A

Major Project Report on

NEXT GENERATION TOURNIQUET

submitted in partial fulfillment of requirements for the award of the degree of

MASTER OF DESIGN

(Product Design)

By

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I, Sharmistha Halder, Roll No. 2K22/MDPD/07, am a student of M.Des. (Product Design), with this declare that the project dissertation entitled "NEXT GENERATION TOURNIQUET" is submitted by me to the Department of Design, Delhi Technological University, New Delhi in partial fulfillment of the requirement for the award of the degree of Master of Design in Product Design. This original work has not been copied from any source without proper citation. This work has yet to form the basis for awarding any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

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ABSTRACT

This thesis introduces an innovative assistive device aimed at enhancing vein localization accuracy, efficiency, and user experience for healthcare personnel. By integrating a flexible tourniquet with a light-based vein detection system, this invention addresses prevalent challenges in existing devices. Current shortcomings include the need for separate tools, susceptibility to ambient light interference, lack of seamless integration, limited flexibility, and complex interfaces. Failure to detect veins can lead to multiple needle sticks and unsuccessful procedures, causing patient discomfort. Through rigorous design and development, this thesis presents a comprehensive solution poised to improve patient care outcomes in medical settings.

Furthermore, it encompasses the culmination of my research and testing efforts during the fourth semester of my master's degree program.

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SHARMISTHA HALDER

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1 INTRODUCTION

1.1 Background

In the medical field, the vein finders have become indispensable by aiding the medical professionals in different ways as well as aiding the different medical devices by locating veins in several medical procedures such as phlebotomy, blood draws for different tests, catheter insertion, etc. Visual inspection and palpation were the two traditional methods used by medical officials to identify veins before the development of the vein finder technology. These traditional methods proved to be challenging for the patients with less venous access or has very less visibility due to problems like obesity or pigmentation in skin. Vein finder technology gave clinicians an enhanced visualization of the veins along with accuracy improvement and it provided non-invasive ways to detect the veins. The accuracy and success rates of the vein finders is much higher than the existing traditional venipuncture methods. Vein finders have revolutionized the medical industry in ways no one can imagine. It enhanced the way medical professionals approach veins in any part of the body and offered real-time images as well as the guidance for precise vein access.

1.2 Importance of Vein Visualization

Vein visualization plays an important role in various medical procedures which include medication administration, blood sample collection, intravenous therapy, etc. Vein localization is basically used to minimize the patient discomfort in several ways and also it reduces the risk of complications of surgeries like hematoma or extravasation, and hence, it optimizes the overall procedural success rates. With the help of vein finders, the healthcare providers are able to identify the veins in patients very easily and quickly and effectively even when the situations are challenging and to find the veins becomes difficult. Vein visualization enhancement helps with procedural efficiency, it reduces the pain and discomfort of the patients also reducing their anxiety and stress related with the procedure by working in a seamless manner. And hence veins visualization helps with the overall patient satisfaction and trust with the healthcare services and healthcare professionals. Procedural errors are also reduced or minimized to zero using enhanced

vein visualization along with the enhancement of patient safety and hence giving a hope for the medical professionals to develop more modern indispensable tools in the same field.

1.3 Limitations of Current Vein Finders

The importance of vein finders is increasing day by day, with the widespread increase of this technology come a lot of limitations for the same. The vein finders that are used currently with widespread utility functions, several limitations are there that affect the effectiveness and the usability of this technology in clinical practices. There is a need for a separate tool for vein detention and for the tourniquet application while using it which in turn leads to procedural inefficiencies and the time is increased for the overall procedure and requirements. These devices are very much susceptible to the ambient light interference which will affect the vein finding accuracy most particularly in the places and environments with bright lights. Vein detection devices may also lack flexibility along with the application.

The above mentioned limitations limit the access to the usability and accessibility of the different devices. Some devices have complex interfaces which require intensive training for the medical professionals for their correct usage and adoption of basic skills before using them. Cost effectiveness is another challenge that is faced with the vein finders. High end models cost a lot in this field with a variety of handheld devices which may offer a superior accuracy, low-cost options may sacrifice the accuracy that is promised by the vein finder technology and thus compromising the successful procedures done by the vein finders. The balance between the cost of vein finders and the accuracy of the vein finders still remains critical despite all the success and its widespread adoption in the medical field.

