Bandage Stabilizer

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Client: Dr. Michael Bentz, Department of Surgery at the University of Wisconsin School of Medicine and Public Health

Advisor: Professor Paul Thompson, Ph. D., University of Wisconsin-Madison

Abstract

In order to treat severe wounds, burns, and other cases where serious injuries have caused damage to the body's peripheral tissue, skin grafting is utilized. The most successful and commonly used skin graft is the split thickness skin graft. The typical donor site for these skin grafts is the upper leg because the incisions and scars made during the surgical procedure are readily concealed [6]. Dressings are applied over the recipient and the donor wound sites. In order to provide additional stability to the donor site dressing, ace bandages are currently used in the hospital industry. However, ace bandages prove to be inefficacious because they commonly slip off the application site. Therefore, the design team has developed three designs in order to solve this dilemma. Three possible solutions utilize compression shorts, slip guard, and the elastic leg wrap, respectively. Through an exhaustive analysis of the positive and detrimental attributes of each design, the elastic leg wrap was deemed the best solution to the problem. The team's future work will focus on fabricating and testing the design.

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Design Motivation

The overall motivation behind this project is to create a bandage stabilizing device to be utilized on the upper thigh. Skin grafts are most commonly extracted from the upper thigh. During the healing process, dressings are applied to the site of the open wound. To minimize the amount of time it takes to heal and minimize infection it is necessary for these dressings to have minimal movement across the wound. Currently these dressings are held in place by ACE bandages but patients have a difficult time keeping these bandages in place as they often times slip down the leg. As a result, the dressings experience movement in turn as they are not held in place with adequate pressure. The design team's goal is to create a device that can take the place of ACE bandages to apply sufficient pressure to the wound without moving down the leg.

Client Information

Our Client is Dr. Michael Bentz, who currently is a professor of surgery at the University of Wisconsin School of Medicine and Public health and is also the chairman of the Division of Plastic and Reconstructive Surgery.

Problem Statement

The client, Michael Bentz, MD, has requested a device to replace the current elastic bandage used to hold dressings in place on post-operative patients. Current methods for maintaining the dressing's position are ineffective since the current bandage typically slides out of place during the course of the healing process. The primary location of use for the device is around the upper leg. Additional areas of applications can include the lower leg, the upper arm, and the lower arm.

Background

Skin grafting involves transplantation of skin from one area of the body to another in order to treat serious injuries to the skin such as lacerations or extensive burns. Benefits of skin grafting include reduction in the required treatment time and improvement in function as well as appearance of the defected recipient site. The type of skin graft that can tolerate the most inclement conditions and has the broadest range of application is the split thickness skin graft [6].

Split thickness skin grafting involves a standardized protocol established and practiced by surgeons. In order to remove the donor skin site, an instrument called a dermatome (Figure 1) is used to produce a split thickness skin graft. A split thickness skin graft contains the epidermis and a portion of the dermis [5]. After removal of the skin graft from the donor site, the donor location still contains a dermal layer that contains hair follicles and sebaceous glands. These dermal structures are important to retain because hair follicles and sebaceous glands contain epidermal cells that rejuvenate a new layer of epidermis.

Figure 1: A surgical dermatome [5].

In order to prevent buildup of edema under the graft, a phenomenon that causes complications in revascularization and reattachment of the skin graft, the graft may be meshed by making lengthwise rows of cuts a few millimeters long. This process helps to facilitate the graft to stretch and cover a larger surface area. The implication of this is that the amount of donor skin needed is reduced. In current practice, two different methods of meshing exist. One method includes utilization of a smooth plastic plate to guide the skin graft under circular notched blades (Figure 2). The other method utilizes two opposing rollers to cut the skin graft as the two rollers meet. This is analogous to a scissor's blades cutting paper [6].

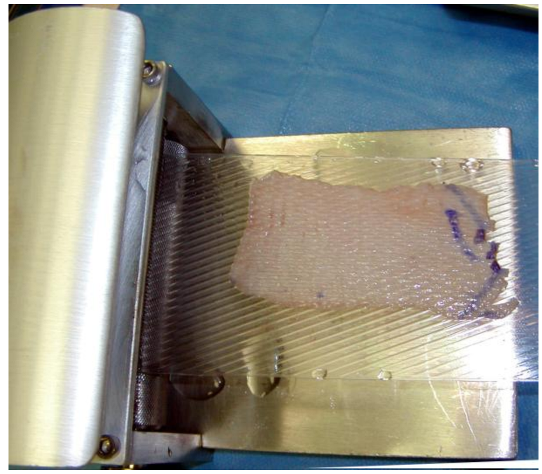


Figure 2: A skin graft undergoing meshing [5].

