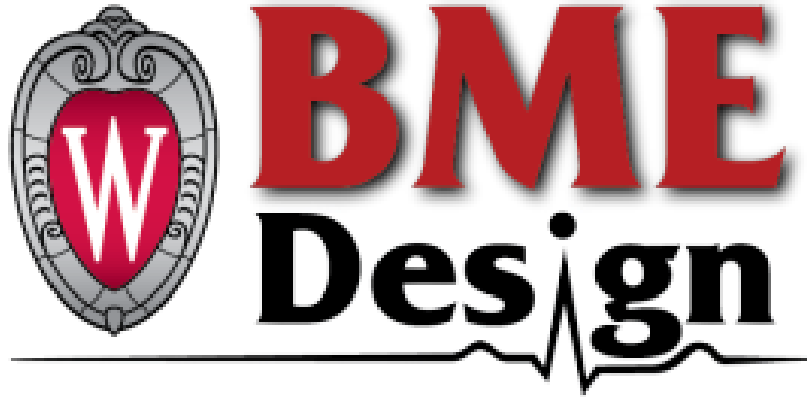


Radiologic Pathologic Correlation in Renal Cell Carcinoma

Preliminary Report



BME 400 Design
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ABSTRACT

Radiologic pathologic correlation is an up and coming technique that utilizes Computed Tomography Texture Analysis (CTTA) to link patterns observed in CT images to histologic tumor patterns. This technology has the capability to predict disease-free survival (DFS) of patients through enhancing accuracy and timeliness of cancer diagnosis and recurrence [1]. However, to reach a point of success, further validation of pathological tissue features from CTTA is required. In order to accomplish this, more data must be collected to accurately correlate histologic patterns with markings observed in CT images. The team is taking over a prior group's device in which a Delrin coring tube and stainless steel blade were fabricated. Their final design was built to aid the pathologist in making resections to the kidney tumor in order to correlate findings directly with CT images [2]. However, this design is currently unusable as the steel blade inflicts too much tissue trauma to the surrounding site, rendering the remaining tumor unimaginable. Therefore, the team seeks to utilize the previous Delrin tube while improving upon the blade design. This report outlines the team's initial designs for an alternative blade, a "winning" design to be fabricated, chosen using a design matrix, and testing protocols to ensure the validity of the new prototype. All together, the team will fabricate and test an alternative blade to be used in combination with the Delrin tube to effectively resect a tissue sample with minimal damage to the surrounding tumor.

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I. INTRODUCTION

1.1 Motivation and Global Impact

In the United States, there are approximately 65,000 new cases and almost 15,000 deaths from Renal Cell Carcinoma (RCC) each year [4]. Not only does it affect a wide range of individuals, but kidney cancer is almost two times more prevalent in men than it is in women [4]. Because of this, it is crucial that the diagnosis process is as efficient as possible. The only possibility of long term survival of RCC involves surgical intervention, especially when detected during early stage progression via CT imaging. A nephrectomy of the diseased kidneys is performed and samples of the tumor are then biopsied from the resected kidney [5].

CT texture analysis is used to quantitatively analyze tumor heterogeneity via pixel distribution, location, and relationships [6]. This imaging technique is especially useful in diagnosing and estimating prognosis of renal cell carcinoma. It is a promising technology for the management of cancer metastases and predicting treatment response [7]. Due to the complex spatial heterogeneity and histologically diverse nature of renal tumors, producing an accurate image analysis is challenging for physicians. These characteristics pose complications when performing biopsies on larger tumors because of the various types of cells dispersed throughout the mass [8]. CT texture analysis allows for slice-by-slice imaging of the tumor, which may help differentiate between different types of renal cell cancers, therefore improving individualized treatment and bettering prognosis [7].

1.2 Existing Devices and Current Designs

The current method to collect RCC biopsies involves the CT imaging of the patient's kidney to create a spatial rendering of the kidney and tumor dimensions. The previous team produced a 3D printed acrylic box to accommodate the patient specific dimensions, which holds the kidney once it is surgically resected (Figure 1). The coring device, with a stainless steel circular blade attached, is then inserted into the top of the box to collect tissue samples (Figure 2). Though this device is effective, the stainless steel blade that is attached to the end of the coring device is too thick and not sharp enough, therefore causing substantial trauma to the surrounding tissue (Figure 3). Without precise biopsy cuts, it is difficult to keep track of the specific locations of biopsy sites. Because of this, the coring device is unusable and needs to be paired with a better suited blade.

