CHAPTER 2
ARIZONA STATE UNIVERSITY

College of Engineering and Applied Sciences
Bioengineering Program
Department of Chemical, Bio & Materials Engineering
Tempe, Arizona 85287-6006

Principal Investigator:

Gary T. Yamaguchi, Ph.D. (602) 965-2268
yamaguchi@asu.edu

A Compact Disc Assistive Device

Designer: Akram Moqbel
Client Coordinator: Ms. Barbara Hightower
National Multiple Sclerosis Society Southwest Branch
Supervising Professor: Gary T. Yamaguchi, Ph.D.
Bioengineering Program
Department of Chemical, Bio & Materials Engineering
Arizona State University
Tempe, AZ 85287-6006

INTRODUCTION

A compact disc (CD) assistive system was designed for a patient with multiple sclerosis. The system consists of two main devices. One device releases the CD from the CD case (releaser), and the other device lifts the CD from the CD case and allows the CD to be placed in the CD player (lifter). The patient places the releaser on his left hand and tightens the Velcro strap around the hand for a snug fit (Fig. 2.1). With the aid of the releaser, the patient can release the CD from the CD case by pushing on the rounded center of the case. The lifter consists of the following components: a cushioned handle, a stainless steel bar, and a tacky adhesive disc. The stainless steel bar is made from a small, telescoping steel pointer to allow the patient to change its length easily depending on how far the CD player is from the patient. The patient holds the lifter in his right hand, places the adhesive disk on the topside of the CD, and lifts it to the CD player. He can follow the same procedure to lift the CD back from the CD player to the CD case. A bag, which can be attached to the wheelchair, was made to store the device when it is not in use.

SUMMARY OF IMPACT

Multiple sclerosis (MS) is a disease of the central nervous system (CNS). Some of the primary characteristics of MS are weakness, numbness, visual disturbance, dizziness, ataxia and pain. Some MS patients are not able to grip a CD to release it from a CD case, lift a CD to a CD player, or put a CD away after using it. Multi-disk CD changers are expensive and are difficult to use because the CDs are lying flat and patients cannot pick them up. As a result, a device that assists MS patients to change the CDs in their CD players is particularly helpful. The assistive device described above helps MS patients to change CDs and improves their quality of life. An added benefit is that a small powerful magnet at the end of the lifter, right above the adhesive disk, allows the patient to also pick up metallic

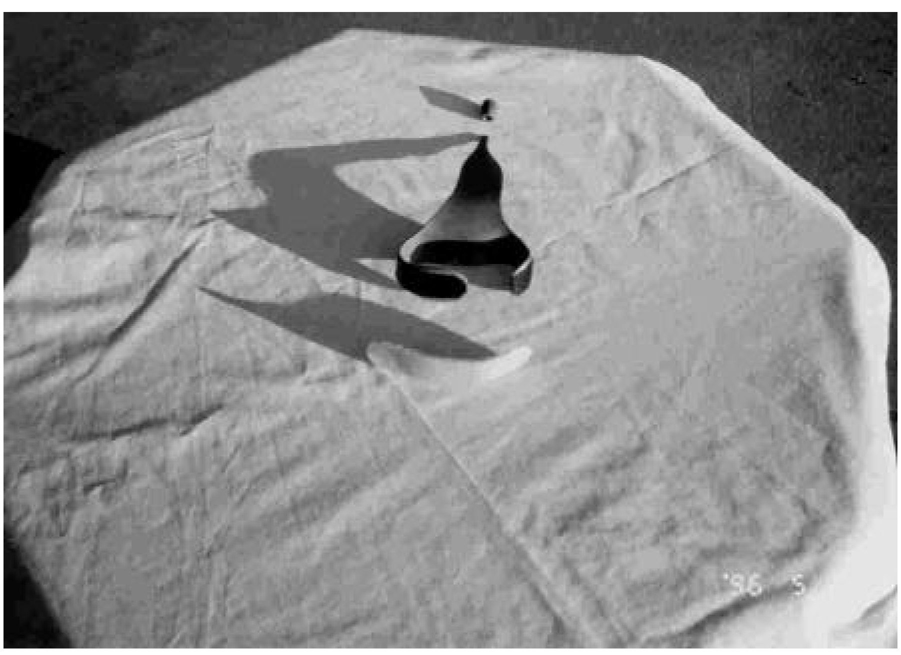

Figure 2.1. The Releaser.

objects (e.g., keys) while sitting in a wheelchair. The compact disc assistive system was designed with a particular client in mind, but this device could be used by anyone who has limited finger dexterity (e.g., arthritis).

TECHNICAL DESCRIPTION

The main design requirements of the system were: 1) it had to function properly in order to improve the quality of life of the patient; 2) it had to be lightweight due to the weakness of MS patients; 3) it had to be affordable; 4) it had to be readily accessible to the user from his wheelchair; and 5) it had to be safe and convenient to use.

The compact disc assistive system has two main devices, the releaser and the lifter (Figures. 3.1, 3.2). Both the releaser and the lifter fit easily into a pocket, purse or the bag designed to be attached to the wheelchair. The Releaser is made of hard plastic, cut to shape, heated, and molded to the patient's hand. A rubber tip was fit over its end. On the top of the releaser, there is a space for the hand to be placed in and a Velcro strap tightened around it for a better fit. The patient can easily push on the center of the CD case to release the CD.

Figure 2.2. The Lifter.

The Lifter does not require any tight gripping, squeezing, or an arm lifting action. The telescoping stainless steel rod reaches from 8 to 34 inches, which allows the user to keep his arms close to his body. The Lifter has a 1.25-inch diameter to eliminate the need for a strong grip. A strap around the back of the hand provides additional stability without requiring muscular exertion. The adhesive/sticky disk attached to the end of the stainless steel rod is made of a tacky rubber compound that will remain tacky for several hundred uses. It is commercially replaceable. A good supply, along with order forms for replacements, was packaged with the unit when it was delivered to the client. A swivel (pin) joint attaching the disk to the rod ensures that flush contact between the tacky disk and the CD will be made without requiring precise alignment.