After all the processing of the skin graft has been completed, the graft is then applied to the recipient site. To secure the skin grafts in the proper position, a few stitches or surgical staples are used (Figure 3). The graft receives nourishment from the dermal capillaries in the wound until revascularization of the graft occurs. The time period from implantation of the graft on the recipient site to vasularization is approximately 2 to 3 days. This phase is typically called the plasmatic imbibition phase [4].

Figure 3: A slit thickness skin graft that underwent meshing followed by securement to the recipient site [5].

After the skin graft has been secured to the recipient site, a final dressing is applied to the recipient location in order to prevent shearing forces, seroma, or hematoma formation between the skin graft and the contacting recipient site. Two different types of dressing exist in order to accomplish this goal [6]. One is the bolster dressing and the other is the negative pressure dressing (Figure 4). A bolster dressing is composed of wrapping moistened cotton balls in petroleum gauze. It is secured to the site by placing sutures radially around the wound and tying them over the dressing [5]. A negative pressure dressing utilizes a foam filler dressing, a drape, and vacuum source to create a negative pressure relative to the atmosphere to the wound environment [2].

Figure 4: Bolster dressing shown on the bottom and the negative pressure dressing shown on top [3].

In addition, in order to reduce pain and to improve healing time by providing a moist environment, dressings are also applied to the donor site. The most common donor site is the upper leg due to its ability for concealment. Surgeons often use occlusive polyurethane to dress the wound. To further provide stabilization to the dressings, the doctors use ace bandages to wrap the donor site in a uniformly pressured manor [6]. However, this method is ineffective at adhering to the site and commonly falls off, increasing recovery time for patients.

Current Practices

The current means of securing post-operational dressings is by applying an ACE bandage over the dressings. These ACE bandages need to be wrapped around the leg numerous times to fully cover the area of concern and to create the necessary pressure. However, these multiple wrappings add weight and cause the bandage to become bulky. Consequently, it is very common for the bandage to slip down the leg. To counteract this, adhesive tapes and glue-like substances can be applied to help maintain the bandages' position, but these measures can be painful and messy upon removal. Patients often find other creative ways to keep the bandages in place. Examples of this include wrapping the bandage around the waste or using a garter belt; however, none of these methods are very successful or convenient.

Requirements and Design Constraints

There are a number of primary specifications and requirements the design must meet. First, the device must hold dressings in place without sliding down the leg. This is crucial to ensure proper healing of the wound. The typical patient will not be doing extensive exercise or movement after surgery; however, this device should be able to work adequately in the rare situations of vigorous movement.

Furthermore this device must be easily applied by the patient without help. This device will be utilized in most cases while the patient is recovering while at home and some patients may also be bed-ridden. It is important for this device to not make a patient dependent on others while going through the recovery process. Therefore the design must be simple and easily attachable.

It is important for this device not to create further problems for the patient. This means that the device cannot cause a tourniquet effect, which can be observed by the leg turning blue or the foot swelling. As a general rule of thumb, the device should be loose enough to be able to force two fingers between the device and the leg. Also, the patients will be in an uncomfortable state due to the recent surgery and it is important not to add to their discomfort. For this reason the device should not cause chaffing or rashes at the site of use. It is important to use hypoallergenic materials to avoid allergic reactions, which may exacerbate a patient's suffering.

Once these primary concerns are addressed there are several secondary issues the device should address given enough time and resources. First it would be ideal for the device to be aesthetically pleasing and customizable. This is both for marketing purposes and as a means of increasing the likelihood of pediatric patients using this device without complaint. This device's design could also be greatly improved if it were machine washable. A patient could be given two devices and while wearing one, wash the other. Making the device machine washable would increase the usability and convenience of the design.

