

Pediatric Kidney Transplant Surgical Instrument Development

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Overview

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Problem Statement

Client: Dr. Kelly Collins and Dr. Jennifer Phillips, UW Health surgeons

Problem: Pediatric kidney transplant surgeries can be challenging because many surgical instruments are designed for adult patients. These instruments may be too large for pediatric patients and may not provide the appropriate amount of clamping force for smaller blood vessels.

Goal: Develop a vascular clamp specifically designed for pediatric kidney transplant surgeries & reduce the risk of vessel damage caused by inappropriate instrument size or excessive clamping force

How: Creating a pediatric-scaled vascular clamp with adjustable jaw size and controlled clamping force

Background



End-Stage Renal Disease (ESRD) [1]

- Kidney failure requiring replacement therapy
- Kidney transplant is the preferred treatment

Pediatric Challenges

- Smaller blood vessels [2,3]
- Smaller surgical field [2,3]
- Adult instruments are often too large [4]

Surgical Need

- Pediatric-sized vascular clamp
- Controlled clamping force
- Reduce risk of vessel damage



Figure 1: Kidney clamp. From *Kidney clamps*, by SURTEX Instruments, n.d., SURTEX Instruments. [5]

Competing Designs

Cooley/DeBakey Style Pediatric Clamps [6]

- Atraumatic serrations/teeth, ratchet system
- Bulky and obtrusive handles



Figure 2:Cooley Pediatric Clamp[6]

Baby Renal Clamps [7]

- Modified angle of handles, very small-sized jaws
- Only applicable for smaller pediatric age/weight groups



Figure 3:
Baby
Renal
Clamp[7]

Bulldog Pediatric Clamps [8]

- No handles, built in spring-loaded occlusion mechanism
- Specialized for specific vessel sizes



Figure 4:Mini Bulldog Clamp[8]

Product Design Specification

Client Requirements:

- Adjustable for accommodating pediatric patients of all ages and vessel sizes
- Atraumatic jaws (58 mm) for avoiding excessive damage to vessels during anastomosis
- Strong locking mechanism with adjustable and maintainable force (2-5 N) that effectively blocks blood flow
- Unobtrusive for pediatric surgical field
- Autoclavable or able to withstand many chemical sterilization cycles
- Composed of safe, biocompatible metal and latex-free
- Reusable/Manufacturable model

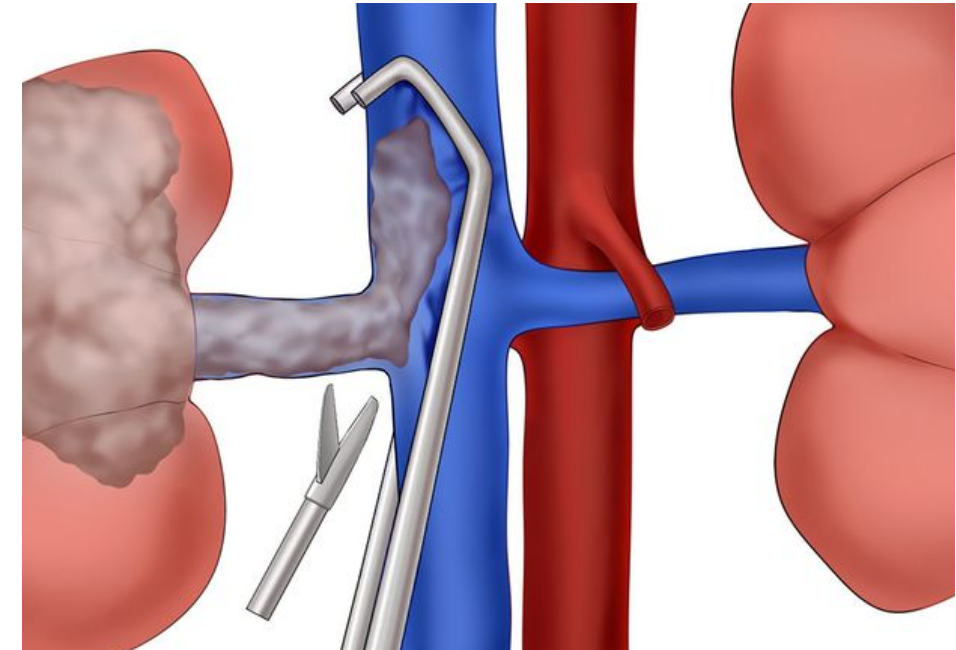


Figure 5: Vascular clamp blocking blood flow from inferior vena cava (IVC) during kidney transplant surgery[9]

FORCE Design Ideas

Design Concepts

- Ratchet system to increase force incrementally with lever to release the tension
- Spring mechanism attached to reduce the force applied
- Adjustable screw that can be set and changed to a specific force limit



