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Prosthesis For Dogs With Back Limb Deformities/Amputation

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Abstract: *Prosthesis is an artificial device that replaces a missing body part, which may be lost through trauma, disease or congenital condition. Prosthetics are intended to restore the normal function of the missing body part. The current canine prosthesis market is catered towards dogs with amputations and is very expensive because of the small number of products available. Due to the variations in limb deformities, there is yet to be a customizable solution. Most of the products available are targeted towards the walking aid but there are only few products which are focused towards rehabilitation and and recovery. There is a need to design a simple products which can be a comfortable walking aid as well as a good recovery aid. There are good chances that a dog will be healed in a case of paralysis so the walking aid should have the facility to help him recover fast.*

Keywords: *Prosthetic, Paralysis, Canine, Cart, Amputation*

I. Introduction

There have been huge achievements in human prosthetics development, but the same cannot be said for the animals.The current canine prosthesis market is catered towards dogs with amputations and is very expensive because of the small number of products available. Due to the variations in limb deformities, there is yet to be a customizable solution. Instead, the production of prostheses for deformities occurs on a 'case-by-case' basis and the products are tailored to a specific user. The goal of this project is to design and fabricate a low cost device that would increase mobility and stabilize the gait of the canine user while being adjustable in use making it more comfortable, sensible and efficient.

Some causes of the immobility are: Tetraplegia, Paraplegia, Amputation, Limb Tumor, Weakness, Parvovirus, Distemper , Kennel cough, Heartworm disease.

Canine Anatomy

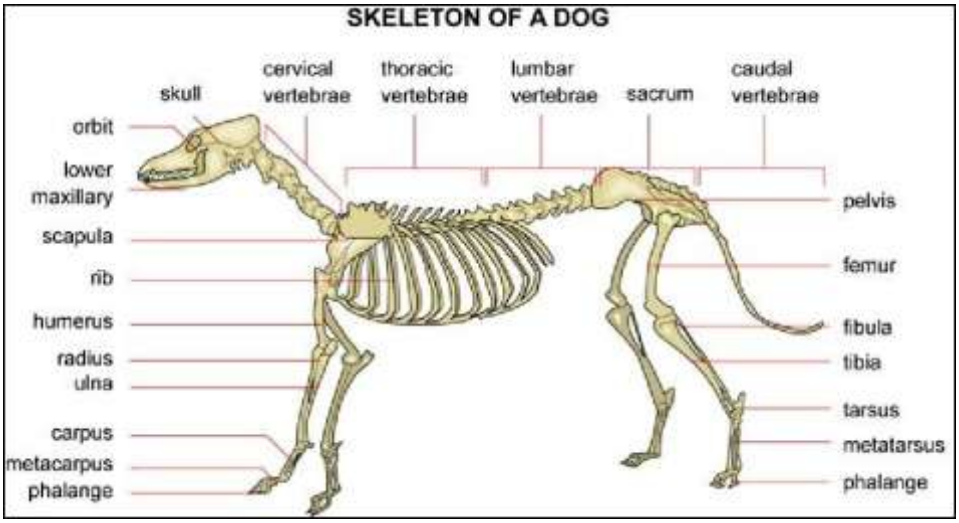


Fig 1. Skeleton Of A Dog

a) **Cervical Vertebrae-** The first two cervical vertebrae are known as the atlas and the axis respectively,

and are modified to allow movement of the head. The atlas has no conventional body, instead it is composed of two lateral masses joined by dorsal and ventral arches.Lumbar Vertebrae-The lumbar vertebrae are longer and more uniform in shape than the thoracic vertebrae. They are also shorter in height, with long, flattened transverse processes that project laterally.

b) **Thoracic Vertebrae-**Thoracic vertebrae articulate with the ribs. They are distinguished by short bodies with flattened extremities, costal facets, short transverse processes and prominent spinous processes.

c) **Sacral Vertebrae-**The sacrum is a single bone formed by the fusion of several vertebrae that articulates with the pelvic girdle. It allows the thrust of the hindlimbs to be transmitted to the trunk. The sacrum narrows caudally and is curved to present a concave surface to the pelvic cavity.

