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COMPARISON OF NITINOL TIPLESS STONE BASKETS IN AN IN VITRO CALICEAL MODEL

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ABSTRACT

Purpose: Tipless stone baskets facilitate caliceal calculi extraction during flexible ureteroscopy. We evaluated the stone capture rate of 9 commercially available tipless stone baskets in an in vitro model using novice and expert operators.

Materials and Methods: The Microvasive Zerotip (2.4Fr, 3.0Fr), Cook N-Circle (2.2Fr, 3.0Fr, 3.2Fr), Bard Dimension (3.0Fr, Sacred Heart Medical Halo (1.9Fr), Vantage (1.9Fr) and Circon-ACMI Sur-Catch-NT (3.0Fr) were tested by 3 novice and 3 experienced basket operators. Each operator performed stone extraction of 2, 5 and 8 mm calculi (size determined by digital caliper with 3 repetitions of each basket. The time to extraction of the calculus from a convex based test tube caliceal model was recorded. Statistical analysis was performed using repeated measures ANOVA and Fisher's pairwise comparisons.

Results: After a learning curve of 27 basket retrievals, there was no significant difference in stone capture times between novice (38 ± 54 seconds) and expert operators (32 ± 49 seconds, $p = 0.174$). For total stone capture (all sizes) the Sacred Heart Halo resulted in the most rapid stone extraction (17 ± 14 seconds) by novices and experts, while the Sur-Catch NT resulted in the slowest stone extraction (78 ± 90, seconds, $p = 0.001$). The Halo (14 ± 9 seconds) and Vantage (19 ± 12 seconds) baskets were significantly faster for 2 mm calculi than the N-Circle (73 ± 60 seconds, $p = 0.006$), Sur-Catch (169 ± 85 seconds, $p = 0.0005$) and Dimension (73 ± 70 seconds, $p = 0.017$). The Zerotip functioned well for 2 mm calculi in the hands of expert operators (15 ± 9 seconds) but not novice operators (94 ± 95 seconds). The Sur-Catch NT was significantly slower for 2 mm calculi than the N-Circle ($p = 0.01$), Dimension ($p = .03$), Halo ($p = .0005$), Vantage ($p = .001$) and Zerotip ($p = .002$). For 5 mm calculi the Halo was superior (12 ± 8 seconds), while the Zerotip were superior for 8 mm calculi (8 ± 3 seconds) compared to the N-Circle (23 ± 28 seconds, $p = 0.026$), Halo (26 ± 18 seconds, $p = 0.021$) and Vantage (23 ± 15 seconds, $p = 0.006$).

Conclusions: The Sacred Heart Halo and Vantage baskets resulted in the most expeditious stone extraction, especially for 2 to 5 mm calculi while the Microvasive Zerotip was optimal for 8 mm calculi. The Sur-Catch NT had the slowest stone capture rate for all stone sizes. Caliceal models of stone basketing may be useful to train novice urology residents and nursing assistants.

KEY WORDS: kidney calculi, ureteroscopy, instrumentation

In recent years several new materials and designs have been introduced in the development of stone baskets. With many options available it is often difficult to determine the best basket for a stone of a particular size and location. Of the few studies that have considered the efficacy of different baskets, most have compared the broadest categories of basket design (ie grasper vs flat wire vs helical basket). We performed a focused comparison of tipless stone baskets, comparing stone extraction time for 9 of the most commonly used stone baskets in an easily reproducible in vitro caliceal model. Additionally, our experiments were conducted with novice and expert users to assess whether a particular basket design was more efficacious for a given skill level.

MATERIALS AND METHODS

Nine different nitinol tipless stone baskets were tested (see table and fig. 1). The caliceal model consisted of a 7 cm length of 10 mm diameter plastic tubing with a convex base filled with 5 ml normal saline and either a 2, 5 or 8 mm smooth pure calcium phosphate feline urolith (fig. 2). In this study feline uroliths were selected due to access to multiple spherical calculi of uniform size. During experimental basket retrievals evaluators operated the 6/7.5Fr Wolf rigid ureteroscope (Richard Wolf Medical Instruments Corp., Vernon Hills, Illinois) and the stone basket simultaneously. A rigid ureteroscope was used so that 1 evaluator could operate the basket and the ureteroscope simultaneously. Were a flexible ureteroscope used, time to stone extraction would depend on the expertise of the ureteroscopist as well as the basket operator. The length of the stone removal procedure was measured with a stopwatch from the moment of ureteroscope insertion into saline until successful removal of the stone from the model. The inability to remove a stone after 4 minutes was considered a failure and time was stopped.

