

# Assessment of refitted mattresses for manual patient handling to reduce ergonomics hazard during patient transfer using computerized 3d modeling.

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## Abstract

Usually while transferring the patient from stretcher to the beds are associated with skeletal and muscular disorders to the person handling the patient. Hospital bed features may be risk of injury. In hospital generally we see that Transfer of patients from one place to other is a labor intensive work. While handling the patients it is very laborious for the handling person. Who handle the patient from ambulance to stretcher and stretcher to bed. Which further increase the stress on the muscles of patient as well as handling person. Our aim to provide a better solution/product for patient handling to hospitals that are having limitations for the use fully automated beds & stretcher. The present research work proposes new idea of refitted mattresses through computerized 3D modeling for handling patient which will minimize the manual handling of immobilized patients. In the product and perish world of hospital companies complete to build product better and cheaper. If one manufacturer does not meet the high standard of performance, it is safe to say that somebody else well. As per the demand provide better solution which shows through computerized 3D modeling of product using CAD/CAM software for reducing problem associated during patient movement.

**Keyword :-** Hospital mattresses, CAD/CAM software, Immobilized patient, Musculoskeletal disorders, Stress

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## 1. Introduction

While handling the patient manually there may be more chance that the patient can get injure due to the stresses developed in the body especially area near the neck, spinal cord and various joint...etc. along with basic medical problem. These are the problems which are observed in the health care workers. Improper handling may cause injuries to patients. For this reason the manual transmission of patient should be avoided. According to a recent survey, it is found that, 38% of nursing staff suffers work related back injuries requiring time away from work, 12% of nursing staff considers leaving hospital job due to low back pain at average age 35. The above mentioned problems are observed mostly in the recent surveys of

patient handling. Frequent patient handlers had 3-5 times higher universality rate versus infrequent handlers, and 38% of low back injury circumstances were associated to patient handling. The three most stressful activities reported to cause injury was lifting, transferring, and responding to sudden reposition of patients. Activities including patient handling, stooping, lifting, carrying pushing and pulling were frequently described as the cause of the injury by the therapists.

All of the above studies concluded that dependent patient transfers pose a significant risk of development of structural failure of the lower back. The present research work proposes new idea of refitted mattresses with mechanical design analysis for handling patient which will totally minimize the manual handling of immobilized patients & additional objective of these research is to measure the various spinal compression forces which is generated in the body of healthcare employee during the transfers of patient & investigate how these various forces can be proved risky to healthcare workers and provide better ergonomic research to minimize various health issues developed in hospital healthcare employee body while patient handling.

## **2. Review study of CAD/CAM software**

As per Our demand required reduce patient & staff problem which induced during patient transfer. Lots of company which manufacture hospital product but few of them accept challenge & try to reduce worldwide patient transfer problem but it not achieved 100%. We provide better solution & 3-dimensional product which show how we minimize problem. By using CAD/CAM software easy to show working of modified mattresses & part created from digital data use CAD/CAM software utilities and related computer application. Review studies of CAD/CAM software are as follows:

### **2.1 A progression of technology**

In the past, technical part print was made and part manufacturer using conventional machine tool and machining processes. This traditional method was used for many years until the age of computers and the introduction of numerical control (NC). It was not long after NC was introduced to machine tools that computer aided design started to replace drafting as a means of producing technical part prints. Eventually, this evolved into cad cam where the information data on cad generated print were used in cam to manufacturer a part. The next logical step in the manufacturing process was the introduction of rapid prototyping and manufacturing for the design and production of prototype model, to reduce or eliminate manufacturing errors and bring product to the market faster and at lower cost.

### **2.2 Solid image solution**

The current line of solid imaging system, software equipment, and materials produced by rapid prototyping manufacturer is now used as instant manufacturing tools with automotive, dental, biomedical motor sport, consumer electronic, and military aerospace application. They are used to speed the production of customized/specialized endues parts. The ability to manufacturer a product using addictive fabrication techniques will radically alter design and manufacture method over the next decade and beyond. Using solid imaging system such as selective laser sintering and other solid imaging solution like those offered by

3D systems, existing design can be manufactured without the cost and lead time associated with hard tooling, and more complex design will become easier to manufacture.

