# Design of Salon Chair to Prevent Varicose Veins.

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**Abstract.**

Varicose Veins is a very common health issue among the barbers, given their working nature. Varicose veins are twisted and enlarged veins. Any vein may become varicose, but the veins most commonly affected are those in legs and feet. That is because, standing upright continuously for long time increases the pressure in the veins of your lower body. Varicose veins can cause aching pain and discomfort. They may also signal a higher risk of other circulatory problems. Because the problem of blood circulation in legs occurs frequently and it also effects the brain. Generally, 30 to 40% of people get affected by the Varicose Veins. In-order to prevent this disease from occurring for hair stylists, we have come up with an idea by introducing an additional setup in the existing salon chair which could significantly reduce the blood pressure and thereby, prevent the disease from occurring. The setup has 6 degrees of freedom and designed as per the load factor.

## 1 Introduction

Varicose veins are defined as cylindrical widened superficial veins, where the widening may be circumscribed or segmental. In general, the dilatation of the veins is associated with tortuosities. Varicosity of the lower limb is a common clinical entity with, age group of 20-40 being commonly affected. Varicose veins have always bothered mankind. These have been recognized as a chronic disorder since ancient times as their discussion is documented from the days of Hippocrates 2500 years ago. The condition, affected by man's upright position and by gravitational forces, is wide spread, involving at least one out of five individuals in the world, hence making this a very common condition. 20% of the population suffers with varicose veins and 2% have skin changes that may precede venous ulceration. The term varicose is derived from Latin word varicose, which means dilated. Varicose veins are not only dilated veins but also tortuous and elongated, but physiologically speaking a varicose vein is one which permits reverse flow through its faulty valves. Varicose veins, though a common condition, many time remains asymptomatic. In the developed countries patients turn up to treatment, for cosmetic reasons, however in our Indian scenario it is the complications and not the cosmetic reasons that brings the patient to the doctor.

In Indian scenario, the disease is one of the common surgical problems in low socio-economic class people, which at times, compel the patient to change his occupation which is very disturbing. With continuing advances in methods of evaluating venous anatomy and haemodynamic system, the therapy for varicose veins is in a period of change. Millions of workers spend majority of the working day standing. Standing burns 20% more energy than sitting because the human body is not designed to stand continuously at work.

Prolonged standing may lead to tiredness, loss of concentration and increased health risks. These health risks include swelling of feet and legs, feet and joint damage, varicose veins, heart and circulatory disorders, lower back problems and pregnancy complications. In the present scenario, one of the most important conditions that results from prolonged standing is varicose veins. Varicose veins of the lower limbs is considered as the most common vascular disorders in humans, creating serious signs and symptoms in patients and sometimes leads to surgical treatments and widespread morbidity. Varicose veins are one of the chief preventable diseases which are associated with veins. It is a serious disease, which poses threat to life of patient when effective and efficient measures are not taken.

## 2 Statistics

Current statistics reveal that nearly 2.7 million people worldwide, suffer from varicosities and the toll is ever increasing. When India is concerned, experts are witnessing a growing prevalence of varicosities especially among women. Nearly, 15% - 20% of women and 10% - 15% of men suffer from varicose veins in India. The condition is most common in people whose occupation require prolonged standing, such as teachers, salesmen, hairstylist, nurses, ancillary medical personnel and construction workers.

Varicose veins can cause aching pain and discomfort. They may also signal a higher risk of other circulatory problems. Because the problem of blood circulation in legs occurs frequently and it also affects the brain. Generally, hair stylists need to stand 5-10 hours per day due to their work.  30% to 40% of people are getting by Varicose Veins.

**Fig.1,** *Before varicose veins*      **Fig.2,** *After varicose veins*

## 3 The Idea

In-order to prevent this disease from occurring for hair stylists, we have come up with an idea by introducing an additional setup in the existing salon chair which could significantly reduce the blood pressure and thereby, prevent the disease from occurring. The setup has 6 degrees of freedom and designed as per the load factor.