1.4 Objective of making a new Vein Finder

The main objective to design a new vein finder is to overcome a lot of limitations discussed in the previous section that are associated with the technologies that are used currently. This is done to develop an assistive device that enhances the overall accuracy, efficiency as well as the user experience of the healthcare personnel who is using vein finder for localization of the veins. If a light-based vein finder is developed which is both adjustable and flexible according to the application in which it is being used. The proposed invention helps in streamlining medical

procedures which require vein access and ultimately improving precision, patient comfort and precision capabilities. The aim of the new age invention of vein finders is to make them in such a way that there is elimination of separate tools, mitigation of ambient light interference and thus simplifying user interface along with cost effectiveness. This invention seamlessly integrates the flexible tourniquet technology with the light-based vein detection system.

The aims of making the new vein finder's accuracy, effectiveness, efficiency in results, precision in getting the end result and the patient trust and comfort in using the vein finder during the vein localization procedures. The key goals are to:

(i) to eliminate the need of a separate tool

(ii) ensuring accuracy in vein detection

(iii) simplifying the usability of vein finders

(iv) maintaining the affordability of this device

Hence, the noble aim of this research is to create a vein finder that revolutionizes the medical field in localization of the veins through the proposed vein finder in this research.

2 LITERATURE REVIEW

2.1 Overview of Existing Vein Finder Devices

A wide range of medical technologies are encompassed by the existing vein finder methodologies that are designed in such a way that they can aid the healthcare departments and medical professionals in localization of veins present in different medical procedures. These vein finder devices utilize different types of imaging modalities which include infrared radiations in the form heat waves, ultrasounds, thermography done through infrared in order to enhance the vein localization properties.

Popular vein finders include hand held devices, different kinds of wearable gadgets as well as the integrated systems which are all incorporated into a single medical equipment. The hand-held devices offer the medical professionals portability of the devices, ease of use while incorporating medical equipment and provide more comprehensive ways and solutions for different medical procedures. Hence, the existing vein finders vary in different parameters such that their design, functionality and usability is different which cater to the needs and preferences of medical and healthcare professionals and different medical procedures.

Table 1 showcases the different vein finders and the table differentiates them on the basis of imaging modality, their usability, features and the cost. This table helps the professionals in knowing which kind of vein finder is more appropriate for a certain procedure and for applications.

Table 1: Characteristics of basic vein finders

Vein Finder Device	Imaging Modality	Usability	Features	Cost
Integrated System	Near-Infrared (NIR)	Comprehensive, Complex	Augmented reality overlays	Expensive
Smartphone	Near-Infrared	Accessible,	Portable, Image	Low

Applications	(NIR)	Cost-effective	sharing capabilities	
Handheld NIR Devices	Near-Infrared (NIR)	Portable, Easy to use	Real-time imaging, Adjustable depth	Moderate
Ultrasound Vein Finders	Ultrasound	Versatile, Accurate	Real-time imaging, Depth	High
Wearable Gadgets	Near-Infrared (NIR)	Convenient, Lightweight	Hands-free operation, Vein mapping	Varies
Infrared Thermography	Infrared	Limited Depth, Bulky	Contactless, Temperature mapping	Moderate

2.2 Functionalities and Features of Current Vein Finders

A plethora of functionalities as well as the features are provided by the existing vein finders that aim at facilitating the vein localization and visualizing the overall procedural outcomes. There are several medical features that are included in the vein finders such as adjustable settings for varying depths as well as brightness, real time imaging of veins, capabilities of vein mapping, compatibility with different skin types and colors as well as patient demographics.

Some advanced vein finders have incorporated Augmented Reality (AR) and different vein tracking algorithms are used to enhance the accuracy and precision of the existing vein finders. Different design elements are incorporated during the development of the product such as lightweight construction, wireless connectivity and intuitive interfaces; these features contribute to the user's comfort and stress. And also, it provides convenience to the medical professionals using these devices with the vein finders embedded in them.