Lastly, it would be ideal if this device could be applicable in a wide variety of areas. For instance, this device could be efficacious for maladies other than skin grafts simply by applying it to injuries dealing with the lower leg, upper arm, and lower arm. If this device could be used in these areas it would greatly increase the marketability and versatility of the product. Furthermore it would be useful if this device could be utilized within veterinarian medicine. Veterinarians have a problem keeping bandages on animals after surgery which increases the likelihood of infection and increases the recovery time for the animal. This device could be of use in these situations.

Proposed Designs

I. Compression Shorts

The utilization of the compression shorts design is similar to simply wearing a pair of shorts. Limiting the need for any type of wrap, adhesive, or tape, the compression shorts would, ideally, replace the current ace wrap method and have the potential for multiple uses. To eliminate any complications that would result from sliding the shorts up the users leg, the design includes a “breakaway” system. The “breakaway” system, which gives the ability for placement while a patient is either unconscious or simply unable, is created by implementing a zipper on the inner thigh of the shorts as well as down one of the sides (Figure 5); thus, allowing for the shorts to be either slipped underneath or wrapped around and then zipped up. Painful and ergonomically unsound, the necessity of having to pull the shorts over the wound site (as a typical pair of shorts would be put on) becomes inessential.

Figure 5: Compression shorts design with zippers on the side and crotch.

The compression shorts design would effectively take advantage of the elastic properties of nylon. Composed primarily of nylon and polyester, the compression shorts are a comfortable, breathable, and simple design. A primary characteristic of the compression shorts is the material of which it is made. Nylon has important properties that make its utilization exceptional for this design. In terms of durability it has a tensile strength higher than those of cotton, wool, silk, and rayon. This tensile strength can mostly be attributed to the intrinsic elastic nature of nylon, which can be described as 100% elastic under 8% stretch [1]. The elasticity of nylon fulfills the specification of creating pressure around the wound without the deleterious tourniquet effect.

II. Slip Guard

The basic premise of the slip guard is the ability for attachment without special elastic materials, adhesives, or other forms of stabilization. Supported by the natural landmark of the knee, the slip guard would simply rest on the user’s leg and provide a base for the already implemented ace bandage (Figure 6). Because of the assumption that the knee can be utilized as an appropriate site for support, the primary materials would be selected based on an assessment of cost and comfort rather than ability of effectiveness and utilization.

Figure 6: Displays the set up of the slip guard stabilizing an ace bandage wrap.

Statistical Assessment of Slip Guard Design

The Slip Guard design is based on the assumption that the leg contains some genre of projection to allow for the device to rest comfortably on the landmark. For proper utilization, however, proper statistical analysis of this assumption is quintessential. Testing was done by following the data analysis guidelines and standardizations table attached in the appendix. Analysis consisted of the measurement of the circumference of the thigh in increments of 5 cm down the leg starting from a straight line drawn across the leg from beginning of the crotch to the top of the patella. Measurements of the length of the femoral region along with overall height and weight were also taken. The population tested consisted of seven females and fourteen males (unequal populations of the sexes is due to differing levels of willingness to participate).

Preliminary analysis of the data was performed by graphing the circumference of each leg relative to the numbered marking associated with the measurement. Each of these graphs were evaluated and it was determined that an average of all graphs was sufficient for looking at the overall shape of the curve (Graph 1). This graph illustrates that a linear regression model can be initially assumed, as shown by the acceptable coefficient of determination. While this curve does show a generalized function for the conic shape of the leg, further analysis was done to create a more universal definition.

In-depth analysis was done by viewing the data in terms of percent (%) change from initial measurement to the measurement in question. This methodology allowed for a more standardized analysis of data. From inspection and the given R-squared value it can be implied that a function of the conicality of the leg lies somewhere between a 3rd degree polynomial (Graph 2) and a linear regression (Graph 3). Table 1 and Table 2 reiterate this assumption. Table 1 displays the average change in circumference for each measurement in terms of what percent the allocated measurement was of the initial measurement. For instance, measurement 2, which was taken 5 cm from the measurement 1 (the initial measurement), is 95.956 ± 0.0085 % of the initial measurement. It should be noted that the final measurement, as seen in the final row and final column of Table 1, is not applicable due to lack of measurements for this location of the leg.

At this time, further analysis as well as further data collection needs to be performed to properly define the conicality of the leg as a function. This fact can be seen in Table 2, which depicts the information in table 1 in terms of percent change of a measurement compared to the previous measurement. The 95% confidence interval for this data set is not sufficient enough to conclude a linear relationship.