## 4 Treatment for Varicose Vein

The treatment is determined by the stage of the disease, early cases are treated with limb elevation and compressive bandages. As the disease progresses there is need for invasive procedures, which include sclerotherapy, surgeries like Trendelenberg's procedure, SPJ ligation, GSV stripping, perforator ligation, stab avulsion and SEPS. Endovenous techniques are providing a great alternative to surgery. Surgery was the mainstay of treatment. The surgical modality was selected on basis of the age, severity and occupation of the patient. When complications like oedema, eczema and ulcer were present, conservative treatment was given with compression dressings, elevation of limb, antibiotics and other general supportive measures. Conservative therapy was continued till surgery was feasible.

**Fig.3,** *Varicose surgeries performed for Varicose Veins*

## 5 Working of salon chair

Existing Salon Chair can adjust its position based on the work, customer requirement, also can rotate $360^0$. The hair stylists are necessary to stand for the entire activity of the work. Based on the customer availability worker needs to stand for a long time. This injures the person by varicose veins.

**Fig.4**, *Existing Salon Chair*

## 6 Our Concept

Our concept has an additional setup attached with existing Salon Chair. The additional setup attached with the existing chairs. The setup consists of Toggle Jack / Scissor Jack, link, roller and mini comfortable (adjustable) chair.

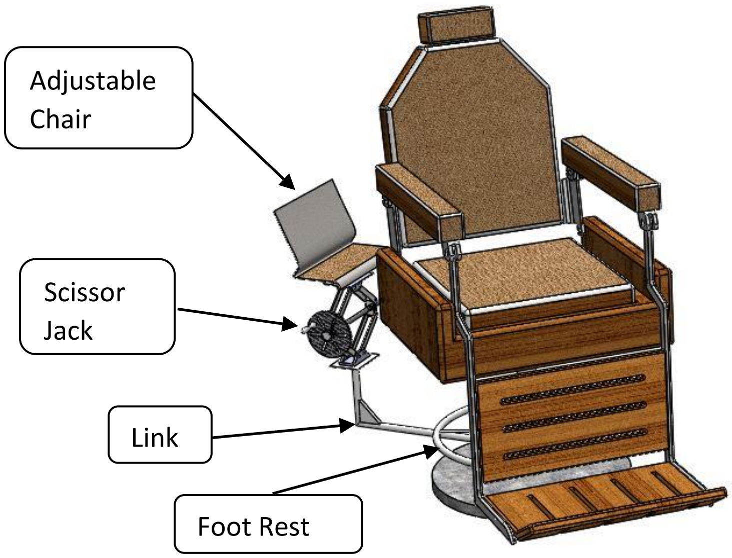


**Fig.5**, *Concept*

### 6.1 Material Selection

For most of the standard jacks, the material used is described as "Heavy Duty Steel". The American Iron and Steel Institute (AISI) developed a classification system for different types of iron and steel alloys. After some research, it was determined that a Nickel-Chromium-Molybdenum steel alloy is the possible material to construct the proposed scissor jack. The particular alloy has a classification of AISI 4340 engineering steel in industries use. High Strength Low-Alloy Steel (40Ni2Cr1Mo28/AISI 4340) is used for links and top plate. A property of AISI 4340, Material used for Base is High Alloy Steel Plates DENERTIA-N8.

## 7 Force analyses in Scissor jack

Consider as Initial Weight = 150 kg

### 7.1 Design of screw:

Total axial force in screw (Ws)

$Ws= 2F1$ → 1

$F1= w/ (2*\tan\theta)$ → 2

$Ws=W/\tan\theta$

Hence, the axial force (Ws) in a screw is maximum when (θ) is minimum.

$\therefore Ws = W / (\tan\theta)_{min}$

$= 1500 / (\tan 30^{0}57')$

$= 2501.3610$ N.

From the material property, we have

$\sigma_{yt} = 834$ N/mm2, and $\tau_s = \sigma_{yt} / 2 = 417$ N/mm$^2$

Assume factor of safety (N) = 3,

Service factor (k) = 1.6

$\therefore \sigma_{allowable} = \sigma yt / k*N$ → 3

$= 834 / (1.6*3)$ → 4

$\sigma_{allowable} = 173.75$ N/mm$^2$

$\therefore \tau_{allowable}$ = allowable/2

$= 173.75/2$

$= 86.875$ N/mm$^2$

The direct tensile stress in screw body is given as follow:

$\sigma_t = Ws / ((\pi/4) *dc^2)$

$173.75 = 2501.310 / ((\pi/4) *d^2)$

d = 4.2816 mm, taking M10 bolt (standard size).