To lift the CD, the following steps must be followed. First, the lifter rod is extended and the sticky disk is placed somewhere on the CD. Then the disk is pressed gently downward to ensure the proper amount of adhesion. The CD is then lifted slightly. It is released by pushing on the center holding area with the releaser.

Tests on the system were conducted by having the client use it. The device completely and efficiently enabled the patient to perform the relevant tasks. One design modification based on the results of these tests is the addition of the hand strap around the handle of the lifter for comfort and safety.

The final material cost of the compact disc assistive device was approximately $110, which included an ample supply of tacky/adhesive disks.

Detachable Wheelchair Headrest

Designer: Salem M. Mostofo
Client Coordinator: Ms. Barbara Hightower
National Multiple Sclerosis Society Southwest Branch
Supervising Professors: Gary T. Yamaguchi, Ph.D. and Daryl R. Kipke, Ph.D.
Bioengineering Program
Department of Chemical, Bio & Materials Engineering
Arizona State University
Tempe, AZ 85287-6006

INTRODUCTION

Multiple Sclerosis (MS) is a disease of the brain and spinal cord, characterized by the loss of myelin that surrounds nerve fibers. Its most frequent symptoms are weakness, deteriorating coordination and tremors. Some individuals with MS use a wheelchair for mobility. Standard wheel chairs cost about $1000. Because of insurance limitations many patients cannot afford more expensive wheelchairs that come with accessories such as headrests, eating trays, etc. Due to weakness and fatigue, MS patients may not be able to sit upright for extended periods of time and thus need to lie back and rest their heads. Therefore, there is a need for an affordable, attachable/detachable headrest that will fit standard wheelchairs. Other wheelchair users would also benefit. It is critical to note that most people who require wheelchairs tend to spend many hours in them. The objective, therefore, is to develop a headrest that is affordable and attachable to standard wheelchairs (Figs. 2.3, 2.4).

SUMMARY OF IMPACT

Some MS patients spend a large amount of time in their wheelchairs. A headrest has been designed as an add-on accessory that helps them to be more comfortable in their chairs. The headrest can be adjusted to a variety of both chairs and patients. It provides the comfort needed and expected by the patient. The contour design of the headrest (Fig. 2.3) provides stress relief of the cervical musculature, which makes it comfortable to remain in the chair for longer time periods. The final design is a useful tool for most wheelchair users and is seen as a potentially helpful device to enhance their quality of life.

TECHNICAL DESCRIPTION

The wheelchair attachable/detachable headrest was designed for one particular MS client, but it can fit any standard wheelchair 14 to 22 inches wide. The headrest was designed to be lightweight, affordable, adjustable in height, simple to manufacture, and easy to detach. It was also designed to provide comfortable head and neck support.

Figure 2.3. Detachable Headrest with Client.

The headrest has two main components: the headrest cushion and the rods attaching it to the wheelchair. Two pieces of aluminum tube are welded together to form an inverted "T". Pieces of tubing that are smaller in diameter fit snugly inside the two arms of the T. Sliding these pieces longitudinally inside the tubes that are larger in diameter accomplishes the length adjustment in both the crosspiece and the vertical support arm. A custom designed clamp is attached to each end of the horizontal crossbar. The crossbar can be adjusted by small increments to fit a wheelchair from 14 to 22 inches by tightening the setscrews. The vertical tubing can also be adjusted and is used to position the headrest cushion at the proper height. The headrest is contoured and custom fit to the client so as to provide some lift at the back of the head.

The client tested the headrest for a short time and found it to be comfortable. The headrest needs to be tested further to determine if the cushion is comfortable for longer time periods.

To start manufacturing the headrest the technical drawings below may be used to communicate to the manufacturer. The following materials are required:

- 24″ of aluminum tube (T6061 was used, 1″ OD x 1/8″ wall); 1 piece @ $22.00
- 36″ of aluminum rod or tube (3/4″ OD x 1/8″ wall); 1 piece @ $7.00
- custom aluminum clamps; 2 each @ $20.00 = $40.00
- stainless steel set screws; 14 @ $ 0.69 = $ 9.66
- custom molded headrest cushion; 1 @ $ 60.00
- machining and welding services; 2 hours estimated @ $ 50.00/hr

The total cost to make the prototype was about $139 dollars excluding labor.

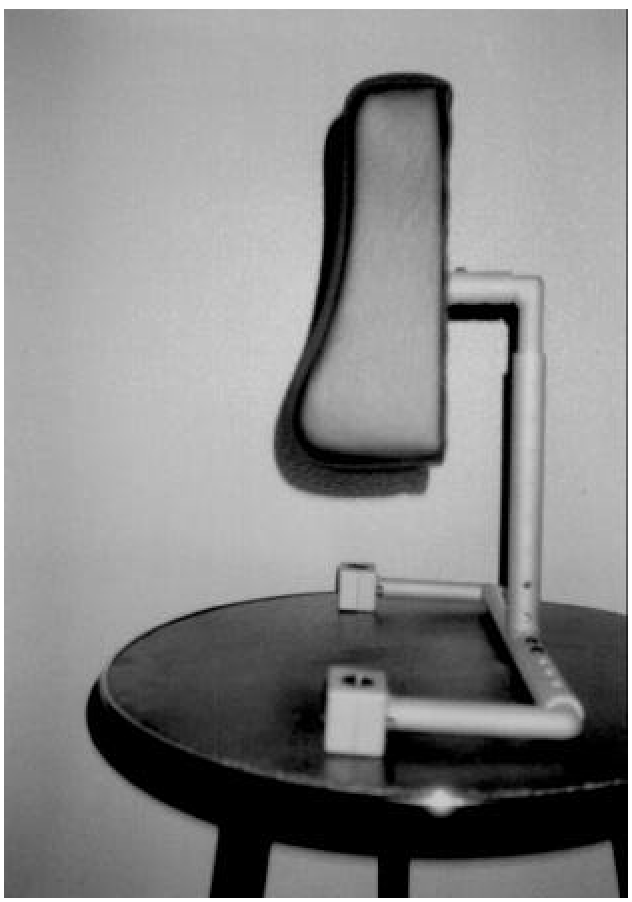

Figure 2.4. Side View of Detachable Headrest.