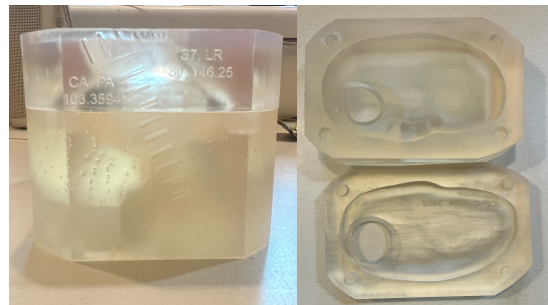


Figure 1: 3D printed acrylic box of patients kidney with tumor.

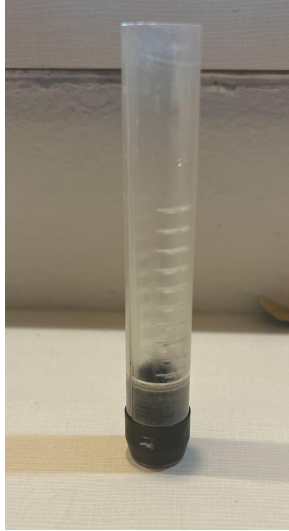


Figure 2: Current coring device prototype with a delrin plastic tube and 304 stainless steel blade.



Figure 3: Previous group's prototype of the stainless steel blade attachment.

An existing and well-known device in the realm of biopsies is the skin punch biopsy device. This device is a common tool used to conduct skin biopsies in order to diagnose various types of cancers (Figure 4) [9]. It is composed of a plastic tube and a sharp, cylindrical blade ranging from 0.5-6 mm in diameter. The device is used to collect samples of the affected tissue by pushing the cylindrical blade into the epidermis in a twisting motion, and then resending back up with the sample in the tube [10]. Though this device is extremely effective in performing skin biopsies, these tools do not have a large enough diameter (up to 10 mm) and are unable to penetrate deep enough into the tissue to appropriately sample RCC tumors.

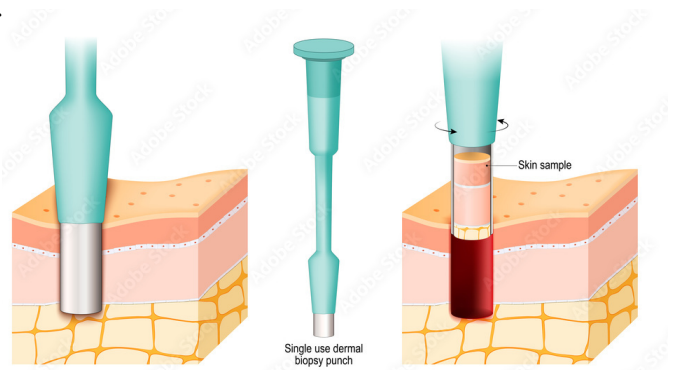


Figure 4: An upclose depiction of a skin punch biopsy procedure. [9]

1.3 Problem Statement

CT texture analysis is a useful tool in analyzing the heterogeneous profile of RCC tumors. The goal of this project is to validate the use of this analysis tool in the diagnosis and treatment planning of patients suffering from RCC. The patient specific, 3D printed box and coring device are advantageous at sectioning and delineating tumor samples for CT texture analysis, but the blade of the coring device is not practical to use in a clinical setting. To improve upon the previous team's successful design, this project will aim to develop a functional blade that will resect a tissue sample of 10 mm in diameter and keep the integrity of surrounding tissue by not letting any damage occur more than 3 mm away from the biopsy site. Additionally, the blade will be detachable from the Delrin coring tube and will have an appropriate diameter to accommodate the large sample sizes needed to conduct RCC tumor biopsies.

II. BACKGROUND

2.1 Anatomy and physiology

Renal cell carcinoma is the most common type of kidney cancer, making up 85% of kidney cancer diagnosis [11]. Renal cell carcinomas develop inside the kidney's tubules and start off as a single group of cancer cells within one kidney. However, it can progress and later develop into multiple tumors in one or both kidneys [11]. While the risk of developing renal cell carcinomas increases with age, factors such as prior radiation exposure to the abdomen, family history, and lifestyle affect the development of kidney cancer [11].

There are more than 50 different types of renal cell carcinomas, with clear cell renal cell carcinoma (ccRCC) being the most common. These different types are classified into four different types based on their size, shape, and staining. Grades I-II are low and grades III-IV are high. High-grade tumors have increased invasive capacities and possibility of metastasis, and have a poorer prognosis [12].