Experimental trials were performed by 3 novices who had never used a stone basket and 3 experts with extensive basketing experience. Three separate trials were performed for each combination of user, stone size and basket type. During experimentation with a given stone size, baskets were drawn at random for each evaluator to minimize bias due to experience with the testing model. Data were evaluated by statistical analysis using 1-way repeated measures ANOVA with Fisher's post-hoc comparisons.

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Description of tested stone baskets

Basket/Manufacturer	Sheath Diameter	Basket Size (mm)	Wire Material	Basket Design (No. wires)
ACMI Sur-Catch Tipless (Stamford, Connecticut)	3.0	16	Round nitinol	Crossed paired wires (6)
Microvasive Zerotip (Natick, Massachusetts)	2.4, 3.0	12, 16	Round nitinol	Open wires (4)
Cook N-Circle (Spencer, Indiana)	2.2, 3.0, 3.2	10	Round nitinol	Open wires (4)
Bard Dimension (Covington, Georgia)	3.0	16	Round nitinol	Open wires (4)
Sacred Heart Halo (Minnetonka, Minnesota)	1.9	9	7-Strand nitinol	Open wires (4)
Sacred Heart Vantage (Minnetonka, Minnesota)	2.4	9	7-Strand nitinol	Open wires (4)

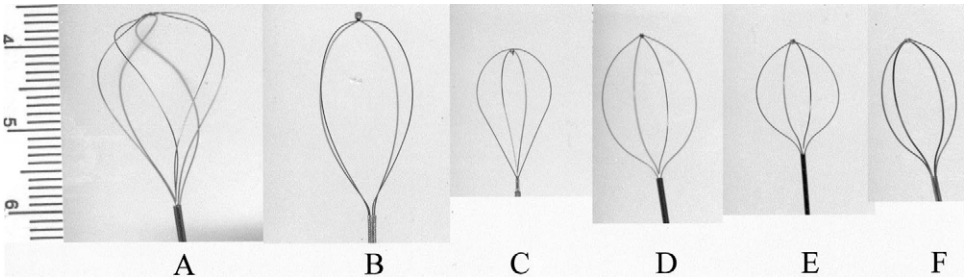

FIG. 1. Tipless stone baskets tested in study. *A*, ACMI Sur-Catch. *B*, Bard Dimension. *C*, Cook N-Circle 2.2Fr. *D*, Microvasive Zerotip 2.4Fr. *E*, Sacred Heart Halo. *F*, Sacred Heart Vantage. Scale in cm.

RESULTS

Results are summarized for each basket and user group for all stone sizes (fig. 3), and 2 mm (fig. 4), 5 mm (fig. 5) and 8 mm (fig. 6) calculi. Comparison of combined times for all baskets from the novice and expert groups yielded no significant differences for the 2 and 5 mm stones ($p = 0.49$). Initial comparison of the combined 8 mm data between groups indicated a significant difference ($p = 0.003$). As evaluations of the 8 mm stone were the first study conducted, a learning curve effect was suspected and therefore, these trials were repeated yielding no significant difference for the 8 mm stone ($p = 0.66$).

For the 2 mm stone the Sacred Heart Halo and Vantage had the fastest average times (0:14 ± 0:09 and 0:19 ± 0:12 minutes, $p = 0.017$), while the ACMI Sur-Catch was the slowest (2:49 ± 1:24 minutes, $p = 0.031$). Additionally, for the 2 mm stone the Zerotip 2.4Fr (0:15 ± 0:13 minutes) and 3.0Fr (0:15 ± 0.09 minutes) baskets were significantly faster in the expert group compared to the novice group (2.4Fr 1:20 ± 1:14 minutes and 3.0Fr 1:34 ± 1:35 minutes, $p = 0.038$).

For the 5 mm stone the fastest baskets were the Halo (0:12 ± 0:08 minutes), Vantage (0:15 ± 0:13 minutes) and N-Circle 3.0Fr (0:18 ± 0:13 minutes), while the slowest basket was the Zerotip 2.4Fr (0:48 ± 0:13 minutes). However, because of the small distribution of times, statistical analysis was nonconclusive. For the 8 mm stone the Zerotip 2.4Fr and 3.0Fr had the fastest average times (0:08 ± 0:03 minutes and 0:11 ± 0:06 minutes, $p = 0.05$) while the Sur-Catch was the slowest (0:27 ± 0:44 minutes, $p = 0.038$).