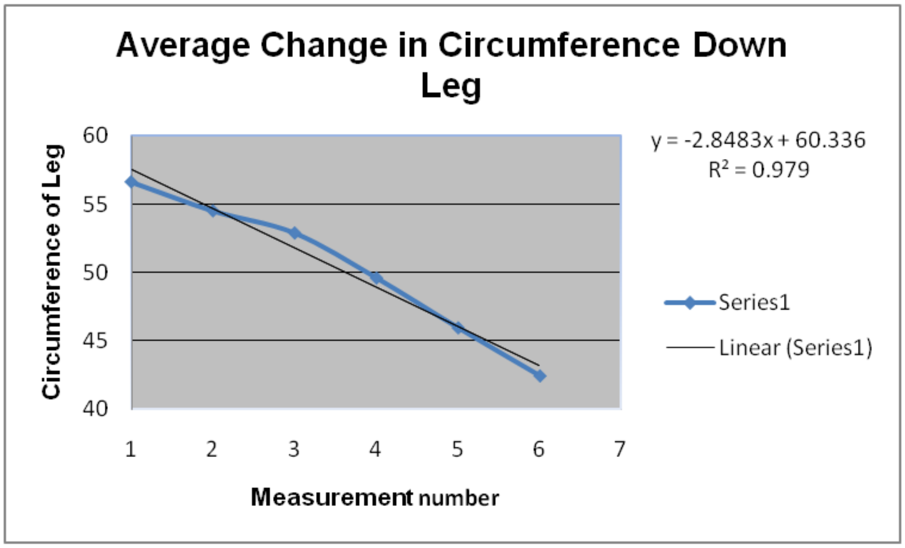
In essence these statistics can be utilized in two parts. Primarily they show that no protuberance is in existence at any point down the femoral region of the leg to the patella. This conclusion, in itself, makes the mentioned above slip guard ineffective. This statistical analysis can also be used for future work of this design in terms of creating different sizes.

Measurement	Distance Down Leg (cm)	Average % of Initial	95% Confidence (%)	95% Confidence (cm)
1	0	100	0	0
2	5	95.956	±0.0085	56.643 ± 0.0048
3	10	92.74	±0.012	54.53 ± 0.0046
4	15	86.64	±0.020	52.91 ± 0.0049
5	20	79.86	±0.026	49.63 ± 0.0042
6	25	74.31	±0.021	45.99 ± 0.0039
7	30	69.27	±0.019	42.48 ± 0.0036
8	35	66.8	±0.026	N/A

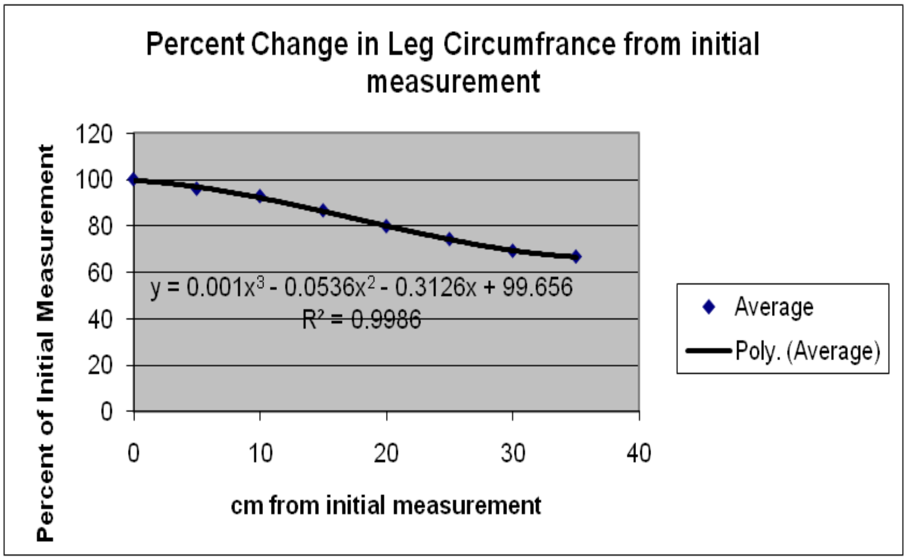
Table 1: Displays the average change in circumference for each measurement in terms of its' percentage of the initial measurement.