Table 2: Features of existing vein finders

Vein Finder Device	Imaging Modality	Usability	Key Features	Ambient Light Resistance	Cost	Versatility
VeinSeek 2	Infrared	Easy to use, Color-coded images	Multi-color display	Moderate	Low to moderate	Low
VeinProbe	Ultrasound	Versatile, Precise	Real time ultrasound imaging	High	High	High
VeinSight Pro	Near-Infrared (NIR)	Compact design, Touch screen interface	Adjustable brightness and contrast	Moderate	Moderate	High
AccuVein AV400	Near-Infrared (NIR)	Portable, Easy to use	Real time vein mapping	Moderate	Moderate	High
VeinSeek Pro	Infrared	Portable, Non-invasive	Non-contact vein visualization	High	Moderate	Moderate
VeinLite LED	Near-Infrared (NIR)	Lightweight, Disposable	Disposable, Single use design	Low	Low to moderate	Low
Vein Viewer Flex	Near-Infrared (NIR)	Hands free operation	Digital vein mapping, Depth control	High	High	Moderate

2.3 Limitations and Challenges of Current Vein Finders

There are different limitations present in already existing vein finders in visualization and imaging and it also impacts the performance of the vein finders. This further degrades the usability of vein finders in the clinical procedures and clinical practice. These challenges include limitation with the penetration depth in the skin, patients with darker skin may find difficulty in penetration procedures. Pigmentation or the excessiveness in the adipose tissue can also be the

reasons for this. Ambient light is also a significant challenge that adds up to the drawbacks of the vein finders and thus affecting its accuracy, effectiveness, and reliability of the vein detection system. Versatility is also a challenge that exists in some vein finders as these medical devices are not able to be utilized in some procedures. Table 2 discusses some of the challenges and limitations prevalent in the already existing vein finders.

Table 3: Limitations in existing vein finders

Vein Finder Device	Limitations and Challenges
VeinSeek 2	● Limited depth penetration compared to ultrasound, may not visualize deeper veins. ● Limited features compared to higher-end models, may lack advanced functionalities required for complex procedures. ● Low versatility in complex clinical scenarios, may not meet the needs of specialized procedures.
VeinProbe	● High cost may be prohibitive for smaller healthcare facilities. ● Bulkier compared to near-infrared (NIR) devices, may be less portable. ● Requires ultrasound expertise for operation, may require additional training for healthcare professionals.
VeinSight Pro	● Moderate cost may still be a barrier for some healthcare settings. ● Limited depth penetration compared to

	ultrasound, may not visualize deeper veins. ● Moderate ambient light resistance may require controlled lighting for optimal performance.
AccuVein AV400	● Moderate cost may limit accessibility in some healthcare settings. ● Limited depth penetration compared to ultrasound, may not visualize deeper veins. ● Moderate ambient light resistance may require controlled lighting for optimal performance.
VeinSeek Pro	● Limited depth penetration compared to ultrasound, may not visualize deeper veins. ● Requires controlled lighting conditions for optimal performance. ● Moderate versatility may not be suitable for all clinical scenarios.
Veinlite LED	● Low ambient light resistance may require optimal lighting conditions for effective use. ● Limited versatility, primarily suitable for routine venipuncture procedures. ● Single-use design may lead to increased waste and cost over time.
Vein Viewer Flex	● High cost may be prohibitive for

	smaller healthcare facilities. ● Limited versatility, may not be suitable for all clinical scenarios. ● Requires training for optimal use, may have a learning curve for new users.

2.4 Comparative Analysis

A comparative analysis gives a view about all the already existing vein finders that are discussed in the previous sections of this research. This helps in analyzing where there is a scope to modify a particular vein finder to make it more exact and more effective for the medical procedures. Table 4 discusses the various aspects of different vein finders that are already existing.

Table 4: Comparative Analysis of vein finders

Approach/ Device	Effectiveness	Features	Ease of Use	Availability	Cost	Safety
Vein Finders	Moderate to High	Vein visualization through infrared light or other technologies	Moderate	Available, but not universally	Moderate to High	Generally safe
Palpation	Moderate	Relies on tactile assessment	Easy	Widely available	Low	Generally safe
Visual Inspection	Moderate	Relies on visual assessment	Easy	Widely available	Low	Generally safe
Near-Infrared Imaging	Moderate	Enhances vein visualization through near-infrared light	Easy	Available, but not universally	Moderate	Generally safe
Augmented Reality	High	Vein image overlay on the patient's	Moderate to Complex	Limited availability,	High	Generally safe, but requires

		skin using AR technology		specialized applications		specialized equipment
Ultrasound	High	Real-time imaging of veins, Depth measurement	Moderate to Complex	Available, but not universally	High	Generally safe, but requires training
Vein Mapping Devices	High	Accurate mapping of veins, Guidance to suitable vein locations	Moderate to Complex	Limited availability, specialized applications	High	Generally safe, but requires specialized equipment
Vein Visualization Goggles	Moderate to High	Hands-free vein visualization, Portable	Easy	Limited availability	Moderate to High	Generally safe