Computer tomography texture analysis (CTTA) is used to quantitatively analyze the spatial heterogeneity of tumors on CT images to improve the prognosis of patients [12]. Using a slice-by-slice tumor analysis technique, doctors can correlate specific tumor slices with histological findings. This more accurately depicts the gene expression and tissue types within the tumor by looking at smaller sections instead of the whole heterogeneous tumor.

Since computer tomography texture analysis is commonly used to study renal cell carcinomas, the goal of this project is to ensure the tumor samples and remaining kidney tissue remains intact with minimal damage in order to be imaged for further analysis and medical knowledge of renal cell carcinomas.

2.2 Client Information

The client for this project is Dr. Meghan Lubner, a pathologist who practices in Madison, Wisconsin. Dr. Lubner is associated with the School of Medicine and Public Health at the University of Wisconsin-Madison. Specifically, she is a professor of Radiology in the Abdominal Imaging Section and she has published many times on different oncologic imaging techniques [13].

2.3 Product Design Specifications

The blade must be reusable, easily detachable from the coring device handle, and easily sterilized in an autoclave. Since the blade will not be imaged, it does not need to be CT or MRI compatible as it will not create artifacts in the images. The client has specified the blade must be able to resect a 10mm diameter tumor sample while causing minimal tissue damage to preserve the integrity of the images. There is a tolerance for 3mm of tissue trauma radiating from the intended cut. The blade should be ergonomically sound and comfortable for the pathologist to use. The blade should be long-lasting and able to withstand 50 resections while remaining sharp

and efficient. Per the client’s budget, the overall device should not be more than \$500. The design specifications can be found in full under Appendix A: Product Design Specifications.

III. PRELIMINARY DESIGNS

3.1 Design 1: Pineapple Corer

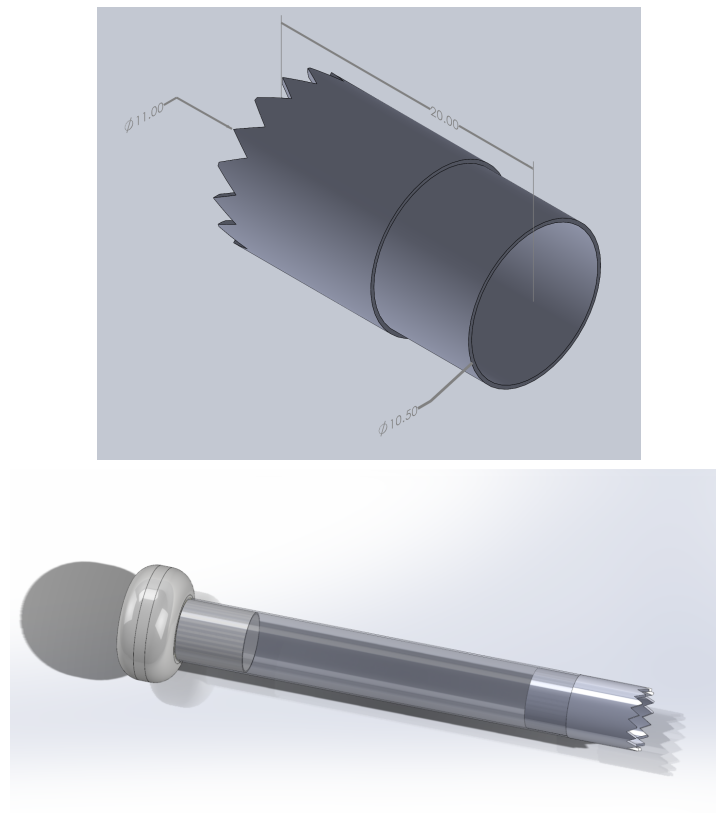


Figure 5: SOLIDWORKS Pineapple Corer Blade which includes toothed, rounded tip; Full Assembly.