### 2.3. Instant digital manufacturing

Selective laser sintering with solid imaging system are reliable and cost effective method of making end use parts for preproduction or production application. Solid imaging systems are expected to become a key enabling method for the customization of design and manufacturing, also called mass customization. Solid imaging is compressive suit of customer driven solution that cover the production of a part starting at the design stage, progressing through the prototype development, and ending with the manufacturing stage. It uses solid imaging technology to directly or indirectly produce end use component or product. Direct manufacturing is the method of creating end use products directly on a solid imaging system. Recent advantages in selective laser sintering and stereo lithography technology have made solid imaging system an alternative to some conventional manufacturing method.

### 2.4 Solid imaging hardware components

The major components of solid imaging system are as follows:-

1. **Stereo lithography system** uses a laser to convert photosensitive resins into solid cross sections, layer by layer, until the desired objects are complete. Stereo lithography system are capable of making multiple part at the same time and are designed to produced prototype or end use part that have a wide range of size and shapes. 1) Part created from digital data use computer aided design and manufacturing or CAD/CAM software utilities and related computer application. 2) A laser beam exposes and solidifies successive layers of liquid photosensitive polymers into solid cross section, layer by layer, until the desired part is formed. 3 )Stereo lithography produced part are used for concept models, engineering prototypes, pattern and masters for molds, consumable tooling, and short run manufacturing of a final product.
2. **Selective laser sintering system** use heat from a laser to melt and fuse, or sinter, powdered materials into solid cross sections, layer by layer, until the desired parts are complete. This system can create part from variety pf plastic and metal powders and are capable of processing multiple parts within the same build cycle. 1) Parts are created from digital data using CAD/CAM software utilities and related computer application. 2) Laser energy is used to melt and fuse, or sinter.
3. **Multi jet modeling technology or 3D printing** uses hot melt jetting technology to print 3-dimensional physical part by accumulating proprietary solid imaging materials in successive layers. This technology is the basic for affordable 3-dimensional solutions for printing any 3-dimansional part from digital part. 1) The thermo jet printer and in vision 3D printer produce model used to verify CAD model geometry, to communicate design intent, and to obtain design feedback from others. 2) It is used to marketing model for design review meetings, customer and prospect presentation, and preliminary assembly

analysis. 3) The thermo jet printer produces wax based patterns for investment casting application.

## 2.5 Solid imaging software components

The part preparation software for personal computer and engineering workstations provides an interface between digital data and solid imaging equipment. Digital data, such as CAD/CAM, are converted within the software package and, depending on the software package, the object can be viewed, rotated, and scaled, and model structures can be added. The software then generates the information that will be used by the SLA, SLS, and MJM system to produce the desired object.

## 2.6 Solid imaging processing materials

Various types of materials are used in solid imaging systems. They fall into two general classes 1) Photosensitive liquid resins for stereo lithography 2) Sintering powdered materials, including functional plastics, nylon, and metal powders, to suit the SLS system.

## 3. Procedure of Present method of Patient handling from Ambulance to wheelchair

For bed to hospital wheelchair patient reposition requires more than two people, depending as per the size of the patient & strength of the health care providers as per shown in fig (1). Patients who require this type of relocation are generally motionless and may be unable to adjust with the transfer. During relocation, Patients need safety when moving from bed to wheelchair. A patient must be collegial and able to sustain weight on both legs and take small steps ahead. If these criteria are not met that time a two-person transfer or mechanical lift is recommended. Firstly always complete a patient risk assessment prior to all patient-handling activities.



Fig (1) Patient handling from Ambulance to wheelchair

### 3.1 Problem associated during patient handling

Hospital patient manual handling activities were examined in the current study: 1) Relocating a patient up in bed 2) laterally displacing a patient, and 3) turning a patient fully to the side. The activities are illustrated in Fig. 1. For displacing, the senior member of the research study team (NW) abets the caregiver from the patient-right side of the bed for all trials. The patient starting position was supine, and the patient was repositioned to a mark approximately 40 cm up in bed from the starting position. The caregiver contributor restart the trial with both feet on the force plate, and was granted to step off the force plate with her right foot as he/she moved the patient up in bed. A visual examination of the biomechanical model was executed and confirmed that the peak spine load occurred before the caregiver stepped off the force plate.