Figure 6: Ratchet system

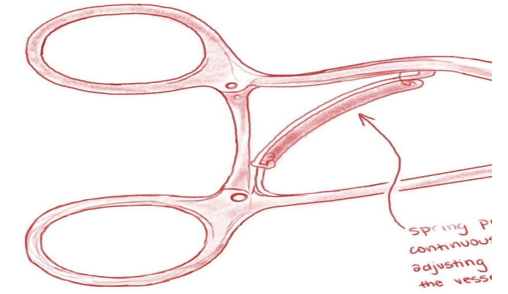


Figure 7: Spring mechanism

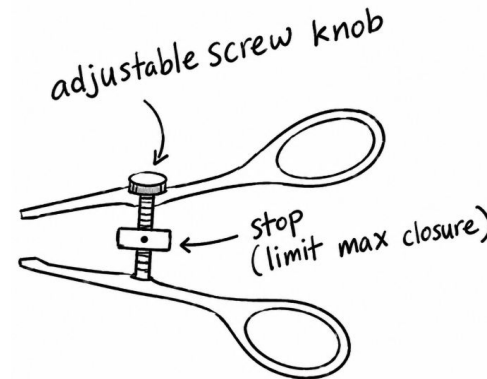


Figure 8: Adjustable screw

Force Design Matrix



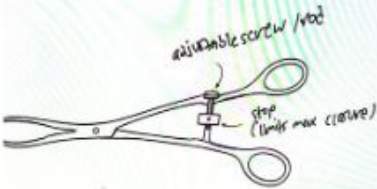
Design Criteria (weight)	Spring Mechanism		Ratchet System		Adjustable Screw/Dial Mechanism	
						
Safety (30)	4/5	24	5/5	30	5/5	30
Versatility(25)	4/5	20	4/5	20	4/5	20
Ease of Use (20)	3/5	12	5/5	20	4/5	16
Ease of Fabrication (15)	4/5	12	5/5	15	3/5	9
Cost (10)	5/5	10	5/5	10	5/5	10
Total Score (100)	78		95		85	

Table 1: Design Matrix of Force Distribution Designs

Detachable Jaws Design Ideas

- Screw-in jaw mechanism with threaded engagement
- Pop-in connection
- Sliding mechanism