The team’s initial design was accurately named the “Pineapple Corer” blade. The design inspiration came from household pineapple corers, which use small teeth and a twisting motion to remove the pineapple core. Similarly, the team’s blade utilizes multiple rigid teeth that are 2 mm in height and line the circumference of the blade. The teeth are designed to grip and tear through multiple layers of tissue, allowing it to assume tumor depths as deep as 10cm. In tandem with the toothed edge of the blade, the design includes a rounded handle that will be 3D printed of PLA plastic to attach on the other side of the corer. The physician will use this handle to insert the assembly into the sample while simultaneously rotating the blade roughly 270 degrees through the thickness of the sample. This motion allows for the blade to effectively cut through

the entirety of the tissue. The blade also employs a circular shape with a 11 mm outer diameter and 10 mm inner diameter. The shape of the blade intentionally allows for the cut of a 10mm diameter sample, which is the ideal size for the UW Health pathologist to observe the sample under a microscope. Finally, the blade will be made of surgical-grade stainless steel that is hardened to the Rockwell C hardness of about 46-53, as observed in the section J of the PDS found in Appendix A.

Other notable components of the design include a lip that has a .5 mm difference in outer and inner diameters. This was designed so the blade can easily attach and detach to the previous team's Delrin corer using a press-fit feel. This is an important function of the blade because it must be able to be sterilized in between uses in an autoclave as well as be disposed of when it becomes too dull.

3.2 Design 2: Recorder Blade

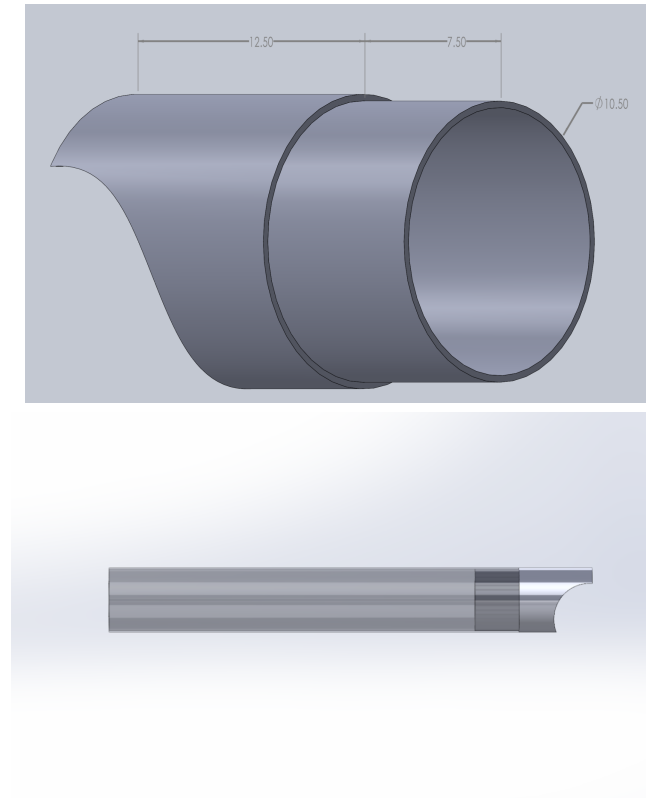


Figure 6: SOLIDWORKS Recorder Blade which includes pointed pressure application at the tip; Full Assembly.

The second design the team considered was the “Recorder Blade”. This idea embodied similar features to the first design, while also taking inspiration from current surgical blades. Firstly, the blade also included a lip with diameter of 10.5mm that would press-fit into the previous team's Delrin corer. The blade will also be fabricated using a stainless steel material to

mimic the hardness outlined by the Product Design Specifications (Appendix A).

However, the difference in this design lies in the edge of the recorder blade. The team wanted to mimic the side profile of a surgical scalpel in order to ensure a precise resection of the tissue. After much initial research, the team decided to create a concave blade with a pointed tip. This is because a pointed blade is typically used for “stabbing” and “precise” incisions [14]. Therefore this design allows for maximum pressure to be applied at the point of contact in order to effectively break the tissue and seamlessly resect a sample. Furthermore, the circular cross-section of the blade will acquire a sample within the client’s size requirements of 10mm diameter.

