as 10.5% (6). Similarly, our complication rate was 9.9% (7.7% Clavien 2, 1.1% Satava 2a and 1.1% Satava 3). Fornix rupture occurred in 2 children in our study. While one of these children was managed with JJ insertion (Satava 2a), the other child developed abdominal distension caused fluid leakage that required laparotomy (Satava 3). It has been shown that complications are more common in children under five years of age when performing RIRS in pediatric patients (14). In our series, children who developed fornix rupture were under five years old. Because of these findings, it can be said that RIRS is preferable in treating kidney stones in children with acceptable success and complication rates. However, considering the higher incidence of complications in young patients.

Study Limitations

This study had some limitations. Although the retrospective design is a limitation, patient data were kept prospectively in the datasheet in this study, minimizing the data loss. The absence of stone analysis is another limitation. However, the density of stones to predict stone hardness was measured from computed tomography. The large sample size was the strength of our study.

Conclusion

RIRS is a minimally invasive surgical modality that can treat kidney stones with high success and low complication rates in children. The large stone size and multiple calyx stones are associated with lower SF rates after one session RIRS. The stone kidney index, with a threshold value of 1.96, can be used as an easy method for SF estimation after the first RIRS session.

Acknowledgments

We would like to thank Prof. Gökhan Ocakoğlu for his statistical support in this study.

Ethics

Ethics Committee Approval: The Clinical Research Ethics Committee of the Bursa Uludağ University approved the study (approval number: 2022-20/26, date: 20.12.2022). The study protocol is in accordance with the international agreements from the Declaration of Helsinki.

Informed Consent: The Clinical Research Ethics Committee of the Bursa Uludağ University waived informed consent due to the retrospective nature of the study.

Authorship Contributions

Surgical and Medical Practices: O.K., Concept: O.K., B.C., Design: O.K., Data Collection or Processing: O.K., L.T., Analysis or Interpretation: O.K., Y.M.A., Literature Search: O.K., B.C., Y.M.A., L.T., Writing: O.K., B.C., Y.M.A., L.T.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Li Y, Bayne D, Wiener S, Ahn J, Stoller M, Chi T. Stone formation in patients less than 20 years of age is associated with higher rates of stone recurrence: Results from the Registry for Stones of the Kidney and Ureter (ReSKU). J Pediatr Urol 2020;16:373.e1-373.e6.
2. Radmayr C, Bogaert G, Burgu B, Dogan HS, Nijman JM, Quaedackers J, Rawashdeh YFH, Silay MS, Stein R, Tekgül S. Guidelines Associates: Bhatt N, L.A. 't Hoen, A. Zachou Guidelines Office: J.A. Darraugh EAU Guidelines on Paediatric Urology 2022; ISBN 978-94-92671-16-5.
3. He Q, Xiao K, Chen Y, Liao B, Li H, Wang K. Which is the best treatment of pediatric upper urinary tract stones among extracorporeal shockwave lithotripsy, percutaneous nephrolithotomy and retrograde intrarenal surgery: a systematic review. BMC Urol 2019;19:98.
4. Kartal İ, Altan M, Çıtamak B, Mammadov E, Bozacı AC, Tekgül S. Factors Influencing the Success of Shock Wave Lithotripsy Treatment for Urinary System Stone Disease in Children Aged 0-2. J Urol Surg 2021;8:162-166.
5. Quiroz Y, Somani BK, Tanidir Y, Tekgul S, Silay S, Castellani D, Lim EJ, Fong KY, Garcia E, Corrales M, Hameed BMZ, Llorens E, Teoh JY, Dogan HS, Traxer O, Bujons Tur A, Gauhar V. Retrograde Intrarenal Surgery in Children: Evolution, Current Status, and Future Trends. J Endourol 2022;36:1511-1521.
6. Ishii H, Griffin S, Somani BK. Ureteroscopy for stone disease in the paediatric population: A systematic review. BJU Int 2015;115:867-873.
7. Fried NM. Recent advances in infrared laser lithotripsy [Invited]. Biomed Opt Express 2018;9:4552-4568.

8. Li J, Yu H, Zhou P, Pan H, Li R, Wang Y, Song C, Lou Y, Zhu J. Application of flexible ureteroscopy combined with holmium laser lithotripsy and their therapeutic efficacy in the treatment of upper urinary stones in children and infants. Urol J 2019;16:343-346.

9. Mokhless IA, Abdeldaeim HM, Saad A, Zahran AR. Retrograde intrarenal surgery monotherapy versus shock wave lithotripsy for stones 10 to 20 mm in preschool children: a prospective, randomized study. J Urol 2014;191(5 Suppl):1496-1499.

10. Çitamak B, Dogan HS, Ceylan T, Hazir B, Bilen CY, Sahin A, Tekgül S. A new simple scoring system for prediction of success and complication rates in pediatric percutaneous nephrolithotomy: stone-kidney size score. J Pediatr Urol 2019;15:67.e1-67.e6.

11. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004;240:205-213.

12. Satava RM. Identification and reduction of surgical error using simulation. Minim Invasive Ther Allied Technol 2005;14:257-261.

13. Xiao J, Wang X, Li J, Wang M, Han T, Zhang C, Du Y, Hao G, Tian Y. Treatment of upper urinary tract stones with flexible ureteroscopy in children. Can Urol Assoc J 2019;13:E78-E82.

14. Lim EJ, Traxer O, Madarriaga YQ, Castellani D, Fong KY, Chan VW, Tur AB, Pietropaolo A, Ragoori D, Shrestha A, Vaddi CM, Bhatia TP, Mani M, Juliebø-Jones P, Griffin S, García Rojo E, Corrales M, Sekerci CA, Tanidir Y, Teoh JY, Gauhar V, Somani BK. Outcomes and lessons learnt from practice of retrograde intrarenal surgery (RIRS) in a paediatric setting of various age groups: a global study across 8 centres. World J Urol 2022;40:1223-1229.

15. Tsai SH, Chung HJ, Tseng PT, Wu YC, Tu YK, Hsu CW, Lei WT. Comparison of the efficacy and safety of shockwave lithotripsy, retrograde intrarenal surgery, percutaneous nephrolithotomy, and minimally invasive percutaneous nephrolithotomy for lower-pole renal stones: A systematic review and network meta-analysis. Medicine (Baltimore) 2020;99:e19403.

16. Ozkent MS, Piskin MM, Balasar M, Goger YE, Sonmez MG. Is Retrograde Intrarenal Surgery as Safe for Children as It Is for Adults? Urol Int 2021;105:1039-1045.

17. Kahraman O, Dogan HS, Asci A, Asi T, Haberal HB, Tekgul S. Factors associated with the stone-free status after retrograde intrarenal surgery in children. Int J Clin Pract 2021;75:e14667.

18. Kaygısız O, Aydın YM, Çiçek MÇ, Çelen S, Coşkun B, Kılıçarslan H. 15 and 30 W Holmium:YAG Laser Lithotriptor in Ureteroscopic Lithotripsy: Which One Is More Effective and Safe? J Laparoendosc Adv Surg Tech A 2021;31:839-842.

19. Tanaka ST, Makari JH, Pope JC 4th, Adams MC, Brock JW, Thomas JC. Pediatric ureteroscopic management of intrarenal calculi. J Urol 2008;180:2150-2153; discussion 2153-2154.