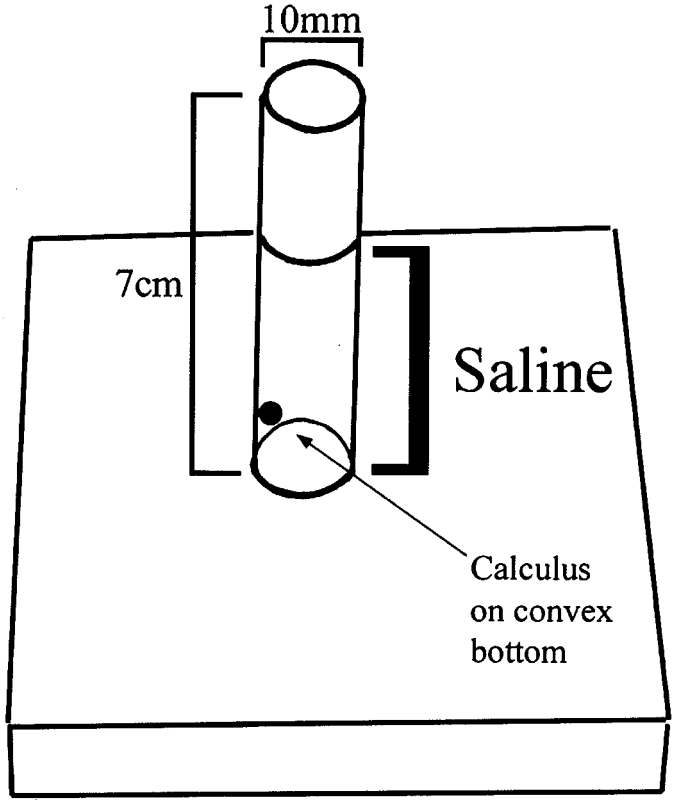

FIG. 2. In vitro caliceal model

DISCUSSION

Despite the widespread use of ureterorenoscopy with concomitant basket retrieval of urinary tract stones, little research has been done to compare the efficacy of different stone baskets. El-Gabry and Bagley compared 5 stone baskets of differing configurations and tested whether a given basket could retrieve a metal bead from a caliceal model but did not compare the time to extraction for different baskets.[1] Ptashnyk et al studied 7 stone extraction devices including 4

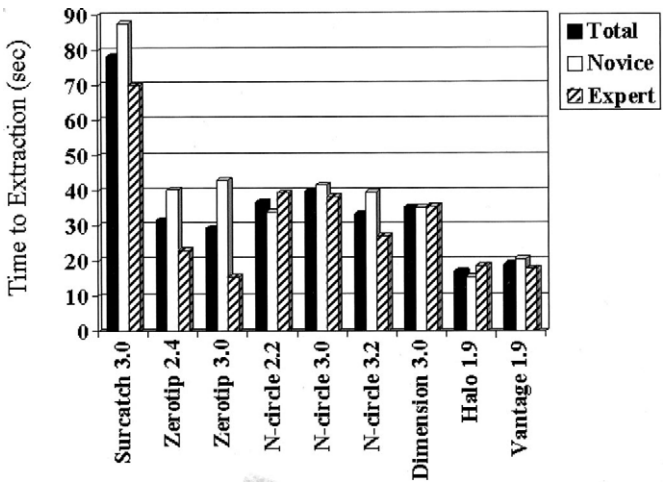

FIG. 3. Total stone capture (all sizes)