3.3 Design 3: Punch Biopsy Design

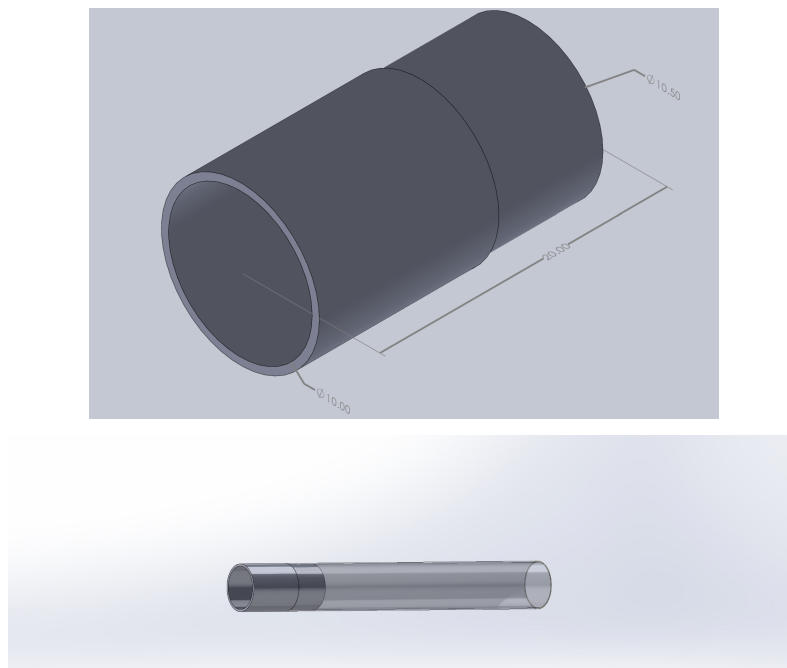


Figure 7: SOLIDWORKS model punch biopsy which includes circular tip; Full assembly.

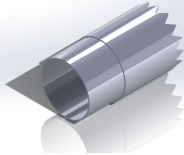
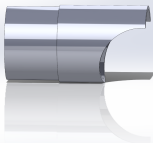
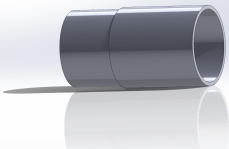
The team’s third and final design was also the most simplistic. The “Punch Biopsy” blade combined both the effort’s of the previous team and a modern day punch biopsy. The prior group had designed a similar device, but received the feedback that the blade itself was much too blunt and caused too much damage to the tissue during sampling. To combat this, the team measured the thickness of the previous blade and reduced thickness to 1/3 in this design—effectively going from 1.651 mm to .55mm. This drastic drop in thickness will allow the blade to be much more precise in resecting a sample from the tissue. This precision will allow for less struggle during the resection and less surrounding tissue damage, maintaining the imaging integrity of the tumor.

Some components of the design are also similar to previous drawings. Characteristics such as the indent used to press-fit into the corer will utilize the same dimensions as previously mentioned (10.5mm ID and 10mm OD). The larger section of the blade will maintain a 11mm OD and 10 mm ID. This blade will also be made of surgical-grade stainless steel that is hardened to the Rockwell C hardness of about 46-53, as observed in the PDS.

IV. PRELIMINARY DESIGN EVALUATION

4.1 Design Matrix for Renal Cell Carcinoma Blade

Table 1: Design Matrix with all methods scored on precision, durability, feasibility, ease of use, and cost.

| Criteria | Pineapple Corer | | Recorder Blade | | Punch Biopsy Blade | |
|------------------|---|----|--|----|---|----|
| |  | |  | |  | |
| Precision (30) | 2/5 | 12 | 4/5 | 24 | 5/5 | 30 |
| Durability (20) | 2/5 | 8 | 3/5 | 12 | 5/5 | 20 |
| Feasibility (20) | 3/5 | 12 | 3/5 | 12 | 4/5 | 16 |
| Ease of Use (20) | 5/5 | 20 | 4/5 | 16 | 4/5 | 16 |
| Cost (10) | 3/5 | 6 | 4/5 | 8 | 4/5 | 8 |
| Score (100) | 58 | | 72 | | 90 | |

4.2 Design Matrix Scoring Criteria

Precision (30%) - Precision is a measurement of how much external tissue trauma the blade creates around the sample site. The trauma should not radiate more than 3mm in any direction off the circumference of the sample. Higher scores were assigned to designs that would cause the least amount of damage to surrounding tissue while lower scores indicate more predicted trauma.

Durability (20%) - Durability relates to how long the blade will last over the course of its lifetime. The blade must be able to effectively resect 50 samples, and be able to withstand an

autoclave without losing its sharpness. Low scores were given the designs thought to dull quicker.

Feasibility (20%) - Fabrication of prototypes should not be difficult. Ideally, the prototypes should be created with resources easily accessible and not require too much finesse to manufacture. High scores are given to prototypes with more readily available resources and less complex fabrication processes.

Ease of use (20%) - Ease of use correlates to the ergonomics of the design, how easily it can detach from the core, how much pressure/strength the client needs to apply to the device, and a low procedure time (< 5 minutes). Higher scores indicate more of these requirements met than designs with lower scores.