The previous table 4 discusses the various aspects of the vein finders but Table 5 tells the advantages and disadvantages of several vein finders that help in noticing which vein finder can be used in what type of medical procedure.

Table 5: Pros and Cons of vein finders

Approach/Device	Description	Pros	Cons
Vein Finders	Devices that use infrared light or other technologies to locate veins	- Provide a visual representation of veins, making them easier to locate	- May be expensive to purchase and maintain, Calibration may be required - Some devices have limitations with deep or small veins
Ultrasound	Ultrasonography is used to visualize veins beneath the skin	- Provides real-time imaging of veins, offering accurate visualization	- Requires specialized training and skill to operate - Requires additional equipment - Time-consuming compared to other methods

Palpation	Healthcare personnel use their fingers to feel for veins	- Widely practiced technique - Can provide a general sense of vein location	- Accuracy can vary depending on the practitioner's skill and experience - Difficult to locate deep or small veins
Near-Infrared Imaging	Devices emit near-infrared light to enhance vein visualization	- Non-invasive and portable - Can enhance visualization of veins	- Limited penetration depth, may not work well for deeper veins - Less effective on patients with darker skin tones
Visual Inspection	Healthcare personnel visually inspect the patient's arm for veins	- No additional equipment required - Low cost and widely practiced	- Relies on the visibility and accessibility of veins - Accuracy can vary depending on the practitioner's skill and experience
Vein Mapping Devices	Devices that use advanced imaging technology to create a map of the veins beneath the skin	- Provides accurate mapping of veins - Can guide healthcare personnel to the most suitable vein location	- Requires specialized equipment and software - Higher cost compared to other methods - May have limitations with deep or small veins
Vein Visualization Goggles	Goggles that use infrared technology to visualize veins and project the image directly onto the wearer's field of view	- Offers hands-free vein visualization - Portable and user-friendly	- Limited field of view - May have limitations with deep or small veins - Higher cost compared to other methods - Requires calibration and may have variations based on individual user perception

Augmented Reality	Overlay of vein images onto the patient's skin using AR technology	- Enhances visualization and accuracy by providing a digital overlay of veins	- Requires specialized equipment and software - Higher cost compared to other methods - May have a learning curve for healthcare personnel

2.5 Recent Advances in Vein Visualization Technologies

There are notable advancements in the recent past in the field of vein finders that is also driven by the ongoing research done for the effectiveness of the vein finders and in order to overcome the existing limitations and challenges of the vein finders. Multispectral imaging is done by the advanced technologies in the vein finders, machine learning algorithms are used to make it more cost efficient and effective, optical sensors and actuators are used accordingly for the vein detection reliability, accuracy and efficiency.

Today's world is the world of Artificial Intelligence and Machine Learning, so there can be an integration between the existing vein finders and these latest technologies which would help in real time imaging, automatic vein detection and segmentation, enhancing the procedural efficiency and the system enhance ability. Wearable vein finders are connected with the android applications in order to get your images in your phone in real time. These recent advancements have led to a new era of innovation with improved patient care in the medical practices.

3 PROBLEM IDENTIFICATION

The vein detection technique in healthcare plays an important role in different medical procedures which includes venipuncture, blood draws, IV insertion, etc. It is necessary to investigate and analyze how the vein finders can be made better and improve with their efficiency and accuracy. Innovative ideas need to be discussed and brainstormed in order to make innovative and effective vein finders.