Selecting standard screw;

Core diameter (d) = 8.160 mm.

Outer diameter $(d_o) = d_c + P$

$= 8.160+1.5$

$= 9.66 \approx 10$ mm.

Mean diameter $(d_m)$ = do-P/2)

$=9.66-(1.5/2)$

$d_m = 8.91 \approx 9.08$ mm.

For standard bolt size Pitch (P) = 1.5 mm.

Length of screw (L)= Bolt contact at min+(2*do) → 5

= 235+2*10

= 255 mm.

Torque required for overcoming the thread friction ($T_f$):

For acme thread, $\alpha = 14.5^0$.

Helix angle (λ) $= \tan^{-1} (l /(\pi * d_m))$

$= \tan^{-1} (l /(\pi * d_m))$

L = lead, = Pitch * No, of starts

N = 1.5

$= \tan^{-1} (1.5 /(\pi * 9.026))$

$= \tan^{-1} (0.0529)$

$\lambda = 3^0 1'$

Coefficient of friction μ = 0.15

$(\mu') = \mu/\cos\alpha$ → 6

$= 0.15/ \cos (14.5^0)$

= 0.1549.

Friction angle $(\varphi) = \tan^{-1} \mu'$ → 7

$= \tan^{-1} (0.154)$

$= 8^0 48'$

Required Torque

$(T_f) = (W * d_m / (2 * (\tan\theta_{min})) * \tan(\varnothing + \lambda)$ → 8

$= (1500*9.026/ (2*\tan 30\ ^0 57')) * \tan (8^0 48'+3^0 1')$

= 2363.9344 N-mm.

Verification of self-locking:

$\Phi = 8^0 48'$

$\lambda = 3^0 1'$

Hence. Φ> λ, So jack had a self-locking.

Efficiency of threads (η) = 1-sinØ / 1+sinØ → 9

$= 1-\sin 8^0 48'/1+ \sin 8^0 48'$

= 73.46%

Actual torque required (T) = $T_f / \eta$ → 10

= 2363.9344/0.7346

= 3217.98 N-mm.

The direct tensile stress in screw body;

$(\sigma_t) = Ws/ ((\pi/4)*dc^2)$ → 11

$= 2501.3610/((\pi/4)*8.160^2)$

$= 47.855\ N/mm^2$.

Shear stress due to torque $(\tau s) = 16*T / ((\pi/4)*dc^3)$ → 12

$= 16*3217.98 / ((\pi/4) *8.160^3)$

$= 30.178\ N/mm^2$

Maximum principle stress theory;

$(\sigma) = \sigma_t/2 + 0.5 \sqrt{(\sigma_t)^2 + 4*(\tau_s)^2}$ → 13

$= 47.855/2 + 0.5 \sqrt{((47.855)^2 + 4 *(30.178)^2)}$

$\sigma = 100.952\ N/mm^2$

$\sigma = 100.952 < 173.75 N/mm^2$

Hence, design is safe.

Maximum Principe Shear Stress theory;

$(\tau) = \sqrt{(\sigma t/2)^2 + \tau s^2}$ → 14

$= \sqrt{(47.855/2)^2 + (30.178)^2}$

$= 38.512\ N/mm^2$.

Hence τ < τ allowable. Design is safe.

### 7.2 Design of Nut:

The unit bearing pressure for the cast iron nut and the soft steel screw is 13 to 17 $N/mm^2$. Using the mean value of 15 N/mm2.

No. of threads on screw,

$Z = (4*W)/ (\pi * S_b (d^2-dc^2))$ → 15

$= (4*1500)/ (\pi * 15 * (10^2 – 8.160^2)$

= 6000/1573.818

Z = 3.812 ≈ 4.

Length of Nut;

L = Z*P → 16

= 4*1.5

L = 6 mm.

The Shear stress in the nut,

$\tau_n = (W/(\pi * d * t * Z)$ → 17

t = Pitch/2 =>1.5/2 = 0.75

= 1500/(3.14*10*0.75*4)

= 15.923 N/mm2.

Width of the Nut = 1.5*do → 18

= 1.5*10

= 15 mm.