Cost (10%) - The overall cost of fabricating the design holder prototype should be no more than \$100. The team was given an overall budget of \$500 but do not expect to exceed \$100 for one individual prototype. Low scores indicate an expensive fabrication process, while high scores are more cost-effective designs.

4.3 Proposed Final Design

After evaluating the “Pineapple Corer”, “Recorder,” and “Punch Biopsy” designs using the design matrix, the team chose to move forward with the “Punch Biopsy” blade design. This design scored the highest in four out of five criteria, including the three highest rated criterion. This is due to the simplistic cylindrical blade design.

In contrast, the “Recorder Blade” and “Pineapple Corer” scored significantly lower in the Durability and Feasibility categories. This can be attributed to their more complex geometries. The teeth on the “Pineapple Corer” and arc in the “Recorder Blade” will be more difficult to fabricate due to their small intricacies. This will also cause these designs to be less durable. Additionally, their greater surface area makes them more susceptible to dulling over time and breakage.

The “Pineapple Corer” design scored highest in the ease of use category. This is due to its handle feature and bladed teeth that will grab into the tumor allowing the surgeon to easily twist through the tumor. However, this process causes excess trauma to the surrounding tumor tissue and makes the sample unusable.

Overall, the “Punch Biopsy” blade design excelled in three of the top categories: Precision, Durability, and Feasibility. Additionally, it scored the highest in terms of cost efficiency. This design is expected to offer high precision, minimizing trauma to surrounding tissue. This assumption is based on the knowledge of standard skin punch biopsy devices, which cause minimal to no trauma due to their extremely sharp-edged blades. Furthermore, the chosen design will be durable as it will be constructed from surgical-grade stainless steel, an autoclavable material widely recognized as a standard blade material. Its feasibility is also

assured as cylindrical blades can be readily sourced from manufacturers, and their fabrication should not entail excessive time, effort, or production costs. Consequently, the winning design stands out as the most cost-effective option.

V. FABRICATION AND DEVELOPMENT PROCESS

5.1 Materials

The blade will be made of Stainless Steel Sheet 304: 12 in x 12 in (304.8mm) Nominal Size (WxL), 0.56mm Thick, 70 Rockwell Hardness [15]. This material is autoclavable and suitable for medical use. This steel will exceed the Rockwell C hardness measurement specification of 46-53 as outlined in the team's Product Design Specifications (Appendix A). This will be one-third the thickness of the previous team's design. Full description of materials and budget can be found in Appendix B.

5.2 Methods

Fabrication methods begin with the acquisition of .05 mm stainless steel sheets from AK Steel. A more detailed CAD drawing of the blade will be made in SolidWorks incorporating the desired dimensions, angles, and features. The team will then use a waterjet or precision cutting machine at the UW Madison TeamLab to cut the stainless steel sheet into a blank of the required shape and size, following the CAD design.

Then a bench grinder will be used to rough shape the blade, ensuring the edges are sharp and aligned with the design. A lathe will then be used to create the press to fit features of the blade. It will be narrowed to the exact diameter of the Delrin tube to ensure a secure fit.

The blade will then be grinded and smoothed to eliminate rough spots or burrs, ensuring the blade is free from defects. Then the blade will be heat treated to improve its hardness and wear resistance, following the industry standards for medical grade blades.

Finally the blade will be polished to a high gloss using appropriate polishing equipment, making it biocompatible and easy to clean. The team will use calipers and measuring tools to ensure the blade's dimensions match the CAD design.

The team will also consult with members of the UW TEAM Lab to determine the best way to go about the fabrication plan. The team must decide whether a precision cutting or waterjet machine will work best to cut the stainless steel sheet into the desired shape. The team will also consult the TeamLab on the best way to grind and smooth the device.

5.3 Final Prototype

Final prototype has not been fabricated yet.

5.4 Testing

Following fabrication, the ultimate design will undergo comprehensive testing in three key areas: blade integrity, tissue damage assessment, and ease-of-use simulation. The blade integrity test will confirm that the blade maintains sharpness throughout its service life. The tissue damage evaluation will ensure minimal harm to surrounding tissues during live procedures. Lastly, the ease-of-use simulation will serve as the final validation of the blade's readiness for clinical application.