Measurement	Average % Change From Previous
1	N/A
2	4.044
3	3.216
4	6.1
5	6.78
6	5.55
7	5.04
8	2.47
Overall Average With 95% CI	4.743 ± 1.24 %

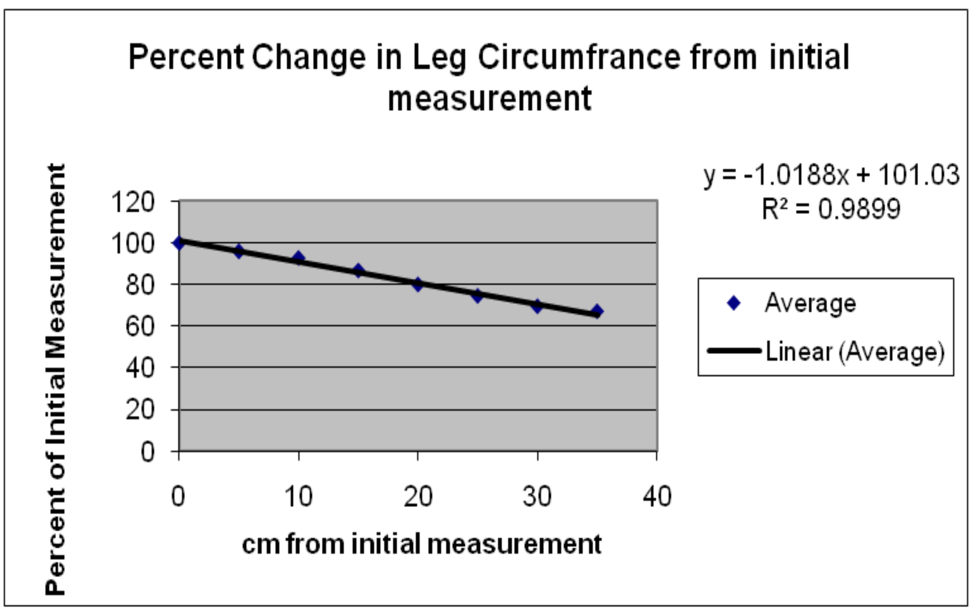
Table 2: Depicts the average percent change of each measurement in terms of how it relates to the previous measurement taken.



Graph 1: Displays the average circumference of the leg with each measurement.



Graph 2: Displays the 3rd degree polynomial of the average percent change in terms of the percentage of the initial measurement



Graph 3: Displays the linear regression of the percentage change in terms of the percentage of the initial measurement.

III. Elastic Leg Wrap Design

The third and final design is called the Elastic Leg Wrap (Figure 7). The Elastic Leg Wrap is essentially a one piece elastic fabric made of either nylon or spandex/cotton fabric. The leg wrap will be wrapped over the existing dressing applied to the wound and will entirely replace the need for an ace bandage. The same design can be used for the upper and lower leg as well as the upper and lower arm. One size of this leg wrap will fit most consumers, but multiple sizes can be manufactured for optimal comfort and stability. Ideally the Elastic Leg Wrap will only go around the thigh approximately one and a half times in order to reduce discomfort, sweating, and too much pressure on the wound. Minimal need to wrap the leg will also result in a light weight, durable product, which will preferably be machine washable and disposable after the patient has fully recovered.

Figure 7: Elastic Leg

To make the Elastic Leg Wrap safe for all consumers the fabric it is made out of must be both hypoallergenic and easy to put on. In some instances, patients are bed ridden after a skin graft or other surgery, so the leg wrap should be able to be placed on a patient while lying in bed with ease. The fabric of choice has not yet been fully determined, but the leg wrap will be made out of a mostly nylon, elastic fabric. The wrap must be elastic in order to apply appropriate pressure to the dressing and also to allow the leg wrap to stay in place on the leg without slipping down the leg and disturbing the wound dressing.

To assist in keeping the leg wrap from sliding down the leg due to the effects of gravity and the conic shape of the thigh, the design team is interested in creating a non-slip lining on the interior of the wrap. This lining will be made predominantly of small squares of rubber (Figure 8). This rubber will be latex free, and will not cover the area of the dressing. The idea behind the small rubber squares is to increase the static coefficient of friction against skin to prevent slipping. Considerations for the rubber lining include; making sure the rubber does not pinch the skin when stretched, having enough breathing room between squares so the leg does not perspire, and creating the right placement of the rubber to maximize the friction on the leg. In order to avoid any friction over the wound dressing the rubber will be localized to only one section of the leg wrap.