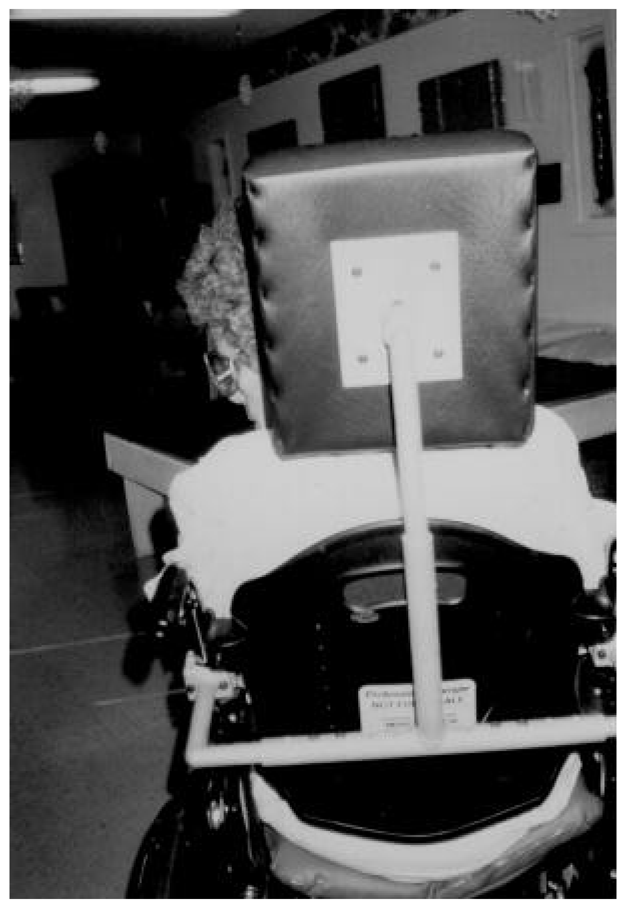

Figure 2.5. Back view of the Detachable Headrest.

Design of a Wheelchair Operable Checkstand

Designer: Ian Rybyczynski
Client Coordinator: Ms. Erika Gehres
Graduate Student, Bioengineering Program, ASU
Supervising Professor: Gary T. Yamaguchi, Ph.D.
Bioengineering Program
Department of Chemical, Bio & Materials Engineering
Arizona State University
Tempe, AZ 85287-6006

INTRODUCTION

A checkstand and register that accommodates wheelchair bound employees has been designed for an employee of Wal-Mart, Inc. The wheelchair accessible checkstand consists of five components: the track system, the chair frame, air cylinders, two steel plates for support, and a pneumatic supply system. The chair frame is mounted on five air cylinders with a steel plate on both the top and bottom of the cylinders to provide rigid support. The steel plate on the bottom is attached to a track system set into the floor so as to be unobtrusive to other checkstand operators. The track system uses linear bearings with a low coefficient of friction so that the chair can be moved easily. Handholds placed on the checkstand allow a person to move freely along the checkstand. The air compressor will allow the air cylinders to raise and lower the chair, and will be stored under the counter in a sound insulated cabinet. The design has been delivered to the client, and awaits an evaluation from Wal-Mart, Inc.

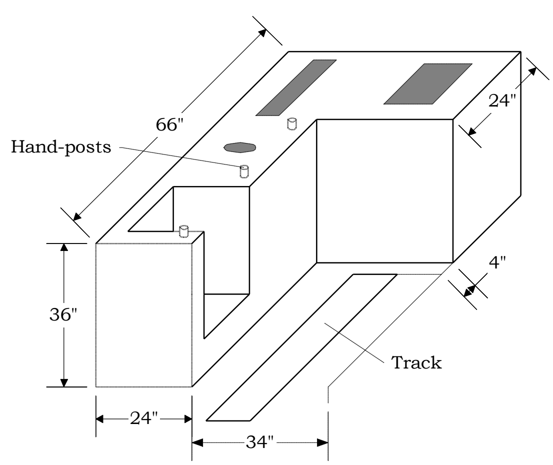

Figure 2.6. View of Wheelchair Operable Checkstand.

SUMMARY OF IMPACT

With the passing of the Americans with Disabilities Act (ADA), businesses must provide reasonable accommodations for their employees with disabilities. Wal-Mart does hire people with disabilities, but those who are not able-bodied are largely unable to work at checkstands because the existing checkstand design does not allow a person in a wheelchair to operate comfortably. This design will give employees at Wal-Mart who use a wheelchair the opportunity to operate a checkstand.

TECHNICAL DESCRIPTION

The wheelchair operable checkstand was designed for an employee at Wal-Mart, Inc., but it may be used by other stores with employees who use a wheelchair and still have the use of their upper body. The main design requirements were: 1) the operator must be able to see and readily use all of the standard register equipment; 2) the operator must be able to transfer in and out and work the checkstand independently; 3) the design must be safe for the user; and 4) the operator must be able to see and greet the customer comfortably. The goals for the design were to create a solution that is independent of the design of the original checkstand, and to ensure that the checkstand can also be used by able-bodied employees.