1. Blade integrity test: The team will perform a test to determine the blade's durability by assessing how many cuts it can make before becoming too dull to cut a sample effectively. Blade dullness is defined as the inability to achieve a 10 cm deep cut. This evaluation will take place in the BME teaching lab, utilizing pig kidney as a tissue source. The success criteria for this test involve the blade making at least 50 cuts without exhibiting signs of dullness, in accordance with the specifications outlined in Appendix A, the PDS.
2. Tissue Damage test: In conjunction with the blade integrity test, the team will utilize the same experimental setup to evaluate tissue damage. The blade will be employed for a minimum of 50 incisions within a pig kidney, ensuring that the surrounding tissue damage does not exceed 3 mm from the circumference of the site. Success in this test is achieved when all 50 trials remain within the specified damage threshold.
3. Ease-of-Use Simulation test: Following the completion of all other tests, the final examination will serve as a conclusive assessment of the blade's ability to produce clear and accurate tissue samples for CT scans. In this test, the team will employ the blade to extract a tissue segment from a pig's kidney, subsequently subjecting it to a CT scan. The resulting scan images will then be forwarded to the client for their evaluation regarding the readability of the CT scan. Success in this test is defined by the client's confirmation of a readable CT scan.

VI. RESULTS

In order to complete the next steps of fabrication, the team must meet with the design experts at UW TEAM Lab. The team will then review the intended fabrication protocols to use the stainless steel sheet and create a cylindrical blade. Once the device is fabricated, the blade will be thoroughly tested. After data is collected, it will be statistically analyzed using a p-test to determine the efficacy of the prototype in comparison to the original design.

VII. DISCUSSION

Discussion will be written once results have been collected.

VIII. CONCLUSIONS

The guidelines established above will be used to create a blade that takes coring biopsies of resected renal cell carcinoma tumors. The design chosen will be a removable blade that securely attaches to the Delrin collection tube when taking samples. The prototype's performance will be evaluated by its ability to cut through the tumor mass while causing minimum trauma to surrounding tissue. Results will be analyzed and implemented to adjust the design for optimal efficiency. Moving forward, the team will begin the prototyping and purchasing stages of the design process, before moving to the testing phase.

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X. APPENDIX

Appendix A: Product Design Specification

Function :

The goal of this project is to develop a blade for a tumor resection coring device. The blade should be able to effectively resect a cross-section from an ex-vivo kidney tumor without causing damage to the overall tissue sample. Currently, the resection device used is too blunt and thick to effectively extract tissue without causing surrounding areas to be damaged and un-imageable on CT. By creating a new blade design, the pathologist can preserve the extracted tumor during the coring process. In maintaining the integrity of the tumor, the pathologist will be able to accurately correlate CT image markings and findings with their location in the patient sample.

Client requirements:

- Timeline: All final deliverables must be completed by December 16th, 2023
- A device is needed to allow for radiologic-pathologic correlation of resected renal cell carcinoma
- The device must accommodate ex vivo tumors of large size, approximately 20 x 7 x 7 cm
- Tissue samples should be cleanly cored without damaging the integrity of the tissue
- The device should be easily sterilized and cleaned between uses
- The device should be reusable and long-lasting
- The blade must be easily detachable from the cylindrical corer
- The team has a budget of \$500 for one device

Design requirements:

1. Physical and Operational Characteristics

- a. *Performance requirements:* The coring blade must be able to resect a single tissue sample from the kidney, roughly 7-10mm in size in order to fit on a microscope slide. The cut must be sharp enough to minimize the trauma to the surrounding tissue. The blade must be reusable and therefore must be able to withstand sterilization in an autoclave. The blade must be easily detachable in order to be removed before imaging.
- b. *Safety:* To ensure the safety of the pathologist, the blade should be round and smooth on the sides while remaining sharp at the point of incision. A cover will be made to cover the blade when not in use to protect the pathologist.