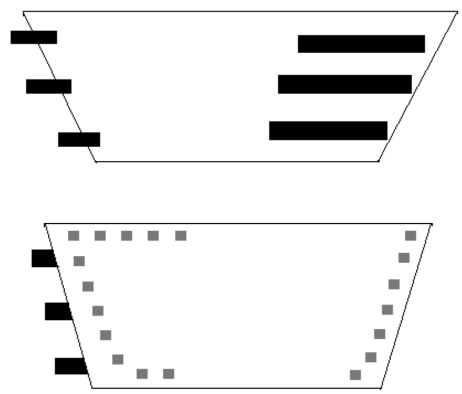


Figure 8: Diagram showing the adjustable Velcro on the outside and the rubber on the inside.

The leg wrap will be secured around the thigh by a series of plastic Dual Lock strips. Dual Lock is essentially Velcro, but instead of cloth it is made out of plastic. This makes it more durable and more secure. By adhering three strips to the outside of the leg wrap, the patient can easily adjust the pressure on the dressing and also the pressure on the leg to keep the apparatus from sliding off the desired area. On the leading edge of the wrap there will be three dual lock tabs that when wrapped around the leg will secure to the three strips. This securing system is extremely durable and adjustable. The Dual Lock will not degrade if the patient decides to wash the wrap.

Design Matrix

Criteria		Possible Designs		
Considerations	Weight	Elastic Wrap	Compression Shorts	Slip Guard
Feasibility	20	19	16	5
Ease of Fabrication	10	9	6	9
Durability	10	8	8	9
Ergonomics	20	19	13	15
Safety	15	15	15	15
Adjustability	10	9	6	8
Client Preference	15	15	12	10
Total	100	94	76	71

Figure 9: Design matrix

This design matrix evaluates the three possible designs in seven different categories. Each category is weighted to give the designs an assigned score out of 100. As shown in Figure 9, the Elastic Leg Wrap outscores the other two designs by a considerable margin. The areas where the leg wrap excelled are feasibility, ergonomics, adjustability, and client preference.

Feasibility combines the effectiveness of the design as well as an overall ranking of whether or not this product would be used by consumers. The leg wrap outscores the other two designs in this region because it will have a good chance of staying in place on the leg, as well as being easy to use and apply. The compression shorts will also stay on the dressing well, but will be more difficult to but on a patient and could potentially make daily activities more difficult. The leg wrap and the slip guard both scored high in the ease of fabrication. They both have fairly simple designs, whereas the compression shorts are more complex and would be harder to manufacture. The slip guard is considered to be the most durable of the three designs because it has the least amount of material, and would require the least maintenance. All of the designs scored well in the durability category because they would all be made out of similar durable fabric with no moving parts. The ergonomics category takes into account the ease of application and comfort level for the user. The leg wrap was decided to be the easiest to put on because it could easily be done by one person while lying down, and would be the most comfortable because it is localized to the donor site. All of the designs are safe and will not harm the user. In the adjustability category the leg wrap was rated the highest again because it can be wrapped as tightly or as loosely as desired, creating room for varying sizes of leg. The last category is client preference in which we asked our client which he preferred. He sided with the leg wrap due to its comfort, ease of application, and ease of fabrication. The Elastic Leg Wrap clearly out scored the other two designs in the seven categories with which they were rated.

Ethical Considerations

Because the product is meant to be used on human subjects, consideration in ethics needs to be addressed. The main target market for the final design is going to be post-surgical patients that require surgical dressings to be stabilized. This market will already be in distress from the pain and the experience of the surgical procedure. Consequently, the final design cannot further cause distress to these patients. In order to ensure this, the final product must not cause further pain and or negative patient responses to the design. The final design will avoid incorporating latex or other allergenic materials to accomplish that goal. In addition, the design must be able to apply a constant pressure to ease the pain of the surgical site, but the pressure must not be so great that it causes further complications such as edema buildup or block off circulation. Furthermore, to facilitate user-friendliness of the design, the final product will be fabricated so that only the patient is needed to apply the design to the intended area. It is important to also note that, in terms of the data collection executed for thigh circumference data, all volunteers have been and will remain anonymous.