3.1 Challenges in Current Vein Visualization Technologies

Several limitations are there in already existing vein finders. Some of them are listed as:

(i) Ambient Light Interference: It is the most significant challenge faced by the vein finders as they are susceptible to the ambient light interferences. In the environments that are brightly lit, vein finders are of no use. These kinds of environments exist in hospitals such as surgical rooms which have bright and dense lighting systems, emergency rooms and operating rooms where there is enough light to make it easier for the medical health professionals to perform procedures on patients. This all can affect the vein identification and thus leading to challenges of vein visualization which may compromise the patient's care.

(ii) Procedural Inefficiencies: There is a requirement of special kinds of tools that are required for vein visualization. This creates joints in the application which can in turn lead to hampering the workflow of the process, it may lead to inefficiency in clinical settings and increases the time of process requirements.

(iii) Limited Accessibility: There is a lack of flexibility in the standalone vein finders which may not be available in the medical settings. This type of limitation affects the accessibility of the medical device. It becomes resource-limited where access is restricted and the medical facilities also become sparse.

(iv) Cost Variability: There is a high variability in the cost of vein visualization, better performance is provided with high-cost devices but they provide a financial barrier to the ones who can't afford these high-end devices. Low-cost devices deal with limitations in accuracy and efficiency which may lead to compromise in patient's health.

(v) Complexity of Use: Extensive training is required by some complex feature based medical devices and hence, they are used ineffectively. There is a widespread adoption of these devices which is hindered by the steep learning curve and this affects their utilization also.

3.2 Importance of Vein Visualization in Healthcare

The accuracy in visualization of veins is very important for implementation of various medical procedures. The reasons why there is a need to make and develop a new vein finder and to improve its efficiency. Some of the key points to be remembered while making a new vein finder are listed below:

(i) Workflow Efficiency: There is a need to streamline the whole vein finding process in order to enhance the workflow efficiency that is very essential in clinical settings. Advanced vein visualization techniques may lead to faster and more accurate vein identification mechanisms and hence it saves time, resources and improves efficiency.

(ii) Patient Comfort and Safety: If there are undetected veins and the vein finder is inaccurate then this may lead to multiple needle insertions which may lead to patient discomfort and also the procedural complications. There is a need in the improvement of vein visualization techniques to reduce the risk of patient trust and minimizing the procedural complications and in turn enhancing the patient care and developing the patient's safety and trust.

(*iii) Precision and Accuracy*: Accuracy of vein finders is very crucial which may lead to saving lives ultimately and help the medical professionals. The accuracy ensures the success of IV insertion, venipuncture and different other medical procedures. Enhanced versions of vein visualization techniques may lead to improvement in precision and accuracy and thus it reduces the likelihood of the

clinical procedural errors and thus enhancing the quality of the care that is provided to the patients.

Hence, addressing the challenges and limitations of the vein finder technology leads to the development of the innovative vein finders which may revolutionize how medical procedures are conducted in today's world. This leads to the advancement of the challenges and thus overpowering the limitations of the already existing vein visualization techniques and methods. This overall improves the healthcare facilities that are provided. Hence, this study explores the limitations and provides possible vein finders that may help in the future and design a latest powerful vein finder methodology at the end of thesis.

4 USER NEEDS AND REQUIREMENTS ANALYSIS

User research is a method that involves a comprehensive approach in order to gather information about different types of users which are different stakeholders, doctors, patients, nurses and phlebotomists. Around 20 people participated in the research study conducted which gave their valuable perspectives regarding the study of vein finder devices and the localization study and experiments. They provided important insights regarding the application area of a vein finder and the problems faced by them and what can be improved to make their work easy in performing medical procedures.

4.1 User Needs and Preferences Identification

Different people related with the medical field and related with the process of vein finder were interviewed in order to identify the user needs as well as their preferences. This is done in order to search and uncover all kinds of experiences, challenges faced by health profession in using current vein finders and what are their expectations regarding the same in using vein finders in different venipuncture and other medical procedures.

4.2 Requirement Gathering

These healthcare professionals that include doctors, nurses, phlebotomists, provide us with different data based on effectiveness of devices, usability of these devices, application areas and what can be the limitations of the same. This data collected through google forms and certain interviews helps in getting valuable feedback on different aspects of vein finders such as their functionality, performance, features and in the end, it can be discussed what can be the future solutions and improvements for this applicative device.