In hospital generally patient weight is an average 80 kg which is lifted by healthcare worker and is a very difficult task and chances to slip down patient as well as certain body problems created in handling worker. When a body is lifted by a health care worker, that time which particular body part is affected, which is shown by a human skeleton diagram in fig(2).

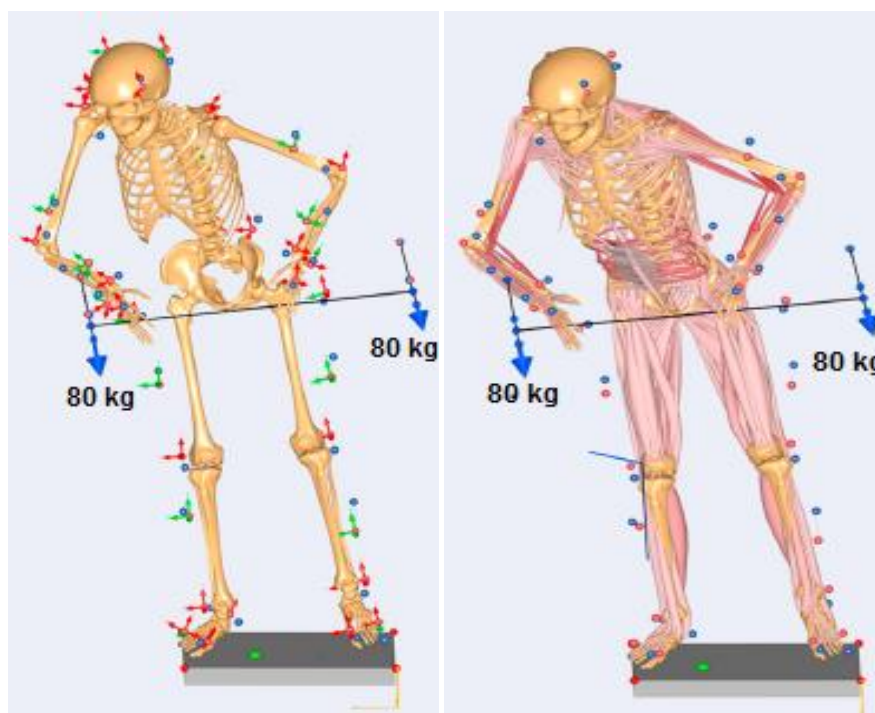


Fig (2) stresses on human body while lifting patient

### 4. Experimental design and procedure of proposed modified mattresses using computerized 3-D modeling

Displacing of patient from hospital bed to CT scan, M R Scan, Sonography centre, X-Ray centre, etc is an incommodes, burdensome & tedious job. Generally from bed to trolley cum stretcher & wheelchair patient move manually. Two persons either wrap the patient in cloth sheet and three to four people lift the patient with bed sheet and put him on trolley. The manual handling of patient is injurious, dangerous & very critical for patient because of that

stresses are produced in the body of patient, especially in neck, backbone, limb joints etc along with basic medical problem. Improper handling may cause injuries to patients. Also the healthcare staff that dislocate the patients also face some health issues like pain in the shoulder / backbone etc. For security of patient & patient handling worker, manual handling should be improved & for achieving that proposed new up gradation of mattresses.

Owing to the important for better of immobilized patients, and working condition of caregiver, the functions, convenience & modification of hospital bed should be improved/upgrade accordingly. Displacing of immobilized patients is usually the work of healthcare staff. Transfer of patients from one bed to another or from bed to wheelchair or from bed to stretcher is a labor rigorous work. It usually needs more than one handling staff to do this job, which is very strenuous & dangerous for both patient & worker, if inappropriate operational step is used. As per the important of demand, proposes a design of new mattresses show in fig (3) which will minimize the critical manual handling of immobilized patients.