The wheelchair operable checkstand has five major components: the track system, the chair frame, air cylinders, an air compression and delivery system, and two steel plates. The track system is a Techno Isel Roller Bearing Pillow Block System. It has a 3/4-inch track and can support up to 1200 pounds. The track has a low coefficient of linear friction, which enables the user to easily slide along the length of the checkstand. One end of the track is placed four inches from the side wall of the checkstand allowing a 22-inch excursion outside the working area of the checkstand. This excess track may be used to put the checkstand chair in a convenient position for transfer to and from a wheelchair. Hand posts are placed along the checkstand to allow the user to move easily from one end of the track to the other. The track system is low maintenance because it only uses the upper half of the roller bearings. This means that even if dust did accumulate along the roller bearings, it would not have an effect on the system.

A 1/4-inch steel base plate is mounted on top of the track system. The air cylinders are bolted to that steel plate to make the system more stable. Five air cylinders are used to prevent the piston rods from bending and binding, ensuring redundancy and safety. If one or two air cylinders break, the other cylinders will be able to operate the chair safely until the broken cylinders can be fixed. The piston rod for the cylinders selected for this application are made out of 3/8 inch stainless steel and the sides are made of 1/8 inch hard coated aluminum alloy tubing. The cylinders are threaded at the bottom and top of the aluminum tube. A 1/8-inch steel intermediate plate with holes for the piston rods is placed over the threaded rods to maintain the vertical, parallel alignment of the rods. The top of the rods are then screwed directly into the underside chair frame.

The air compressor provides up to 220 psi at 1.5 hp. The air compressor, accumulator, and valving will be placed on a shelf enclosed with sound insulation under the counter. Only the pneumatic tubing and wiring for the switch will come out of the compartment. The switch will be placed on the inside wall of the counter so that the user may activate the compressor. The tubing will enter the arm of the chair where it will be hooked up to a pressure release valve. The release valve will prevent over inflation. From there, the tubing will go to a manifold under the chair that will allow the tube to be divided into five tubes of equal length. These tubes will go to each of the cylinders to provide equal pressure to each of the five cylinders and ensure that the cylinders will work together and lift the chair evenly. Each cylinder can lift 100 pounds. at 100 psi.

The chair seat is 20 inches wide by 17 inches long. The chair back is 18 inches high. The chair does not have any padding so each user can add the appropriate padding to match his or her needs.

The final cost of the parts which includes 5 air cylinders, track slide, 5 foot track, 1.5 horsepower air compressor, chair frame, 1/4 inch and 1/8 inch steel plate, and tubing and other miscellaneous parts is estimated to be $924, excluding labor.

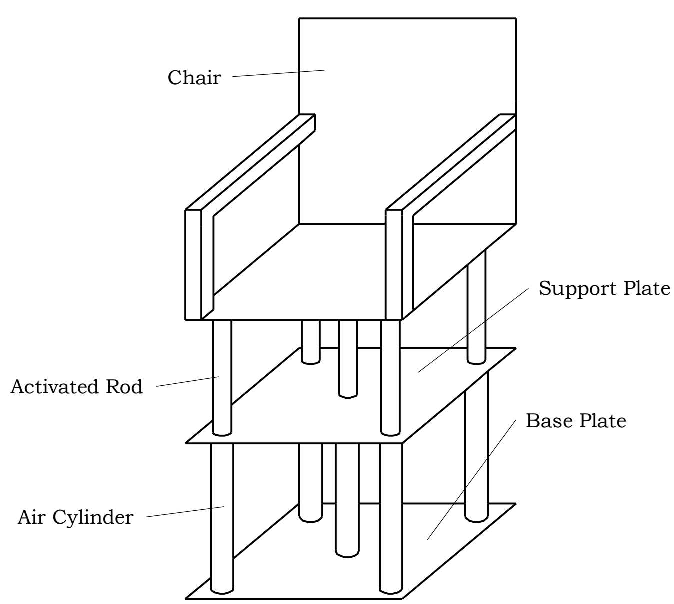

Figure 2.7. Another View of the Wheelchair Operable Checkstand.

A Gear Shifter for an Arthritis Patient

Designer: Nathan Othman
Client Coordinator: Mrs. Cindy Ivy
Physical Therapist, Mayo Clinic, Scottsdale, AZ
Supervising Coordinator: Gary T. Yamaguchi, Ph.D.
Bioengineering Program
Department of Chemical, Bio & Materials Engineering
Arizona State University
Tempe, AZ 85287-6006

INTRODUCTION

A gear shifter was designed for an arthritis patient at the Scottsdale Mayo Clinic. The gear shifter consists of four components: the push button, the gear casing, the steel plate, and the button cover. The gear shifter has a frame similar to the standard gear shifter on the patient's car. The stock gear shifter required the patient to use her thumb to release the gears, but she was unable to do so without letting go of the steering wheel so as to bring both hands to the task. The new gear shifter transfers the releasing force to the palm of the hand, which relieves the weaker thumb from this task. The unit is easy to use, install, remove, and looks like part of the original car.

SUMMARY OF IMPACT

Many arthritis patients cannot do simple tasks because they have limited use of their fingers. Using one finger in isolation can cause severe pain. For instance, the client had difficulty using her thumb to shift the gears in her car. These patients may benefit from having a gear shifter in their car that does not require the use of their fingers or thumb. The gear shifter designed and constructed here met these needs by relocating the previous thumb button gear release to the area contacted by the palm of the hand. This gear shifter is attractive and easy to use, giving the patient the ability to drive a car without causing pain.

Figure 2.8. A Gear Shifter for an Arthritis Patient.

TECHNICAL DESCRIPTION

The gear shifter was designed with a particular client in mind, but could be beneficial to other people with arthritis or other conditions that limit finger and thumb use. The main design requirements of the gear shifter were that it be: 1) painless for the patient to use; 2) easy to use; 3) safe; 4) affordable (having a target price of less than $150); 5) lightweight; 6) similar in size to the old design; and 7) appearing as it were part of the original car.