4.3 Current Scenario of Vein Finders

(1) Some nurses showed reluctance and denied using vein finders during the venipuncture procedure rather they took advice and assistance from their senior colleagues and doctors in these cases whenever necessary.
(2) A Gastroenterologist was contacted to get some insights of vein finders in that field and it was told that there was difficulty in using vein finders and they showed a preference of using manual methods as compared to vein finders.
(3) A Phlebotomist was also contacted to get data and he noted that the efficiency of vein finders in dark rooms and environments and where the light is too much is difficult. This was highlighted that the efficiency of vein finders decreases where ambient lighting conditions are not satisfied.
(4) An interview of a patient was conducted who shared their concerns regarding the fear of using a vein finder device to localize their veins as it was an additional equipment used during a simple procedure of drawing the blood.

Different stakeholders have shown their positivity towards using much easy technology and have supported the evidence-based research methodologies that support the effectiveness of vein finders. There was lack of convincing evidence, technological failures, more trust and confidence over the manual methods and time constraints and other cost concerns. Valuable insights have been collected from the user research and interviews in order to develop perspectives, needs and challenges regarding the vein finders. This user data helps in understanding concepts, features, usability issues, improvement in device's effectiveness and then providing evidence in order to support clinical practice.

Fig 1: Interview with Phlebotomist

Fig. 2 Vein localization with existing vein finder

Fig. 3 Palpation and blood draw procedure

Figure 1 shows an interview conducted with a phlebotomist in which a hemoglobin test was conducted using an already existing vein finder to check its quality and efficiency. Figure 2 shows ambient light effects the current vein finders and a hand is used to block the light from outside in order to get the correct vein. Figure 3 shows how palpation is used to find a vein for the blood draw procedure. Figure 4 shows an interview with a doctor and how current vein finders are used and how light is used to detect veins.

Fig. 4 Interview with Doctor

5 DESIGN CONCEPTS AND IDEATIONS

A systematic design and concept generation is done in this section of the research process and this methodology helps in developing more innovative designs as compared to previous designs of the vein finders. This process aims at developing the different designs as well as concepts for developing a vein finder which can address the user needs as well as their preferences effectively. This need-to-basics approach in research will help the designers to make a vein finder device which is effective, efficient, fulfills all the user needs, help the medical healthcare professionals in working in an easier way.

5.1 Initial Design and Concept

Several designs have been discussed and made for the design development of vein finders and all the insights have been collected from the user's data and the process of requirement analysis is also done.

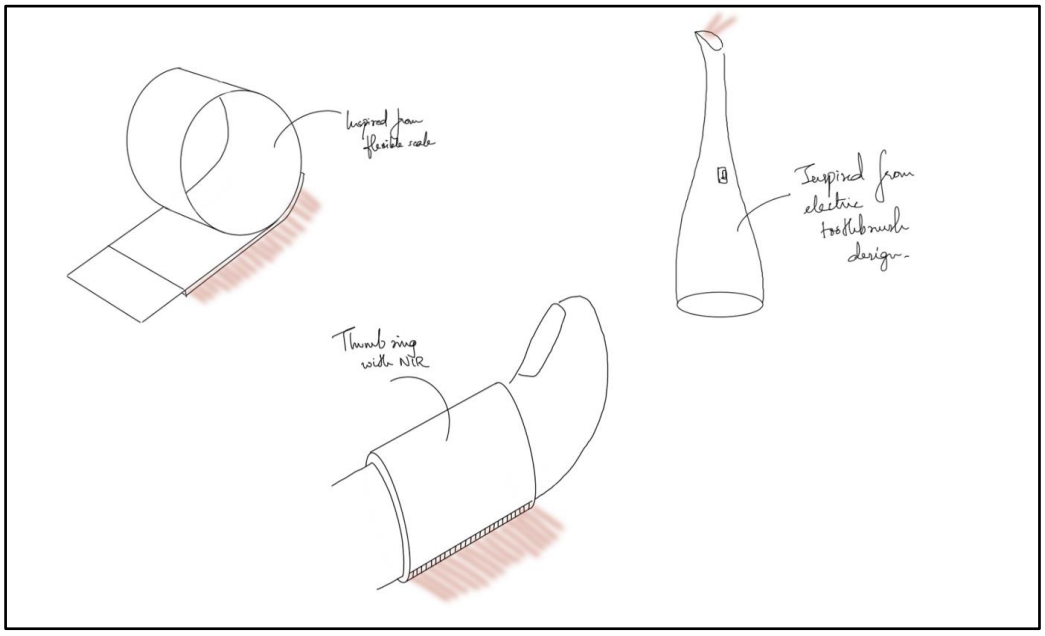

Fig. 5: Initial ideations

A wide range of conceptual development and feature enhancement procedures have been discussed and developed which aim at only one thing that poses as a limitation of vein finders that is