### 7.3 Design of Pins in Nut:

Since, the pins are in double shear therefore load on the pins F or $W_s$

$Ws = 2 * (\pi/4)*d^2 * \tau$ → 19

$2501.3610 = 2*(\pi/4)* d^2 * 50$

Assume, τ = 50 Mpa.

$2501.3610 = 2*0.78539*50*d^2$

$d^2 = (2501.3610/78.539)$

d = 5.643 ≈ 6 mm.

Diameter of Pin head = 1.5 * d → 20

= 1.5 * 6

= 9 mm.

Thickness of the Pin head = 3mm.

The Split pins are used to keep the pins in position.

### 7.4 Design of Links:

The load on the links, = Ws / 2 → 21

= 2501.3610/2

Load on link = 1250.6805 N.

Assuming the factor of safety = 5.

The link must be designed for buckling,

Wcr = Load on link * F.S → 22

= 125.6805 *5

Wcr = 6253.4025 N.

$t_1$ is the thickness of the link,

$b_1$ is the width of the link.

A = $t_1$ * $b_1$ (ie) b1= 3 t1

A= $3*t1^2$

Moment of inertia of the Cross section of the link.

$I = 1/12 * t * b_1^3$ → 23

$= 2.25\ t1^4$

Radius of gyration; K = √(I/A) → 24

$= \sqrt{(2.25(t1)^4)/3(t1)^2}$

K = 0.8666 t1

Consider as a buckling load of the link in vertical plane. The ends are considered as hinged, therefore equivalent length of the link,

L=l=130 mm.

Rankine's Constant a = 1/7500 (for Steel)

According to rankine's load formula for buckling load,

$Wcr = (\sigma c * A)/(1+a(L/K)^2)$ → 25

$6253.4025 = (\sigma c * 3t1^2)/(1+(1/7500) *(130/0.866t1)^2)$

σc = 1.25 * σt → 26

σt = σyt / F.O.S

σyt for steel 260 $N/mm^2$ ; F.O.S = 5.

σt = 260/5 => 52 $N/mm^2$.

σc = 52*1.25 => 65 $N/mm^2$.

$6253.4025 = (65*3(t1)^2)/(1+3(t1)^2)$

$6253.4025/195 = t1^4/(t1^2+3)$

$32.0687 * ( t1^2 + 3) = t1^4$

$t1^4+32.0687\ t1^2+96.2061 = 0$

$= (-b\pm\sqrt{(b^2)-4ac})/2a$

= (32.0687+37.5928)/2

= 69.6607/2

$t1^2$ = 34.830 mm

$t_1$ = 5.9017≈6 mm

$b_1$ = 18 mm.

Now let us consider of the link in a plane perpendicular to the vertical plane.

$I= 1/12 * b1\ (t1)^3$

$= 1/12 * 3t1^4$

$I= 0.25\ t1^4$

Cross Sectional area of link,

A= t1*b1

= t1 * 3t1

$A = 3t1^2$

Radius of gyration k = √ (I/A)

K = 0.29 t1

Length of the link L = l/2

l = 130 mm

L = 130/2 => 65 mm.

$Wcr = (\sigma c * A)/(1+a(L/K)^2)$

$= (65 * 3t1^2)/(1+(1/7500) *(65/0.29t1)^2)$

$= 195\ t1^2 / (1+(6.698/t1^2))$

= 7020 / 1.18605

Wcr = 5918.806 N.

Since the buckling load is more than calculated loading value. Therefore, the link is safe for buckling.

## 8 Illustration

The additional setup consists of the following components: Adjustable Chair, Link, Scissor Jack and Foot rest. As shown in the figure 5, the base of the existing chair is to be altered as illustrated. The link should be able to rotate freely in the profile path. The Scissor Jack is attached to the link. A Disc connecting the Scissor Jack is capable of adjusting Power Screw. Adjustable chair is mounted by a support pipe block. This set-up paves way for adjustable chair to linearly move about X-axis and rotate about Y-axis. Thus providing a comfortable chair for the barber to sit and do his job.

## 9 Conclusion

I believe, with this design, we can reduce the standing hours of Salon Workers thereby reducing the chance of them getting affected by Varicose Veins in a proactive approach.

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