d) **Caudal Vertebrae-**The number of caudal vertebrae varies greatly even within species. There is a progressive simplification of their form.

e) **Pelvic Girdle-** The pelvic girdle consists of two symmetrical halves. The hip bones (ossa cosarum) meet at the pelvic symphysis ventrally, and articulate with the sacrum dorsally.The ilium is craniodorsal and extends obliquely forward from the hip to articulate with the sacrum. The cranial wing varies between species. Femur- The femur is the strongest of the long bones and provides the origin and attachment for many muscles and tendons. This means that it is characteristically modelled for each species

f) **Phalanges-**The proximal phalanx of the main digits (II - V) have a concave articular surface and the palmar border has a groove to accommodate the articular surface of the metacarpus when the joint is fixed. The distal head has two convex areas separated by a groove.

II. Problem statement

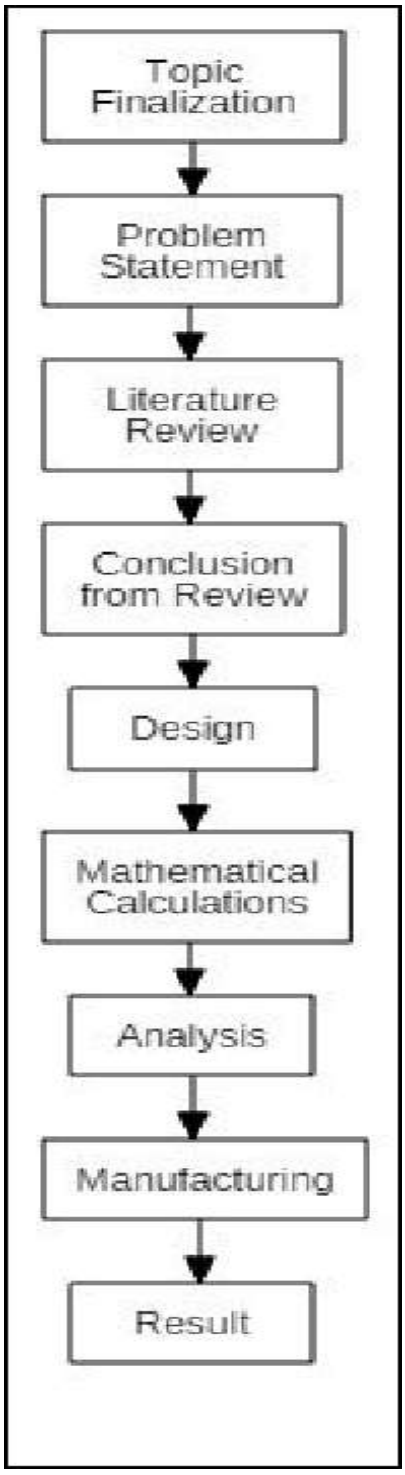
While looking for our graduation project we were made aware of the problems that dogs with amputations and different kinds of paralysis mainly with dogs left with two functioning limbs. Prosthetics available in current market are not flexible for various sizes of the dogs. Products available are very costly, bulky and hard to get . Also the spares parts are not available in normal market. The products available are not as per the requirement of the lifestyle of an average dog and many a times they can cause more hindrance than help. Feeling that the situation needed to be addressed our group decided to design prosthesis for Dogs with back Limb deformities/amputation.

III. Objective

We want to design products which are economic and their spare parts are easily available in the market and will be comfortable to the user. We are also trying to implement new mechanisms in future products which will help in giving more freedom to the dogs at the same time being comfortable for them to use and their caretakers to manage.

IV. Methodology

Fig 2. Methodology



Mainly used operations

Injection molding: Injection molding is a manufacturing process for producing parts by injecting material into a mould..

Vacuum Forming: Vacuum forming is a simplified version of thermoforming, where a sheet of plastic is heated to a forming temperature , stretched onto a single-surface mold, and forced against the mold by a vacuum.