improving its efficiency, effectiveness, usability and enhancing the user experience. All the concepts include variant approaches such as ergonomic designs, vein visualization and localization, enhanced user interfaces and integrated technology and services.

Figure 5 shows the initial ideations on how a vein finder device can be made with motivation taken from different areas and also to make the vein finder more portable and can be used single handedly.

5.2 Selection Criteria for Design Concepts

Evaluation of selection criteria is done for design concepts such that the already established concepts can be prioritized effectively and efficiently. Different criteria have been formed for

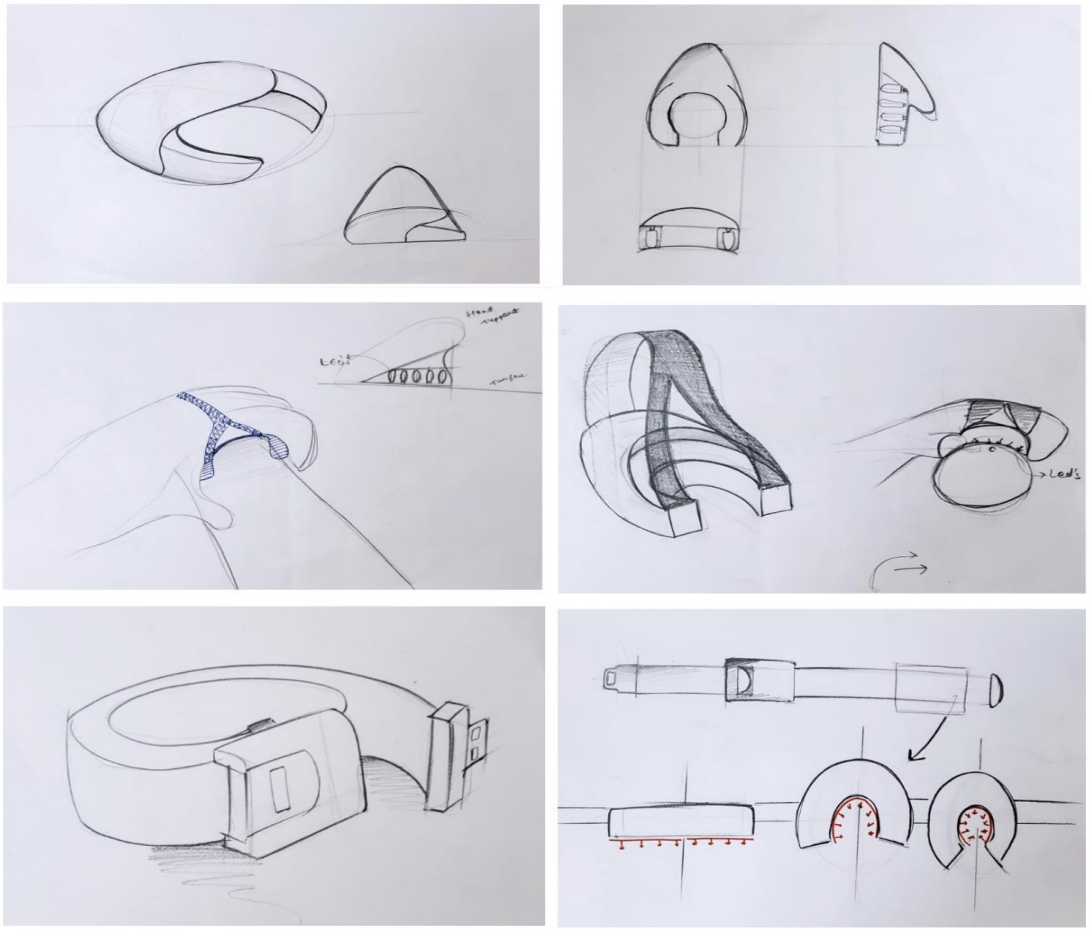

Fig. 6 Multiple design concepts

the design and development of vein finders such as feasibility, scalability, cost-effectiveness, alignment with the needs and preferences of the users. Concepts were made in such a way that they can assess with all their potential and can help with the limitations and challenges of the users and the medical healthcare professionals and give innovative solutions for the same to enhance the vein visualization and localization.