- c. *Accuracy and Reliability:* The device must be effective enough so that it takes only one cut to insert into the tumor. The extent of trauma to the surrounding tissue should be no more than 3mm in diameter.
- d. *Life in Service:* The blade portion of the coring device should be reusable and able to perform at least 50 resections of tissue samples without becoming dull. Therefore, it should compare to the hardness of sterile surgical blades which are outlined in BS 2982:1992 and BS EN ISO 7153 Part 1 [1].
- e. *Shelf Life:* The blade must have a minimum shelf life of 3 weeks due to the timeline of the entire procedure according to Dr. Jason Abel. When not being used, the device should be stored in sealed packaging in dry, room-temperature conditions (<50% humidity, 27 °C) [2].
- f. *Operating Environment:* The coring device should only be used in a clinical pathology lab. This laboratory should be compliant with the ISO 15189 standard [3].
- g. *Ergonomics:* The blade should be comfortable and easy for the pathologist to use. Therefore, it will be lightweight (< 1 lb), have no rough edges, and be balanced so that it only takes one attempt to successfully collect a sample in less than 5 minutes [4].
- h. *Size:* The coring device must produce samples that can be comfortably observed on microscope slides. Therefore, the diameter of the circular blade must be between 7 to 10 mm according to Dr. Jason Abel. The core blade must resect a tumor that is 10 cm in depth.
- i. *Weight:* The design should be as simple as possible, minimizing unnecessary bulkiness. The coring aspect of the device should be less than 1lb to not put any strain on the pathologist's hands when collecting a sample.
- j. *Materials:* The blade of the coring aspect should be made of surgical-grade stainless steel that is hardened to the Rockwell C hardness of about 46-53 [5]. The material of the blade must be able to withstand high temperatures in order to be sterilized in an autoclave.
- k. *Aesthetics, Appearance, and Finish:* The device should be smooth and simple. There are no appearance or finish specifications required by the client.

2. Production Characteristics

- a. *Quantity:* There is only a requirement for one device, however considering the possibility of mass production, the number of devices may need to meet market demands.
- b. *Target Product Cost:* The target product cost for this device is \$500. It will be paid for via UW Health research funds.

3. Miscellaneous

- a. *Standards and Specifications:* The device would need to adhere to the ISO 13485:2016 regulation which outlines requirements for regulatory purposes of medical devices. Regarding the blade for a tumor resection coring device, this standard specifies that a technical support device must consistently meet customer and applicable regulatory requirements [5]. In addition, the device must follow ISO 15189:2022 so that it meets the quality and competence requirements to be used in a medical laboratory [6]. Because the blade may need to be detachable, the device should also adhere to ISO 7740:2018 which states the dimensions and features needed to be a detachable blade used in a laboratory [6]. Lastly, the model would also need to follow the FDA's Code of Federal Regulations Title 21, Volume 8 which outlines the requirements for medical devices [7].
- b. *Customer:* Dr. Meg Lubner is a professor (CHS) in the Abdominal Imaging Section at the University of Wisconsin School of Medicine and Public Health. She is asking for a blade that would be compatible with the tumor resection coring device that was fabricated by the previous group. Dr. Daniel Shapiro and Dr. Jason Aebl will act as alternate contacts for this project as well. Both doctors have specialties in minimally invasive surgery and urologic oncology, giving the team specialized knowledge about RCC.
- c. *Patient-related concerns:* The device will not interact directly with the patient, only with the kidney tumor after it has been fully surgically removed. However, it is crucial that the coring device takes an accurate and interpretable biopsy of the tumor. Minimizing the tissue trauma caused to the kidney tumor when taking a core biopsy is critical to conclude an accurate diagnosis and to collect data from the procedure.
- d. *Competition:* Currently, there is a lack of available devices in the market designed for core biopsies of kidney tumors. The existing method involves excising square sections around markers within the tumor. However, this approach falls short of providing comprehensive insights into the depth of specific areas of interest. A device

sharing a similar underlying principle already present in the market is the punch biopsy tool employed for skin graft procedures. In a punch biopsy, a circular-tipped cutting instrument is utilized to extract deeper layers of skin for diagnostic purposes [10]. This tool is rotated into the skin and then withdrawn to generate a columnar biopsy of the skin's deeper layers. However, these devices cannot be used to create a core biopsy of a kidney tumor because they do not cut deep enough.

References:

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Appendix B: Expense Spreadsheet

| Item | Description | Manufacturer | Mft Pt# | Vendor | Vendor Cat# | Date | QTY | Cost Each | Total | Link |
|-----------------------|---|--------------|---------|----------|-------------|------------|-----|---------------|----------------|----------------------|
| Category 1 | | | | | | | | | | |
| Stainless Steel Sheet | 12 in x 12 in nominal size (WXL), 0.022 in thick, stainless steel sheet 304 | Grainger | 796XT3 | Grainger | 796XT3 | 10/10/2023 | 1 | \$37.40 | \$37.40 | Link |
| | | | | | | | | | \$0.00 | |
| | | | | | | | | TOTAL: | \$37.40 | |