The gear shifter has four main components: the push button, the gear casing, the steel plate, and the button cover (Figs. 2.8, 2.9). The push button, the gear casing, and the button cover are machined from PVC plastic. The stainless steel holder is dimensioned at 7 x 3 x .15 centimeters. The cover button is dimensioned at 8 x 4 x 1.5 centimeters. The gear casing is dimensioned at 8 x 9 x 4 centimeters. The press button is dimensioned at 6 x 2.4 x 3.85 centimeters. PVC plastics were used because PVC has a high melting temperature, which is especially critical in the summertime climate of Phoenix, where the user resides.

The final test on the design began with the installation of the device on the patient's car. The gear shifter was installed on the patient's car by taking two screws off the original shift knob, inserting the new design in its place, then reusing the old screws to secure the new device. The patient was very happy with the final design because it met all her requirements and needs.

The material cost of the gear shifter was approximately $50.

Figure 2.9. Another View of the Gear Shifter for an Arthritis Patient.

Knee Fracture Brace Joint

Designer: Natasha Tomecak
Client coordinator: Mrs. Becky Heffron, CO
Prosthetic Orthotic Associates, Scottsdale, Arizona
Supervising Professor: Gary T. Yamaguchi, Ph.D.
Bioengineering Program
Department of Chemical, Bio, and Materials Engineering
Arizona State University
Tempe, Arizona 85287-6006

INTRODUCTION

A knee joint on a fracture brace, was designed to be adjustable by locking at a variety of flexion angles, was designed. The mechanism was made to allow free motion to the angle of extension and flexion that is set (Fig. 2.10). The total range of the brace includes the normal knee flexion range of 0 to 135 degrees. The state-of-the-art knee fracture brace joint can only lock at 180 degrees and the range of motion is limited to a small number of angles. In the new mechanism, if limited motion is desired, the limits of flexion and extension can be set in 10 degree increments over a 180 degree span, using 3 stainless steel pins.

SUMMARY OF IMPACT

A large number of patients in the United States damage the hard and/or soft tissues of the knees. Knee bracing plays an important role in rehabilitation following injury. A rehabilitative brace is designed to provide a progressive range of controlled motion for persons with knee injuries treated both operatively and non-operatively. These braces offer increased patient comfort because they are lightweight and adjustable for optimal fit. They also permit easy removal and reapplication for wound inspection and rehabilitation. They permit passive and active motion and are used for rigid immobilization when necessary. The angles of limited motion allowed after an injury differ for every individual and are prescribed by the doctor.

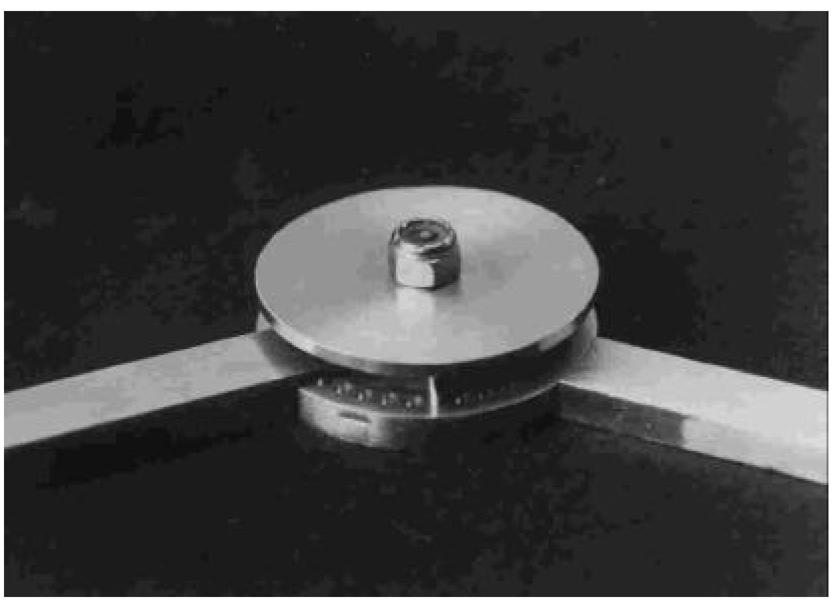

Figure 2.10. Knee Fracture Brace Joint.

In the treatment of knee injuries or following surgery, regaining full range of motion is of primary importance. Two aspects of rehabilitation, continuous passive motion (CPM) and therapeutic exercise done in conjunction with knee bracing, may allow for earlier recovery. CPM following ACL reconstruction has three goals: 1) improved ROM by early passive exercise; 2) control of anterior/posterior drawer forces during the motion; and 3) improved pain management following surgery. Patients can now be fitted with the hinged rehabilitation device so that the ROM can be controlled by the brace while the leg is in the CPM device. Also this improved hinge design gives rehabilitative knee braces the ability to adjust to a wider range of patients and injury conditions.

TECHNICAL DESCRIPTION

The knee fracture brace prototype was built out of balsa wood. Changes were made throughout the construction of the prototype. The changes included the cover design, the number of adjustment angles, and the locking mechanism. The material chosen for the working prototype was aluminum T-6061, currently used in the aircraft industry. This material can withstand a great deal of stress, yet is very lightweight, easily machined, and readily available.

The brace consists of a bar eight inches long, 0.625 inches wide, and 0.125 inches thick. The other part is a bar with a circle attached to it. It is 6.5 inches long, 0.625 inches wide, and 0.125 inches thick. The circle has a diameter of 2.25 inches. There are 25 holes, 0.125 inches in diameter, arranged in a circular fashion. These holes are 10 degrees apart. There is also a cover of 2.25 inches in diameter, and three 0.125-inch diameter steel pins.

Brace hinges function well in limiting flexion and extension motions. The question arises as to how well they function in alignment with the knee joint. Subjects observed were able to achieve 15 to 20 degrees more extension than the original hinge had allowed, due to play between the soft tissues of the leg and the brace. It is suggested that an extension stop of at least 10 to 20 degrees greater than the desired limit be used for all patients, particularly those in a more active stage of rehabilitation.