Extrusion: Extrusion is a process used to create objects of a fixed cross-sectional profile. A material is pushed through a die of the desired cross-section.

3-D Printing: Also known as Additive Manufacturing (AM), refers to processes used to create a three-dimensional object in which layers of material are formed under computer control to create an object.

Materials used: Titanium Alloys: Titanium alloys are metals that contain a mixture of titanium and other chemical elements. Such alloys have very high tensile strength and toughness (even at extreme temperatures). They are light in weight, have extraordinary corrosion resistance and the ability to withstand extreme temperatures.

Aluminium Alloy: Aluminium alloys are alloys in which aluminium (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, tin and zinc.

Stainless Steel: In metallurgy, stainless steel, also known as inox steel or inox from French 'inoxydable' (inoxidable), is a steel alloy with a minimum of 10.5% chromium content by mass. Stainless steel is notable for its corrosion resistance, and it is widely used for food handling and cutlery among many other applications.

Carbon Fiber: Carbon fiber reinforced polymer, carbon fiber reinforced plastic or carbon fiber reinforced thermoplastic (CFRP, CRP, CFRTP or often simply carbon fiber, carbon composite or even carbon), is an extremely strong and light fiber-reinforced plastic which contains carbon fibers.

Polypropylene: Polypropylene (PP), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications including packaging and labeling, textiles.

Polyethylene: Polyethylene or polythene (abbreviated PE; IUPAC name polyethene or polymethylene is the most common plastic.Its primary use is in packaging (plastic bags, plastic films, geomembranes, containers including bottles, etc.).

V. Literature Review

In medicine, a prosthesis is an artificial device that replaces a missing body part, which may be lost through trauma, disease or congenital condition. Prosthetics are intended to restore the normal function of the missing body part. It involves healthcare professionals including psychiatrists, surgeons, physical therapists and occupational therapists. Prosthetics are designed with the help of CAD, a software interface that helps creators visualize the creation in 3D form. The first prosthetics were found in Egypt in 950 BC- 750 BC which was a left big toe.

Fig 3. First Human Prosthetic

Ambroise Paré (c. 1510 – 20 December 1590) was a French surgeon who served in that role for kings Henry II, Francis II, Charles IX and Henry III. He is considered one of the fathers of surgery and modern forensic pathology and a leader in surgical techniques and battlefield medicine, especially in the treatment of wounds in his time. He was also an anatomist and invented several surgical instruments .

Gr. L. SHEPARD, May 17, 1864[8] invented a new and improved way of constructing metallic legs.The nature of his invention focuses on giving support to the artificial limb or lower extremity a knee and ankle joint, as well as a joint or movement for the toes that combine to provide all the necessary mechanical motions obtained in the natural limb.

Nov. 2, 1965 T. R. SHORT(Patent-US3215117) [1] An object of his invention is to provide a mobile cart which enables an animal inflicted with posterior paralysis or related conditions of the spine and/or hind limbs to become completely self propelling. According to the inventor, three important conditions must be met in order to help the animal heal and rehabilitate. First, the primary injury which causes the paralysis must be protected from additional trauma during treatment and convalescence. Secondly, normal body position and posture must be restored in a comfortable manner and in such a way so as to permit unrestricted movement of the hind limbs. Finally, mobile support must not add an additional burden to the paraplegic but should rather allow for efficient normal mobility on uneven terrain as well as on smooth surfaces. These three considerations are amplified in cases of permanent paralysis.

Some of the complications and problems commonly associated with the paraplegic's recovery include decubital ulcers, constipation, retention of urine with bladder distention and empending cystitis, apathy, lack of exercise, disuse and atrophy of leg muscles, habit scoliosis, pain associated with movements of an injured spinal column, dermatosis as a result of fecal and urinary contamination, the great amount of time required to give proper attention to the paraplegic, and the necessity of euthanasia in cases with permanent paralysis or those cases expected to require long rehabilitation periods.