Figure 6 shows multiple design ideations and concepts that have been made. Different criteria have been brainstormed and hence drawn. The design ideations have been made in such a way that challenges and limitations of the existing vein finders can be overcome.

6 SOLUTION

6.1 Purpose and Overview

- The purpose of this solution is to design and develop an assistive device that significantly improves the accuracy, efficiency, and user experience of healthcare personnel in locating veins.

- This solution addresses the challenges (listed below) in current vein assistive devices by seamlessly combining a flexible and adjustable tourniquet with a light-based vein detection system. The goal is to streamline medical procedures requiring vein access, ultimately improving precision, efficiency, and patient comfort.

    - Current vein assistive devices often require separate tools for vein detection and tourniquet application, resulting in procedural inefficiencies and increased time requirements.
    - Existing vein detection devices are often susceptible to ambient light interference, affecting the accuracy of vein identification.
    - Existing vein assistive devices often function as standalone tools, requiring coordination between various devices and procedures.
    - Standalone vein detection devices may lack flexibility in application and might not be readily available in all medical settings.
    - Some vein assistive devices may have complex interfaces, requiring extensive training for healthcare professionals.

6.2 Application and Operation

To use the Next Gen Tourniquet, the flexible strap is securely applied to the patient's limb. The user activates the vein detection system, and the device shows the underlying vasculature through the light emitted by the LEDs. Real-time feedback is then provided, guiding medical professionals to identify and select the most suitable veins for the intended procedure.

6.3 Benefits

- The device becomes part of the process itself.
- Facilitates accurate and efficient vein identification.
- Enhances patient comfort and experience during medical procedures.
- Reduces the likelihood of multiple needle insertion attempts.
- Improves overall success rates of venous access procedures.
- Streamlined process with simultaneous tourniquet application and vein location.
- Consistent and accurate vein visualization in varying lighting conditions.
- Integration of tourniquet and vein detection into a single user-friendly device.
- Availability of vein detection technology in various medical settings.
- Intuitive design minimizes the learning curve for healthcare professionals.

6.4 Potential Applications

The invention is applicable in various medical settings, including hospitals, clinics, phlebotomy and emergency care situations, where quick and accurate vein identification is crucial for timely medical interventions.

7 PROTOTYPE DEVELOPMENT

7.1 Prototyping Methodology and Approach

The prototyping methodology and approach involved a systematic process for transforming initial design concepts into functional prototypes of the new vein finder device. The methodology aimed to validate design ideas, test functionality, and gather feedback from stakeholders to inform further development iterations.

Fig. 7 Prototype Progression: Visual Representation of Design Evolution

Figure 7 shows the working prototype and how it can be revolutionized to provide the best results for the patients and the medical healthcare professionals who use this device.

7.2 Materials Selection for Prototype Construction

Careful consideration was given to the selection of materials for prototype construction to ensure durability, usability, and compatibility with the intended application. Materials such as lightweight plastics, durable metals, and flexible polymers were chosen to meet the requirements of the device's form factor, ergonomics, and functionality.

8 CONCLUSION

This research has been done through collaboration of different stakeholders and the people who interviewed for the development of innovative vein finder technology. This research is seen as a commitment to the people working in the healthcare sector. Different research designs, innovative collaborations, ideations, iterations and prototypes have been developed in this final stage of the thesis. The authors of the research have tried to address the challenges that are present in the current vein finders in vein visualization and localization. Engagement with stakeholders has been proved effective and incorporating their feedback is of utmost importance during the designing of the vein finders. Despite encountering different limitations and challenges, the journey towards innovation remains unwavering and unresilient. Feedbacks play an important role as this would help in guiding refinements and creating such a device that will help the healthcare community. The future of this research is to see the potential impact that it causes in the innovation and improvement of patient care and ease the work of medical healthcare professionals.

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