A suggested pattern of usage follows. After knee ligament surgery of an athletic person, the extremity should be placed in a brace and locked at 60 degrees. Motion allowed by the brace is encouraged if continuous passive motion is used. A range of 70 degrees of flexion and -40 degrees of extension is set. After 4 days the brace is set at 60-90 degrees. The hinges are adjusted at eight weeks, allowing motion mirroring the motion present in the knee (about 20 to 100 degrees). For at least one year postoperatively, bracing is used for any athletic activities to control rotational instability as well as medial and lateral instability. Patients should be until they can perform normal eccentric and concentric contractions.

This brace joint is compatible with current rehabilitative knee braces. The design meets the requirements and specifications listed by the client coordinator, a certified orthotist. Overall, cost was $420 for a single unit, including labor, which would decrease significantly in mass production.

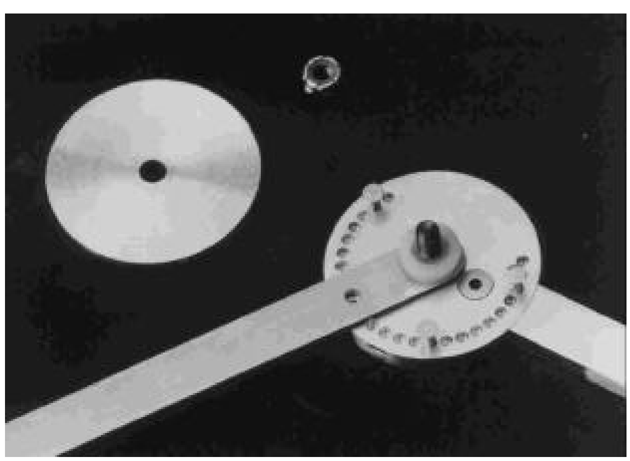

Figure 2.11. Another View of the Knee Fracture Brace Joint.

Laundry: Not A Chore Anymore

Designer: Kelly Jordre
Client Coordinator: Ms. Erika Gehres
Graduate Student, Bioengineering Program, ASU
Supervising Professor: Gary T. Yamaguchi, Ph.D.
Bioengineering Program
Department of Chemical, Bio & Materials Engineering
Arizona State University
Tempe, AZ 85287-6006

INTRODUCTION

A laundry cart has been designed for a person with multiple sclerosis (MS). The cart is a single unit comprised of a clothing receptacle with a handle and wheels attached (Figs. 2.12, 2.13). The body of the cart consists of a rectangular, four-sided metal box frame. A handle extends from the back of the frame of the cart to allow the subject to push or pull the cart. Located at the base of the front of the cart are two metal posts that act as a "kickstand" and will support the cart when the subject is not moving it. The base of the cart is enclosed by five sheets of metal: two on the sides, one on the back, one on the front, and one on the bottom. The two side sheets extend just beyond the height of the wheels to prevent contact with anything that may be transported in the cart. Hanging inside the cart are two full sized laundry bags for easy separation of the clothing articles. The wheels are sized for ease of use in traversing the concrete stairway at the client's apartment building.

SUMMARY OF IMPACT

The patient has a neurological disorder that sometimes causes her left leg and left arm to stiffen up, and that induces episodes of poor balance. During these times, she finds it difficult to walk, especially up and down stairs, and to carry items of significant weight for any length of time. The subject lives on the second floor of her building, and the laundry room is about a block away. These circumstances, combined with her condition, make it extremely difficult for her to do her laundry. Currently she carries a plastic hamper to and from the laundry room, but continues to have difficulty. One can see that what may be a simple chore for some, is very trying and time consuming for her. Ultimately, the patient desires to be able to carry at least two loads of laundry at a time along with all of her various detergent items. The design of this laundry cart will make the chore of doing laundry much simpler for the subject. Not only will it allow her to carry the desired two loads of laundry plus detergent items to and from the laundry room, but it will also allow for easy mobility up and down the stairs.

Figure 2.12. Laundry Cart.

TECHNICAL DESCRIPTION

The laundry cart was designed with a particular patient in mind; however, the device could be beneficial to any individual needing to transport a variety of different articles. The design of the laundry cart had a number of constraints, but the main design requirements were as follows. The design of a device must be "stair friendly." In other words, the subject must be able to get the device up and down the stairs easily. From here, the subject must be able to get the device to and from the laundry room easily. The device also needed to be lightweight. For best results, it was desired that the assembled weight of the cart, plus laundry and detergent items, (total weight) be less than 30 pounds. This thirty-pound limit was based on the subject's estimated load carrying capacity. The device also had to be safe to use. As a final constraint, the cart needed to be sturdy and stable, ensuring that it would not tip over, and that it would support the patient if she lost her balance. After various brainstorming activities, an initial design was decided upon. Technical drawings were made, and a prototype was designed and built. Unfortunately, at the time of manufacturing, the materials desired for use in the prototype were not available. Consequently, the prototype could not be manufactured as originally specified. The materials used for the manufacturing of the prototype were chosen solely based on availability. As expected, the prototype model alone weighed 43 pounds. (More than the desired maximum total weight). However, if the prototype had been built with the desired specified materials, it would have weighed 24 pounds. The cost of the manufactured prototype cart was $502.

In the specified prototype, the wheels have a pneumatic configuration with a plane bore hub assembly. This means that the hub assembly is gone and is replaced solely by a steel shaft into which the axle is inserted. As stated previously, differences between the manufactured prototype and the specified prototype lie in the materials and wheels used. The tubing wall thickness and the sheeting thickness used in the manufactured cart were .125 inches and .083 inches respectively, versus the .072 inches and .050 inches specified for the prototype cart. Also, the wheels used in the manufactured cart are of a much heavier-duty construction with a load capacity of 150 pounds., and have a semi-pneumatic configuration with a ball bearing hub assembly. These differences account for the large weight difference between the manufactured and specified carts.