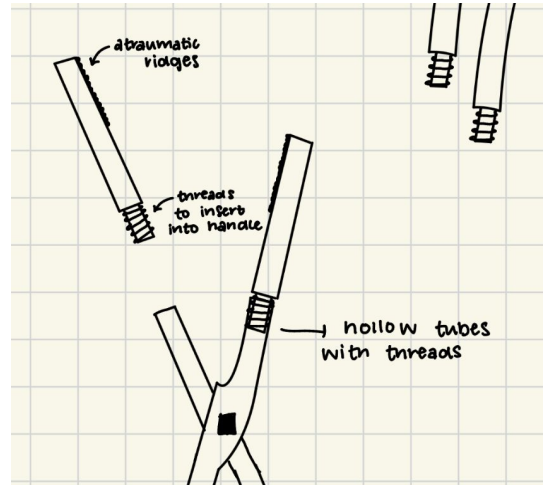


Figure 9: : Threaded screw-in mechanism

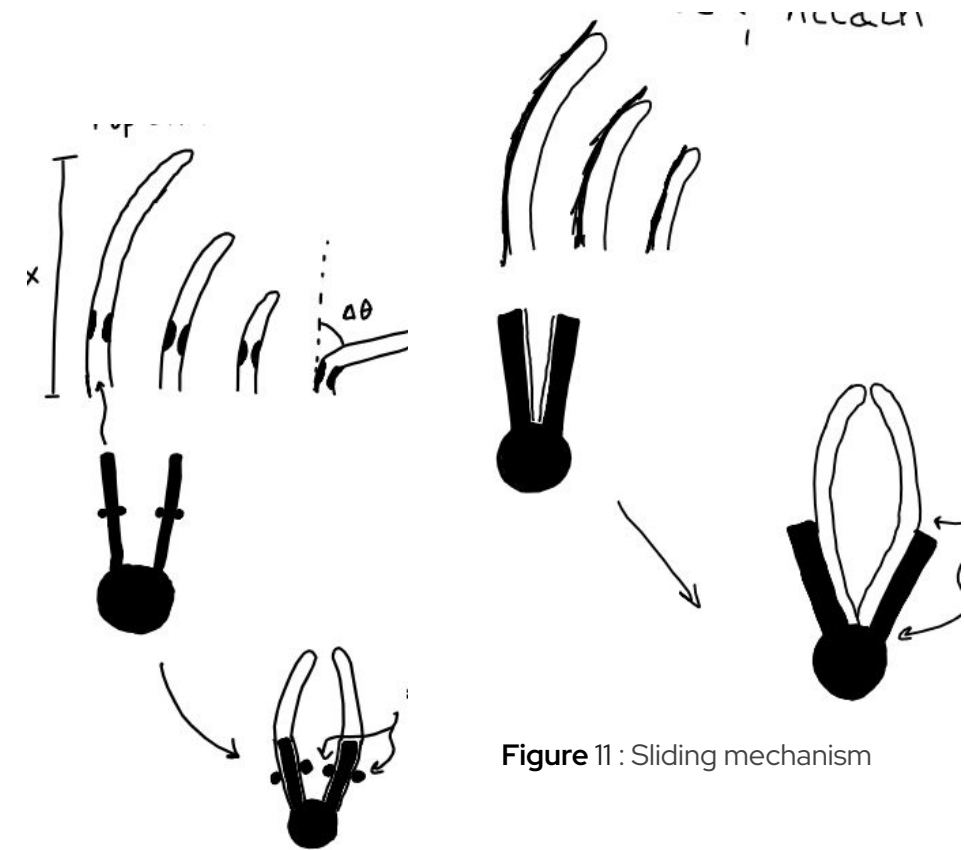


Figure 10: Pop-in connection

Figure 11 : Sliding mechanism

Detachable Jaws Design Matrix



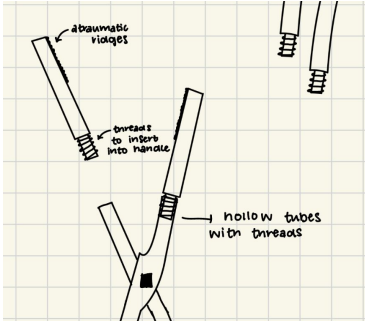
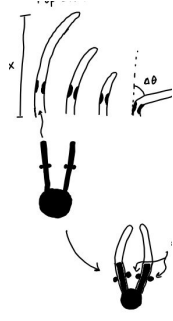
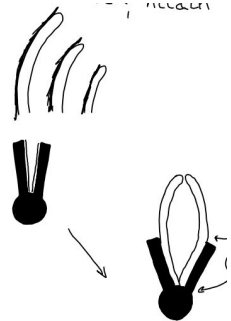
Design Criteria (weight)	Screw Mechanism		Pop-In Screw/Swiffer Mop Extension Mechanism		Sliding Mechanism	
						
Stability (30)	5/5	30	4/5	24	3/5	18
Ease of Use (25)	3/5	15	4/5	20	5/5	25
Ease of Fabrication (20)	5/5	20	3/5	12	4/5	16
Versatility (15)	3/5	9	5/5	15	4/5	12
Cost (10)	5/5	10	4/5	8	3/5	6
Total Score (100)	84		79		77	

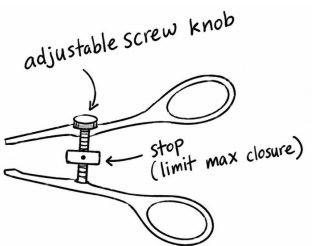
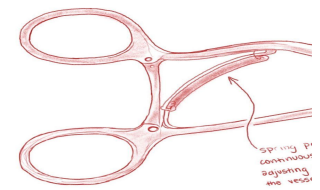
Table 2: Design Matrix of Detachable Jaws Designs

FORCE (advantages and disadvantages)



Advantages:

- Allows incremental, controlled force application
- Maintain force without continuous pressure
- Multiple locking positions
- Simple and compact
- Easy to use and replace
- Wider/more continuous range of force application
- Prevents over-compression
- Fine-tune the amount of force
- Easily reproduce the same setting



Disadvantages:

- Large force jumps between ratchet positions
- wear and tear on the locking mechanism
- Harder to sterilize
- Spring fatigue
- Needs extra refinement
- Hand exhaustion during prolonged use
- Slower to adjust
- More mechanical components
- Threads may wear over time

DETACHABLE (advantages and disadvantages)

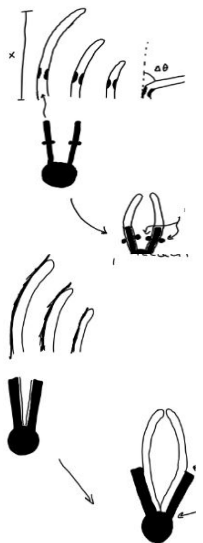
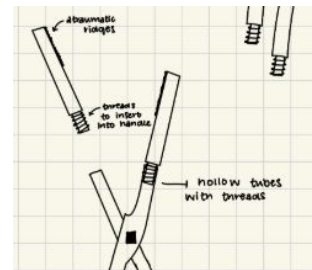


