

Management and Construction Procedure of Bilateral Split-Bucket Type Hip Disarticulation Prosthesis

By Peter A. Ockenfels, C.P.
Columbus Orthopedic Appliance Co.,
Columbus, Ohio

The patient, a 37-year old white male, received traumatic injuries while involved in an auto-truck accident in October, 1965. Both limbs were severely crushed, and very high amputations were necessary. The physical appearance of the patient resembled that of a bilateral hip disarticulation amputee; however, closer examination of the patient revealed that a femoral neck and head were present. The skeletal remaining structure of the femur can be measured at approx. 3" on the left and 4" on the right side. (*Figure 0*)

It was felt that this patient would represent a difficult problem regarding a prosthetic fitting. (At this point I would like to quote a sentence from an article which appeared in this Journal previously as follows, "it should be pointed out that there is no longer any need to attempt to leave an inch or two of femur at hip level because of advances in the prosthetic art.")

The patient was first hospitalized at the Allentown Hospital in Pennsylvania, and then became a patient at the St. Vincent's Rehabilitation Center in Erie, Pa. There he received initial rehabilitation training and became ADL independent.

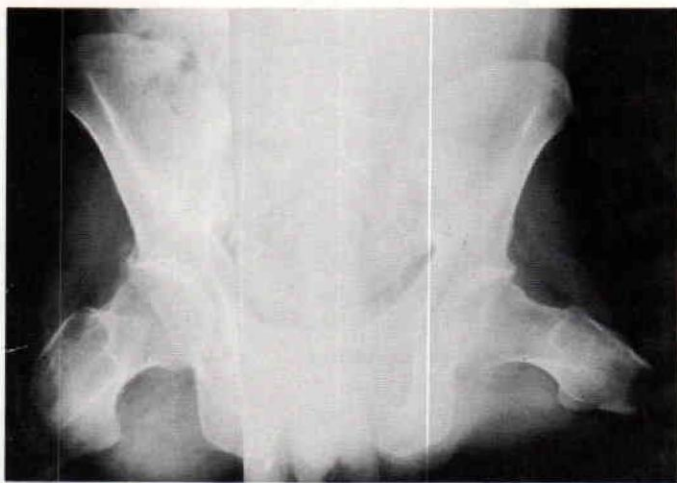
He was fitted with a walking device consisting primarily of a pair of control braces with a pelvic band and an ischial seat bar attached to both sides of the control braces hip joint area.

He was presented at the Ohio State University Hospital Rehabilitation Center Prosthetic Conference on September 29, 1967, and a prosthetic prescription for a definitive prosthetic unit was written.

The Clinic Team then discussed the components for this prosthetic unit, and under careful consideration the following prescription was worked out and written by the Clinic Team:

"Modified bilateral hip disarticulation prosthesis with modified plastic split hip disarticulation buckets for bilateral use, North Western stride control hip joints, single axis knee units with positive locks and SACH feet."

The split bilateral hip disarticulation bucket was prescribed with the hope that the patient would be able to accelerate one foot after the other and, consequently, would walk with a semi-normal gait (taking full advantage of the remaining femoral skeletal structures bilaterally). The stride control with hip locks and positive knee locks would give him stability during walking and stance.



Taking of the Cast

The negative mold of the patient's body was obtained by utilizing the North Western Type Four Point Suspension Technique. A double layer of 10" wide nylon stockinette was tailored to the patient's body. The proximal portion of this stockinette was doubled, and two 2" by 2" webbing patches were sewn anteriorly and posteriorly to the brim of this tailored body stocking. A $\frac{3}{8}$ " hole was punched into each of the patches, through which the $\frac{3}{8}$ " Manila rope of the Four Point Suspension System was tied. The patient was freely suspended approx. 3 feet off the floor, and the body stocking conformed snugly to the patient's body. (*Figure 1*)



FIGURE 0

The outlines of the prosthetic socket to be and all bony protuberances, such as the remaining femoral bony structures, the anterior superior iliac spines, the iliac crests, and the ischial tuberosities, were carefully marked with indelible pencil. These markings would later transfer to the male mold. (*Figure 2*)



FIGURE 1

Four inch fast setting Plaster of Paris bandages were used for the wrapping. A roping of Plaster of Paris bandage was pulled in deeply bilaterally behind the iliac crest, or iliac crest concavity. This would later supply the major suspension of the bucket on the patient's body. The wrapping of the entire cast was applied firmly. (*Figure 3*)



FIGURE 2

After the wrapping was completed, the patient was lowered to a platform on a stool until the ischial tuberosities would touch moderately and the patient stabilized. A plumb line anteriorly and posteriorly was defined, and the cast was then quartered and posterior as well as anterior and lateral reference lines were established. (*Figure 4*)

Now the cast was split anteriorly and posteriorly and removed from the patient's body. (*Figure 5*)

Filling of the Negative



FIGURE 3

The anterior and posterior opening cuts were sealed with two strips of Plaster of Paris bandages, and the negative was positioned on a table with all four vertical reference lines exactly aligned with a level. A mandrel, or $\frac{3}{4}$ " iron pipe, was positioned and aligned with the four reference lines by using a special holding device. A 16 oz. paper cup was attached to the pipe and inserted just to the brim of the negative to obtain a vacuum chamber needed for lamination. The filling of the negative proceeded in the usual manner. (*Figure 6*)



FIGURE 4

After hardening of the plaster, the reference lines were punctured with an awl and marked on the top surface of the cast. The lateral reference lines were used to establish a fictitious trochanter bilaterally.