Although the prototype would have ultimately met the original specifications, further investigation showed that some changes could be made to im-

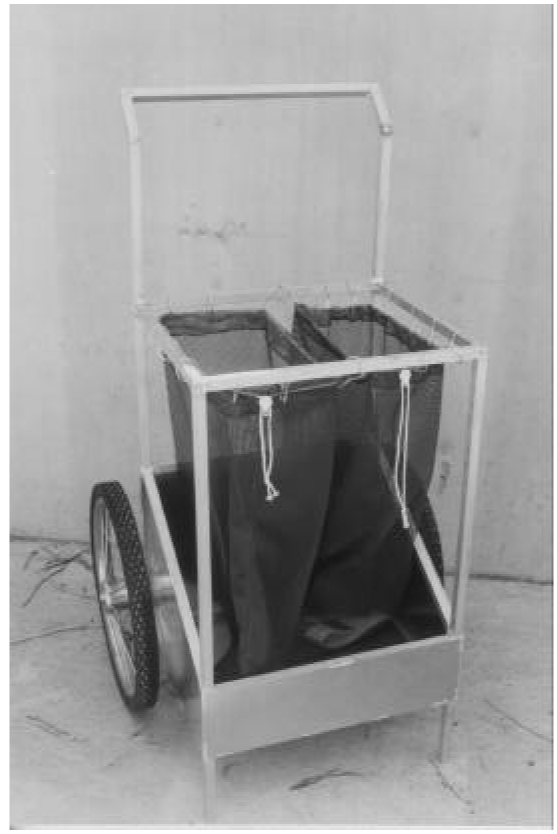

Figure 2.13. Another View of the Laundry Cart.

prove the design. The materials and wheels used in the new design remained the same, but the volume of the new cart was reduced by approximately 50%. In the prototype design, two loads of laundry were viewed as two bags of laundry. In actuality, one bag is more than sufficient to hold two loads of laundry. This would allow the size of the laundry cart to be reduced. In the new design, the cart is estimated to weigh 21 pounds. Assuming that the average load of laundry is approximately 4 pounds., the total weight of the cart and items would be 29 pounds.

Final design drawings have been drafted and all specifications have been determined for the new design. If time permitted, the new design could go on to the manufacturing stage. The final cost of this cart design would be $440.

A Shaving Device for Pregnant Women

Designer: Stelios Zarvos
Client Coordinator: Ms. Erika Gehres
Graduate Student, Bioengineering Program, ASU
Supervising Professor: Gary T. Yamaguchi, Ph.D.
Bioengineering Program
Department of Chemical, Bio & Materials Engineering
Arizona State University
Tempe, AZ 85287-6006

INTRODUCTION

A leg-shaving device was designed for a pregnant woman. The device consists of three main components, the locking mechanism, the holder, and the arm. The locking mechanism has two plastic parts that screw together, and between the plastic parts is a tightening ring to ensure a good mechanical lock of the arm to the holder (Figs. 2.14, 2.15). The ring tightens when the two plastic parts screw together, and loosens when the plastic parts are unscrewed, allowing elongation of the shaving device. The holder consists of an aluminum pipe, a grip around the pipe, and an end-fitting plastic cap with a string to hang it up. The grip has anti-slip characteristic under wet conditions so that the device does not slip when the woman is using it in the shower. The arm consists of an acrylic pipe, a small polyvinylchloride (CPVC) pipe, 45° CPVC joint, and a standard safety razor with replaceable blade. The device is safe to use, inexpensive, lightweight, adjustable, and portable.

SUMMARY OF IMPACT

During the last two to three months of pregnancy, the ability of a woman to bend forward or to the side is significantly reduced. Furthermore, the spinal cord carries an eccentric load, because the center of gravity of the woman is moved anteriorly towards the fetus. In many cases of pregnancy the eccentric load leads to back pain that restricts the range of motion even more. As a result, the pregnant woman's task of shaving her legs becomes difficult and potentially can lead to injuries. Both the woman and her unborn child are exposed to the possibility of slipping in the shower or bathtub. The shaving device makes shaving much easier and provides a margin of safety. Also, there are further improvements that can be made on the device, such as attaching a strap to go around the back of the hand, which will make the device usable for persons with arthritis.

Figure 2.14. Photograph of the Shaving Device for Pregnant Women in Use.

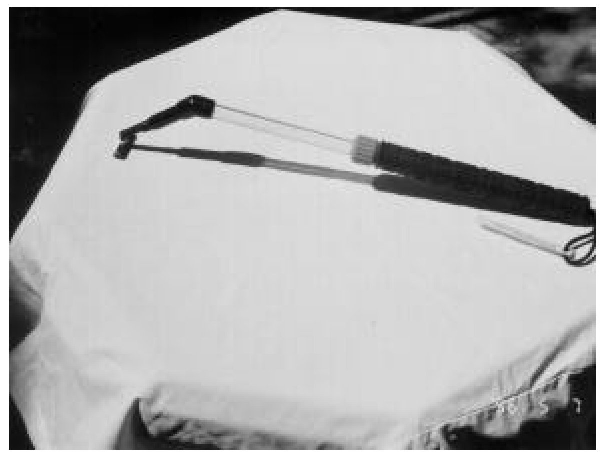

Figure 2.15. Close-Up Photograph of the Shaving Device for Pregnant Women.

TECHNICAL DESCRIPTION

The leg-shaving device was custom designed for a particular client, but could be useful for any woman that has trouble with reaching provided she has no trouble with grasping. The main requirements of the shaving device were that it: 1) reach all areas of the woman's leg that could be shaved, without requiring her to bend; 2) allow shaving of the leg from 2 inches above the knee down to the ankle; 3) not cause any injury of the skin; 4) be relatively lightweight; 5) be water and mold resistant; and 6) be safe to use.