Future Work

Proceeding from this point on a large amount of work is still needed to design a properly functioning bandage stabilizer. The final design is the third design, the Elastic Leg Wrap. There is still much to be considered with this design however. One of the most crucial design elements will be determining the proper dimensions for the wrap. The wrap should ideally wrap around the leg one and a half times, but due to the varying size of patients' legs this will only be a bench mark. We must also determine the width of the wrap and the thickness. We can implement multiple layers of elastic fabric if we feel one will not provide enough stability or elasticity.

We must also determine the proper rubber material that will be used inside of the wrap. The rubber must be non-latex based, have some elastic properties and have a high coefficient of friction with human skin. The rubber must also be thin enough to not cause the leg to be too hot, or it will sweat and destabilize the bandage on the thigh. The rubber will preferably be fastened to the wrap in squares ranging from a quarter to a half inch, depending on which performs better in testing.

Another potential aspect of the Elastic Leg Wrap will be an optional belt attachment. The belt would also be made out of elastic material so it would easily fit under the waist band of pants, and would be adjustable in size. The belt would secure to the existing dual lock strips on the leg wrap and this would provide added stability and prevent slippage. The optional belt would be well suited for patients who are more active and exercise more. All additional aspects of the leg wrap will be subject to testing. Testing the wrap under normal walking circumstances will show whether the inner lining is working properly to prevent the wrap from slipping down the leg and removing the dressing from the wound.

To remain on task in completing the final design, a schedule was composed as shown in Figure 10. Even though our client gave no specified budget and that he would support anything that is reasonable, the team's goal is to remain under $300 in the design and fabrication of the final design. However, it is the team's goal to have the market price of the design to be less than $40.

Tasks	January	February				March				April					May
	28	4	11	18	25	4	11	18	25	1	8	15	22	29	6
Research			X	X	X	X									
Brainstorm			X	X	X										
Prototype Design						X									
Fabrication															
Testing															
Meetings															
Client		X			X										
Team	X	X	X	X	X	X									
Presentation															
Mid-Sem						X									
Final															
Deliverables															
PDS		X				X									
Peer/Self Evaluation															
Progress Reports	X	X	X	X	X	X									
Mid-Sem Report						X									
Final Report															
Website	X	X	X	X	X	X									

Figure 10: Project schedule

Conclusion

Dr. Michael Bentz requested that we devise a new form of bandage stabilizer. After surgery on the thigh, most commonly skin grafting, a patient must keep a proper dressing on the wound for up to six weeks. Currently the only way to hold the dressing in place is with an elastic Ace bandage. This form of bandage does not stay on the wound and slips off of the leg with any sort of motion. It is also very hard to apply to patients while in bed. In order to solve this problem we have came up with an elastic leg wrap. This is a one piece elastic bandage that wraps around the leg and secures against itself using Dual Lock. Our hope is that this new bandage will not slip down the leg and will allow patients to have a normal range of motion. The design is still being revised and will eventually include a rubber nonslip lining, and an optional belt attachment for added stability. With further testing and design improvements the Elastic Leg Wrap will replace the need for an ace bandage in the result of skin graft harvesting, and will reduce discomfort.

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Appendix

I. Product Design Specifications

Elastic Bandage Stabilizer (PDS)
3/11/2011

Jay (Baljit) Kler, Taylor Jaraczewski, Lucas Schimmelpfenning, and Cody Bindl

Function: The client, Michael Bentz, has requested a device to replace the current elastic bandage used to hold dressings in place on post operation patients. Current methods for maintaining the dressing's position are ineffective since the current bandage typically slides out of place. The primary location of use for the device is around the upper leg. Additional areas of applications can include the lower leg, the upper arm, and the lower arm.

Client requirements:

- Must hold dressings in place even with normal patient movement.
- Must be easily applied by the patient without external help.
- Cannot create a tourniquet effect on the outer extremities.
- Cannot cause excessive chaffing or rubbing.
- Tension and size should be adjustable for use by various sized patients.