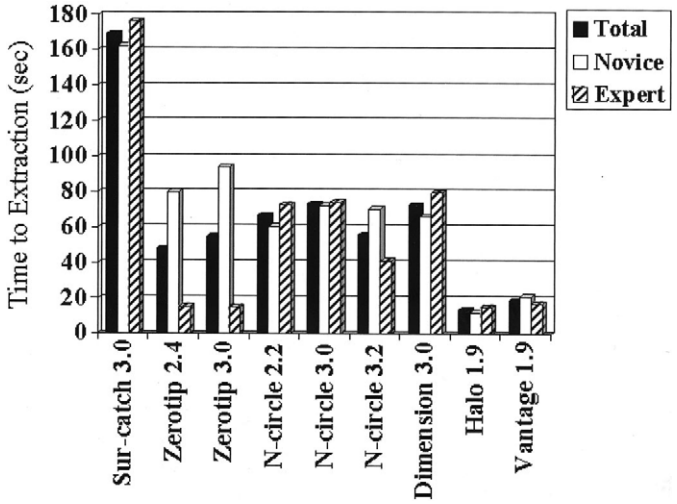

FIG. 4. 2 Mm stone capture

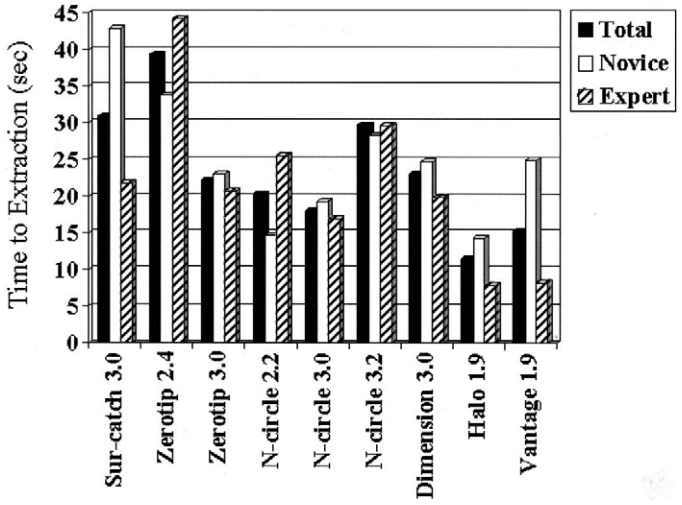

FIG. 5. 5 Mm stone capture

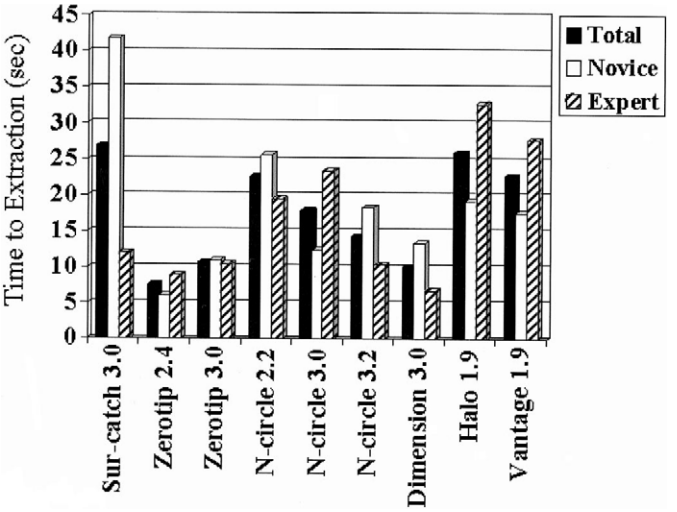

FIG. 6. 8 Mm stone capture

basket designs in an ex vivo model.[2] However, they only compared different design types and attempted no statistical analysis to validate findings.

In our study we limited our analysis to the stone extraction time of 9 nitinol tipless stone baskets using a simple in vitro caliceal model. Honey has demonstrated that tipless stone baskets are superior for caliceal stone extraction as extraction times are faster and risk of urothelial damage is less compared to other basket designs.[3] This finding has been supported by Chenven and Bagley who further found articulating nitinol baskets to have the best release characteristics.[4] By comparing baskets with a large number of users with different experience and using statistical analysis, we attempted to more precisely determine differences in efficiency of caliceal stone extraction. Additionally, because we have 2 groups of users, those with and without experience, we attempted to determine whether a certain basket would benefit the inexperienced user such as a novice urology resident or operating room nurse.

Our data suggest that for smaller stone sizes (2 and 5 mm) the Sacred Heart Halo and Vantage appear to have the best retrieval characteristics. This finding was consistent between user groups and supported by statistical analysis. This difference may be related to braided nitinol wire construction of these baskets which allow for more deformability in the caliceal model in addition to the small basket size. The Microvasive Zerotip baskets achieved similar results exclusively in the expert group, suggesting that this basket be reserved only for more experienced urologists. For the 2 mm stone the ACMI Sur-Catch was significantly slower than all other designs. This finding may be due to the complex 6-wire design of this basket which may complicate entry of the stone into the basket. For the 8 mm stone size the Microvasive Zerotip baskets along with the Bard Dimension yielded the best results, while the Sacred Heart Halo and Vantage along with the ACMI Sur-Catch were the slowest. These results are likely related to basket size, as the Zerotip and Dimension baskets are larger while the Halo and Vantage are smaller. Again, it is suspected that the complex 6-wire design inhibited stone entry for the Sur-Catch.

An unexpected result in our study was the overall similarity between the novice and expert users. The only overall difference between the groups was found after the initial 8 mm trials and this difference was not present when these trials were later repeated for the novice group. These data suggest that a fast learning curve was developed and that the novice group gained significant proficiency after only 27 trials at stone extraction. Therefore, practice with a similar caliceal model may be of benefit for novice nursing assistants and residents before they assist in the operating room with endourological stone extraction.

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