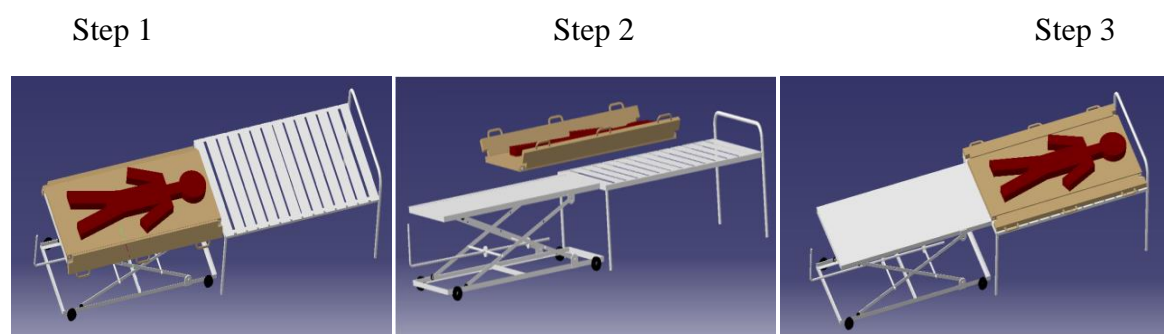


Fig (3) proposed method of patient handling

##### 5. Analysis of various mechanical factors acted on hospital mattresses due to patient weight.

Reposition of patient is very dangerous task for staff & fulfills this requirement proposed design of new refitted mattresses to eliminate this situation. As per demand Designing of modified mattresses while considering patient body weight range from 400N to 1000N. During movement of patient certain mechanical factor acted on mattresses & important to find out various factor like stress, strain, modulus of elasticity, pressure, tension, deformation in mattresses...etc. during reposition, patient lifted by hospital staff that time various stress & strain generated in mattresses. Both factor classified in compressive stress & strain and tensile stress & strain which affect respectively.

As per need required to move up for next up gradation & according to that demand we proposed design of new mattresses. During Designing of new product consider 80kg patient weight and according to that analysis human load which is acted on mattresses is uniformly distributive load i.e. 1000 N shown in fig (4). And due to UDL load how total deformation generated in mattresses is analyze.

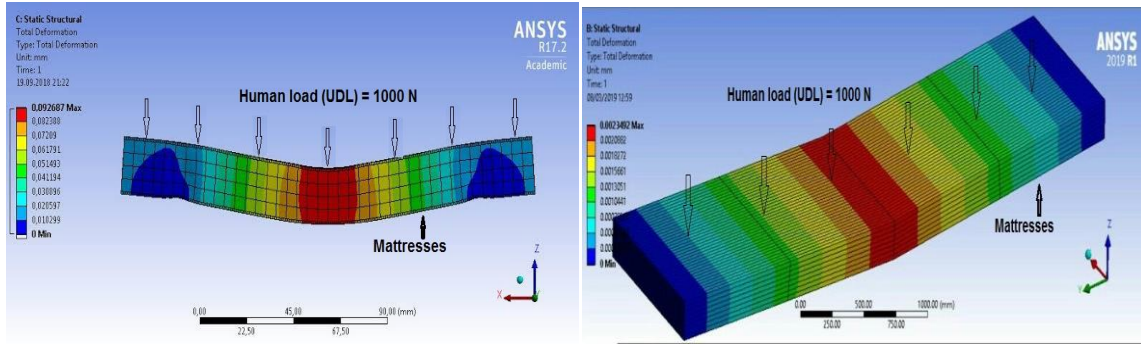


Fig (4) Total deformation of the mattresses when occupied by patient weight

The graph below shows the plot between compressive stress versus compressive strain & tensile stress versus tensile strain. The compressive stress versus strain plot shows the behavior of compressive stress as 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7 & compressive strain as 0.2, 0.4, 0.6, 0.8, 1, 1.2, 1.4. Same for tensile stress versus tensile strain plot show the behavior of tensile stress as 0.1, 0.2, 0.3, 0.4, 0.5 & tensile strain as 0.02, 0.04, 0.06, and 0.08 shown in fig (5). Graph show how stress & strain affect as per patient weight.