Design requirements:

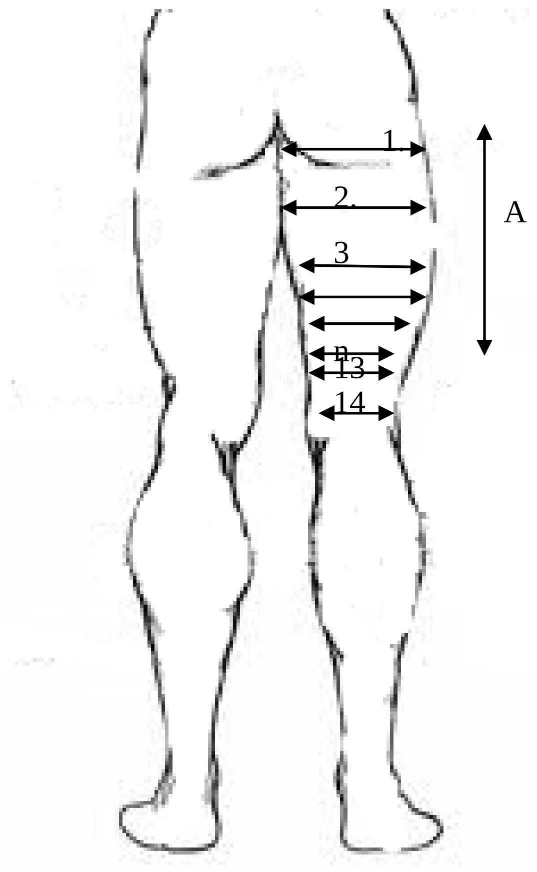
1. **Physical and Operational Characteristics**
    a. *Performance requirements:*
        i. The device must hold the dressings in initial position.
    b. *Safety:*
        i. The device must be made out of non allergenic materials such as latex.
        ii. The device must not limit blood flow or lymphatic circulation.
        iii. The device must be washable or disposable to prevent infection of the exposed wound.
    c. *Accuracy and Reliability*
        i. The client wants a device that will be effective in 99 percent of the cases.
    d. *Life in Service:*
        i. The device must be usable for 4 to 6 weeks.
    e. *Shelf Life:*
        i. Sterile before use.
        ii. Easily storable.
    f. *Operating Environment:*
        i. Attached to a human limb.

        ii. Must be able to accommodate locomotion and be contained under clothing.

    g. *Ergonomics:*
        i. Comfortable for patient.
        ii. Must be easy for patient to apply without help.
        iii. Must maintain its position with normal patient movement.
    h. *Size:*
        i. Must be able to anchor a dressing in range from 2-15 mm in thickness.
        ii. Must be big enough to cover a 3x4 inch graft.
    i. Weight:
        i. Light enough to not fall off from shear weight.
    j. *Materials:*
        i. Cotton or nylon is preferable.
    k. *Aesthetics, appearance, and finish:*
        i. Function over aesthetics.
        ii. Possibility for future customization (i.e. colorful or themed).

2. **Production Characteristics**
    a. *Quantity:*
        i. At least one proof of concept prototype.
        ii. Eventual varying sizes and lengths for different sized patients.
    b. *Target Product Cost:*
        i. Flexible.
3. **Miscellaneous**
    a. *Standards and Specifications:*
        i. Must be non allergenic.
        ii. Must be durable.
    b. *Customer:*
        i. Customer wants the ability to easily create a themed and/or colored product to be more appealing towards children.
    c. Patient-related concerns:
        i. Must take into account patient allergies.
        ii. Must not create tourniquet effect.
    d. *Competition:*
        i. The current protocol for stabilizing dressing is wrapping the wound with Ace bandage tape.

II. Data Analysis Guidelines and Standardization Table



Gender: Male/Female

Age:____________

Height:__________

Weight:__________

Leg Circumference

1________

2________

3________

4________

5________

6________

7________

8________

9________

10_______

11_______

12_______

Knee Circumference

12_______

13_______

14_______

Thigh Length (1-n)

A________

Measurement Process and Standardizations:

- Measure total height, mass, and gender of subject.
- All measurements should be taken in metric (weight may need conversion)
- All measurements should be taught enough to prevent slack without an impression.
- All circumferential measurements should be taken straight across leg (along horizontal line)
- Determine the highest point along the groin. (1)
- Measure from predetermined point to top of the patella (A)->(1-n)
- Mark five centimeter increments from 1-n.
- Measure circumference at each point with the top of tape at marked point (at point n, use bottom of tape) (1,2,…n)
- Measure at top, middle, and bottom of the patella. (12,13,14)