Lincoln J. Parkes patented (US4375203)[2] a wheeled cart in March of 1983 to which the animal is to be harnessed, the cart having a yoke that could be attached to the animal's thorax, a hip support member for carrying the animal's rear quarters, and a shin support for the animal's rear legs. It was also an object of his invention to provide a prosthesis which would be adjusted to the exact dimensions of a particular animal, to support it their natural position, and to allow the maximum possible freedom of movement. Comprising a wheeled cart to which the animal is to be harnessed, the cart has a yoke attachable to the animal's thorax, a hip support member for carrying the animal's rear quarters, the hip support member adjustably mounted upon the cart for carrying the rear quarters at a natural position with respect to the thorax, and, shin support means for the animal's rear legs, mounted upon the cart and adjustable vertically as needed, independently of the adjustment of the hip support means, whereby the animal's rear legs are carried above their natural position.

On July 6th 1993, Richard W.Hill and Robert D. Hill (US5224444)[4] both of Courtland Drive U.K came up with a new walking aid which included a cradle that could be attached below the animal's means for the support member comprises a helical coiled spring attached between the support member and said linkage. Said linkage incorporates a first stop member to limit the pivotal movement of the support member in the direction of the spring bias applied thereto.to fig 7, wherein said second stop member was attached to said linkage and, on abutment with said cradle, limits pivotal movement of said support member relative to said cradle.

In November 4, 2003, another paper was submitted by Dana J. Cool [5]in New York, USA. It mainly focused transferring the load from the legs to the prosthetic. She designed a animal lift frame that provides a mechanically adjustable support structure for restraint and skeletal support for an animal. This device was very helpful for animals recovering from injury or surgery. This model was light and versatile to facilitate use by the user. presented above by utilizing a one-piece design making it simple to use While assisting the animal to Walk or maneuver during the rehabilitation process

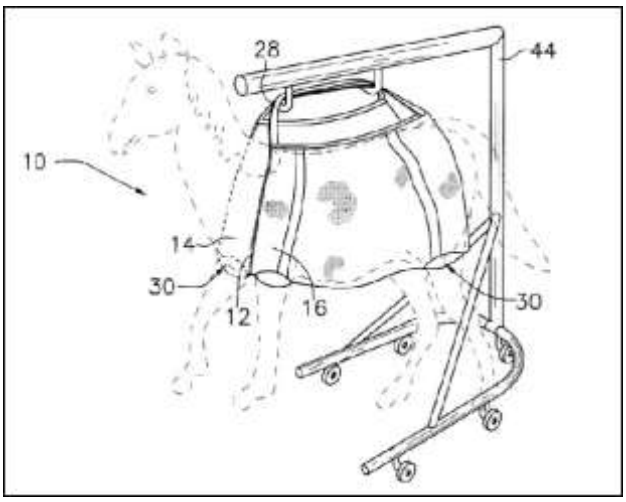


Fig 4. Animal support apparatus

Arnold P. Costell[3], submitted a patent on rear support pet leash includes a loop portion and a lifting both portions being formed of flexible material. The loop portion has first and second ends and a medial section. Each of the first and second ends is attached next the Short medial section to form first and second leg loops for fast about the upper rear legs of a pet. The lifting portion Pares is attached at an attaching end to the medial portion of the Bellinger loop portion and has an adjustable handle at a lifting end .The lifting portion is adjustable to accommodate pet's varying height. Leg loop pads are removable Cleveland attachable to the first and second leg loops to provide additional comfort for the pet. Sliding adjustment means are date different size pets. The adjusting means may be rings spam buckles or fabric loops. As pets, particularly larger breeds of dogs, age they often develop problems With their hips, back or rear legs.

Ltn Coln, J. Parkes, submitted a patent(NO: US6820572B1) [6]on November 23, 2004. In the earlier models support height required for raising the extended rear length creates a stressful forward angulation on the shoulder of the animal, Providing flexion on the rear limbs by means of slings, allows levelling of the body to a normal walking position. An adjustment of axle wheel position horizontally achieves proper weight distribution between front and rear quarters, reduces stress to a minimum while the animal is walking. They also included Yoke in their model.