The leg-shaving device has three main components, the locking mechanism, the holder, and the arm (Figs. 2.14, 2.15). The locking mechanism has two low density polyethylene (LDPE) parts that screw one onto the other with a screw pitch of 0.7 mm. Between the two parts there is a LDPE tightening ring that has an outer diameter of 20 mm and an inner diameter of 16.5 mm.

The holder consists of three parts. The first is an aluminum pipe that has a length of 240 mm and an outer diameter of 23 mm. The second is two neoprene grips that each has a length of 120 mm, an outer diameter of 30 mm, and an inner diameter of 22 mm. The surface of the grip is rough enough to ensure a firm grip in the presence of water. The last part is an end-fitting plastic cap that closes the end of the aluminum pipe. The cap is glued to the aluminum pipe with silicon sealer.

The arm consists of four parts. The first is a 200-mm clear acrylic pipe, having an outer and inner diameter of 17 mm and 11 mm, respectively. The second part is a 45° CPVC pipe joint, that has an outer diameter of 20 mm and an inner diameter of 17.5 mm. The acrylic pipe is glued into the one side of the joint with CPVC cement. The third part, a CPVC pipe of 40 mm, having an outer and inner diameter of 17 mm and 11 mm, respectively, is glued with CPVC cement into the other side of the joint. The last part of the arm is the shaving razor. It is a Gillette razor with a replaceable blade. The razor is glued into the CPVC pipe with a fast drying epoxy.

The device was tested by the client, a late-stage pregnant woman. She shaved while sitting in the bathtub. The device had a good grip even under water, and it was very easy to use.

The final cost of the leg-shaving device was $ 34.

Figure 2.16. Components of the Shaving Device for Pregnant Women.

Titanium Knee Joint Locking Mechanism

Designer: Brian Jasper
Client Coordinators: ASU Sports Medicine
Supervising Professor: Gary T. Yamaguchi, Ph.D.
Bioengineering Program
Department of Chemical, Bio, and Materials Engineering
Arizona State University
Tempe, AZ 85287-6006

INTRODUCTION

A common complaint from athletes who wear knee braces is that the brace slows them down because it is too heavy. A knee joint that can be set to lock at any degree of flexion has been designed to help rehabilitate a gymnast following major knee surgery. This titanium device allows the athletic person to return to his or her sport with a very strong, lightweight and compact brace.

SUMMARY OF IMPACT

The design of the knee joint locking brace was discussed with the Sports Medicine staff at Arizona State University (ASU). A brace with a locking knee joint is used in the rehabilitation of medial collateral ligament and anterior cruciate ligament tears. Based on ASU athletic injury statistics, the locking joint developed here (Fig. 2.17), can be used by approximately 70 percent of the athletes with knee sprains. Although the number of serious knee sprains is small compared with the number of overall athletic injuries at ASU, the injuries are serious enough to require a knee brace with a better design.

Figure 2.17. View of Knee Joint on Neoprene Brace.

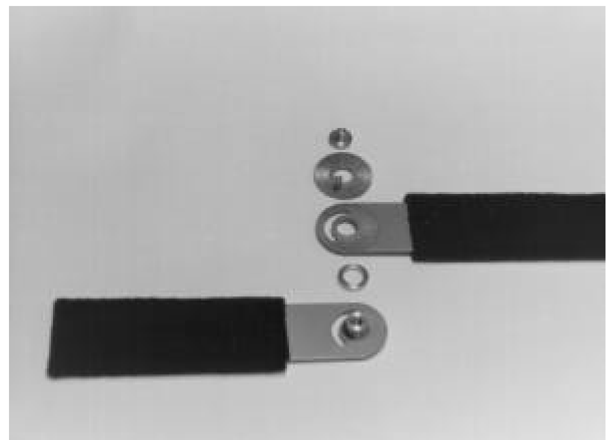

Figure 2.18. Individual Joint Components.

TECHNICAL DESCRIPTION

The new locking knee joint is made out of medical grade titanium because it has extremely strong integral properties and is very lightweight. The titanium was machined into three pieces (Fig. 2.18) out of a single 1/8" x 1.5" x 24" bar. Two served as the femoral and tibial components, and the third became the adjustable locking mechanism that actually determines the degree at which knee flexion will stop (Fig. 2.19). This design gives the athlete (Fig. 2.20) 28 different adjustments for the range of motion between 0 (full extension) and 135 degrees, in five-degree increments. This is an improvement in adjustability over previous, commercially available designs.

The knee joint was tested by the client, a gymnast at ASU. Testing showed that the joint would hold up to the force the athlete applies during his rehabilitation period. However, the testing also showed that the locking grooves needed to be deeper so that the locking mechanism would not slip out of position during shock loading.

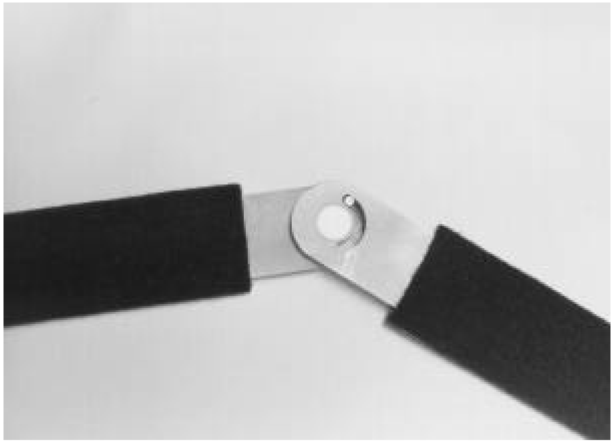

Figure 2.19. Back View of Knee Joint.

The cost of the actual joint is $254 for the titanium, and $6 for the Velcro to attach it to the neoprene. The overall material cost of the joint is $260, excluding labor. Machining costs are somewhat higher than for aluminum, and similar to machining costs for stainless steel.

Figure 2.20. Knee Joint in Use.