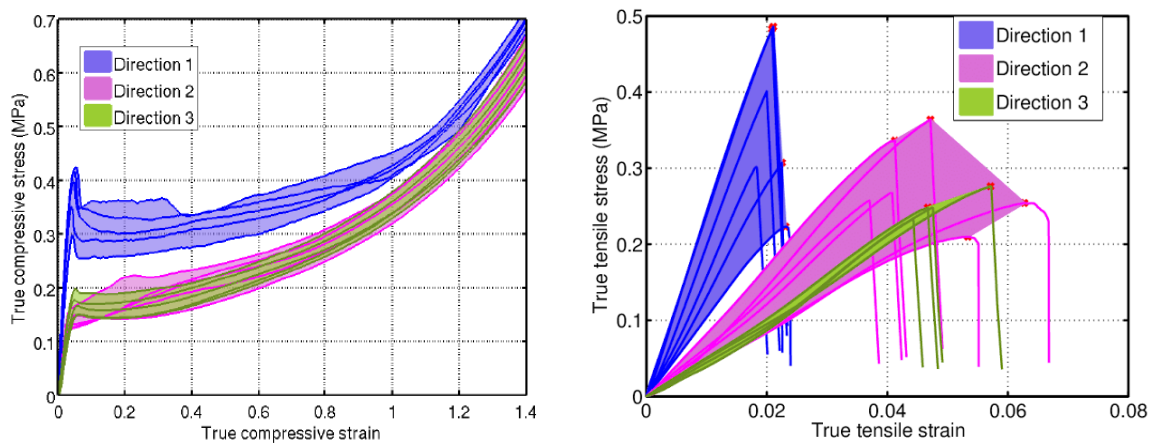


Fig (5) Stress & Strain graph when mattress is occupied by patient

Refitted mattresses play vital role in patient transfer procedure for that reason very important to look out different mechanical factor which affect on mattresses & considered it during new mattresses. Mattresses are generally made from different type of foam. For making new modified mattresses, black foam & fiber sheet used which is having required properties to fulfill all need. Black foam sheet is mainly used for providing back to sealant. It helps in maintaining the constant temperature which is very needful for preserving hot and cool energy. The main feature of black foam sheet are resistant to moisture, light weighted, shock absorption.

Properties of polyurethane black foam sheet	
Property	Minimum Value
AS600	Expanded Polyethylene Foam
Specification	FMVSS302

Color	Black or White
Temp Range	-75°C to 100°
Density	32 kg s/m <sup>3</sup>

<b>Properties of fiber sheet</b>	
<b>Property</b>	<b>Minimum Value</b>
Modulus of Elasticity	3,000 ksi
Moment of Inertia	36.15 in <sup>4</sup> /ft
Section Modulus	11.25 in <sup>3</sup> /ft
Cross Sectional Area	4.03 in <sup>2</sup> /ft
Width / (tolerance)*	19.0" (+/- 0.10")
Depth / (tolerance)	7.25" (+/- 0.05")
Thickness / (tolerance)	0.250" (+/- 0.015")
Weight (per lineal foot)	4.54 lbs/ft

The characteristics of fiber-reinforced plastics having good factors such as the mechanical properties of the matrix and the fiber, FRPs have a light weight but are incredibly strong, and have good impact ,fatigue and compression properties. Table show the different Fiber sheet properties like modulus of elasticity, moment of inertia, section modulus.

## 6. Conclusion

Each of the assistive composition integrated into the hospital beds that were tested in this report provided a reduction in the physical stresses on caregivers when handling, repositioning, and turning. Compared with spinal load, hand force was much higher relative to the suggested injury thresholds, suggesting that repositioning activities may pose a greater risk of shoulder and upper extremity injuries. Combining assistive functions with appropriate relocating aids may be a potential solution when a single feature or aid is not sufficient. Although effective at reducing physical stresses on caregivers, the assistive features studied do not reduce the risk of injury when repositioning patients. This work suggests those new modified mattresses together with repositioning lift sheet remains the safest and most easy way to move or mobilize all patient weights.

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