Mark C. Robinson on March 23rd 2009 published a paper on wheelchair with extender adjustably designed(Pub No: US2009/0101084 A1)[7]. A wheelchair for animals includes a harness support frame having first and second lateral supports spaced from each other and a width extender adjustably connected between the first and second lateral supports, first and second knuckle clamp assemblies where each one of the first and second knuckle clamp assemblies has a first clamp component and a second clamp component, a plurality of harness connectors attached to the harness support frame, rst and second leg assemblies where the second clamp components receives aleg assembly proximal end of one of the first and second leg assemblies, where each one of the first and second wheels is rotatably connected adjacent to a leg assembly distal end of one of the first and second leg assemblies, and a harness assembly detachably connected to the harness support frame. Each first clamp component has a lateral bore for receiving one of the first and second lateral supports therethrough and is positioned between a support frame proximal end and a support frame distal end. Each second clamp component has a clamp recess that receives the leg assembly proximal end and is rotatably and adjustably connected to the corresponding first clamp component.

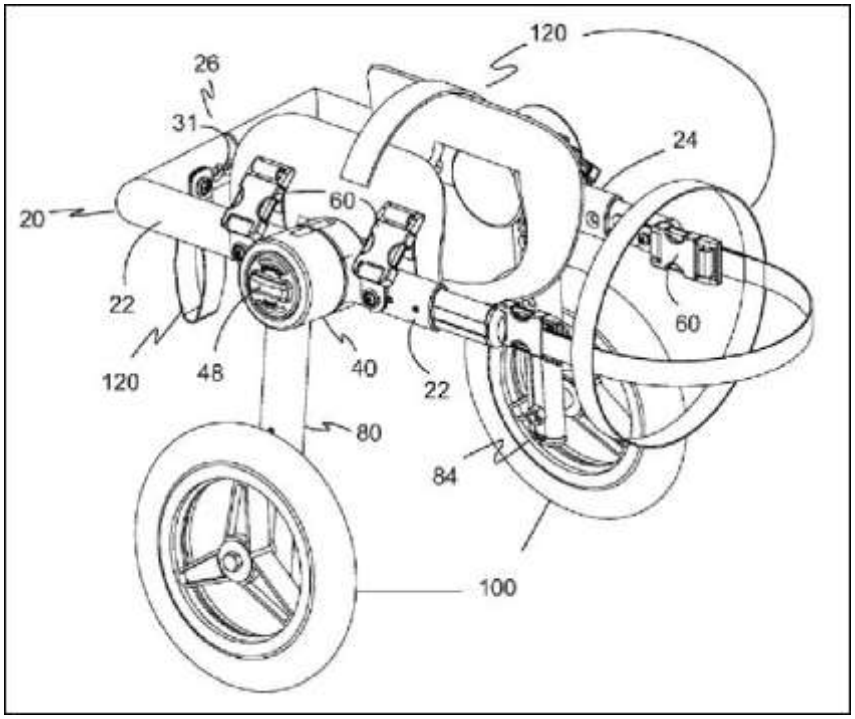


Fig 5. Design of wheelchair for animals

VI. Conclusion

Prosthetics started very early in times. There have been many developments since 970 BC.G.L shepherd introduced first on paper prosthetic model . Development further continued when T.R.Short introduced first dog cart and from there onwards we saw many models by A.P. Costell, Richard, Robert D Hill .So far we have seen improvement in design ,suspension, manufacturing etc. With the rising technology there is a great scope in future with new materials and low cost. We have reached a conclusion that we have to design a product which should be adjustable and should have a aid for recovery like a moving part that can help the canine to move its weaker parts in the natural moments.

VII. Acknowledgement

It's our great pleasure to acknowledge sense of gratitude to all those who have helped us in making this project stage I work. It gives us great pleasure to express our deep gratitude to our project work guide Prof. Y.B. Shendge for his valuable support and help from time to time during project work. We are also grateful to our director Prof. Dr. A.B. Auti head of the department Dr. J. S. Gawande for giving us opportunity to present this Project report. We would like to thank our entire faculty and friends who assisted us directly or indirectly throughout the duration of this project work.

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