Advantages:

- Strong, secure connection since it's less likely to detach accidentally
- Good durability with repeated use
- Quick attachment and removal
- supports multiple interchangeable jaw configurations for different applications.
- Easier reposition
- compact design, it can fit within a narrow attachment area

Disadvantages:

- Takes longer to attach/remove
- Threads can still wear or strip
- May loosen with repeated use, lower security than threaded connection
- Longer fabrication process
- Can slide unintentionally if not locked
- Sliding contact can make adjustment less smooth



Testing



Testing tightness of threads

- Blood acts as natural lubricant
- Liquid of composition 40% glycerol and 60% saline[10]

Testing clamping force

- Insufficient force will not stop the blood flow
- Excess force will crush blood vessel

Testing sufficiency of length of clamp

- Incorrect length will result in inefficiency of clamp
- Ergonomics of hand positioning may cause complications



Future Work

- Understand how the degree of curvature of the jaw relates to the diameter of the blood vessel and apply it to our manufacturing of the jaws
- Brainstorm an additional mechanism to the screw mechanism of the jaw - clamp system to lower the chances of it 'unscrewing' during surgery
- Begin designing a 3D model of a jaw and clamp in SolidWorks



References

- [1] J. P. Roach, M. E. Bock, and J. Goebel, "Pediatric kidney transplantation," *Seminars in Pediatric Surgery*, vol. 26, no. 4, pp. 233–240, Aug. 2017, doi: 10.1053/j.sempedsurg.2017.07.006.
- [2] M. P. Corzo, S. K. Rasmussen, and J. D Nathan, "Management of Surgical Complications in Pediatric Kidney Transplantation," *Journal of clinical medicine*, vol. 15, no. 2. Switzerland, p. 779, Jan. 18, 2026. doi: 10.3390/jcm15020779.
- [3] T. Prudhomme, B. Mesnard, O. Abbo, B. Banuelos, A. Territo, and EAU – Young Academic Urologist (YAU) group of Kidney Transplantation and the EAU – Young Academic Urologist (YAU) group of Paediatric Urology, "Postoperative surgical complications after pediatric kidney transplantation in low weight recipients (<15 kg): a systematic review," *Current opinion in organ transplantation*, vol. 28, no. 4. United States, pp. 297–308, Aug. 01, 2023. doi: 10.1097/MOT.0000000000001074.
- [4] S. V. Parelkar, B. V. Sanghvi, S. R. Shetty, H. Athawale, and S. N. Oak, "Needle in a haystack: Intraoperative breakage of pediatric minimal access surgery instruments," *Journal of postgraduate medicine*, vol. 60, no. 3. India, pp. 324–6, 2014. doi: 10.4103/0022-3859.138823.
- [5] "Surtex Instruments.com," *Surtex Instruments.com*, 2023. <https://surtex-instruments.com/product-category/haemostats-clamps/haemostats-clamps-kidney-clamps/> (accessed Oct. 01, 2026).
- [6] Product Series, "Wexler Surgical," *Wexlersurgical.com*, 2026. <https://www.wexlersurgical.com/cooley-pediatric-clamp-full-curved-cooley-atraumatic-jaws-medium-curved-shanks-titanium-65quot-165cm-p-265.html?type=search-instrument-type> (accessed Oct. 02, 2026).
- [7] "Teleflex Incorporated – Pilling Surgical Instruments Catalog," *Teleflexsurgicalcatalog.com*, 2026. <https://www.teleflexsurgicalcatalog.com/pilling/product/353534-cleveland-clinic-baby-renal-clamp> (accessed Oct. 02, 2026).
- [8] "Pediatric Bulldog Clamp – Surgi Portal," *Surgi portal*, June 2026. <https://surgiportal.com/product/pediatric-bulldog-clamp/> (accessed Oct. 02, 2026).
- [1] "The inferior vena cava (IVC) was partially clamped using a side biting satinsky clamp," *Research Gate* , https://www.researchgate.net/figure/The-inferior-vena-cava-was-clamped-using-a-Satinsky-clamp_fig2_340668164 (accessed Oct. 2, 2026).
- [10] P. C. Sousa, L. B. Neves, G. Nobrega, J. Carneiro, and J. M. Miranda, "Review on blood analogue fluids," *Recent Advances in Hemodynamics and Blood Mimetics*, pp. 285–300, 2026, doi: 10.1016/b978-0-443-24066-9.00002-7.



Acknowledgements

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- Prof. Shawn Gomez



Thanks for Listening

What questions do you have for us?