These trochanters were located $1\frac{1}{2}$ " proximal from the end of the cast. With a 45° angularly cut 1" thick plywood the positioning lines for the placing of the hip joints were marked by positioning the plywood exactly



FIGURE 5

on the point previously marked for the trochanters, with the lower point anteriorly.

The waist was then peeled until only the male mold remained.

Modification of the Male Mold

All reference lines punched with the awl were connected and retained. All marked bony protuberances were elevated with Plaster of Paris to approx. $\frac{3}{8}$ " to $\frac{1}{2}$ ". This included the ridges of the iliac crest, the anterior superior iliac spines, the ischial tuberosities, and the very short distals of the remaining femoral structures bilaterally. Outlines for the definitive bucket were reinforced. These outlines consisted of a proximal brim approx. $\frac{3}{4}$ " below the rib cage and anterior and posterior teardrop openings, 4" by 5", connected with each other (width: 1 inch). The cast was then smoothed and the markings bordered with $\frac{3}{8}$ " Plaster of Paris roping, which was then filled with Plaster of Paris and molded to a flare of an approx. $\frac{3}{4}$ " radius. This would give the patient comfort in the prosthetic bucket. (Figure 7)



FIGURE 6



FIGURE 7

The mold, modified and smoothed, was then allowed to dry in an oven for 24 hrs. at a temperature of 115° F. Then the cast was positioned in the vice exactly at 45°, using a specially milled 45° steel positioning block. The mold was rotated and the trochanter reference lines positioned vertically with the aid of a plumb line. These lines, clearly established, would serve as the exact positioning for the hip joints.



FIGURE 8

Two cardboard cylinders, 4" in circumference and 3" high, were taped to the cast, keeping the hip joint reference lines exactly centered. Both cylinders were covered on top, and only a hole in the size of a Quarter coin was left open on each cylinder through which the liquid styrofoam was poured for the styrofoam hip joint mounting blocks. (Figure 8)



FIGURE 9

Hip Joint Mounting

The top of each block was cut level and level to the ground and as closely to the cast as possible. The hip joint mounting reference lines were marked on the styrofoam, and both hip joints positioned. (Figure 9)



FIGURE 10

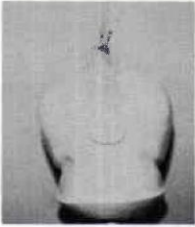


FIGURE 11



FIGURE 12

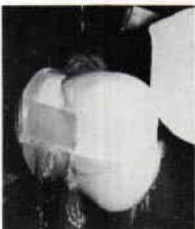


FIGURE 13



FIGURE 14

The base plates of the hip joints were marked, and the styrofoam block was shaped to blend in with the entire cast. The base plates were attached with Plaster of Paris, and the entire styrofoam build-ups sealed with Plaster of Paris.

An extra build-up of Plaster of Paris of approx. $\frac{3}{4}$ " thickness was provided over the entire seat area, which would later give space for a comfortable foam rubber (silastic) seat pad. The cast was now air dried rather than treated in the oven to avoid expansion and contraction of the styrofoam. (Figure 10)

Preparing of the Cast for Lamination

A 12" long $\frac{1}{4}$ " drill was used to drill suction channels to provide for maximum vacuum during lamination. A channel was drilled in each deep concavity leading to the provided air chamber at the opposite side of the cast. The entire model was smoothed and lacquered with a high gloss lacquer. A PVA sleeve was tailored and, by using a lubricant, tightly and smoothly pulled over the entire cast. The vacuum was attached, and the cast was ready for lamination. (Figure 11)

Lamination of the Split Bucket

The first lamination consisted of four layer 8" wide nylon stockinette. After this lamination was completed, the PVA pressure sleeve was removed and the entire laminated area was roughened with very coarse sand paper. Nine feathered layers of fiber glass cloth were laminated with epoxy (C-8 Resin) over each hip joint mounting area for reinforcement. Three more 8" wide nylon stockinette layers completed the lamination lay-up of the split bucket (a 90-10 laminac mixture was used for the lamination, 90% 4110 — 10% 4134). (Figure 12)

The completed laminated bucket was split in the center and removed from the cast. The two half buckets were trimmed to the trim lines, sanded, and smoothed with a felt cone. (Figures 13, 14, 15)

Removal and Restoring of Cast

The styrofoam blocks and $\frac{3}{4}$ " Plaster of Paris build-ups for the seat areas were carefully removed, and the

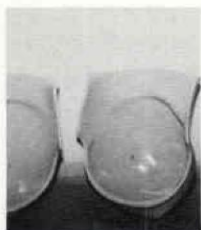


FIGURE 15



FIGURE 16



FIGURE 17

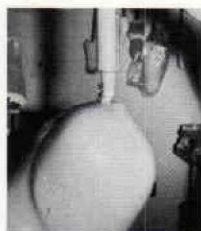


FIGURE 18



FIGURE 19

entire cast smoothed and lacquered with a high gloss lacquer and restored as in Picture #6. The entire area then received a fine Vaseline coating. (Figure 16)

The interior hip joint mounting plates were positioned and attached with two screws, leaving one screw hole and a $\frac{3}{8}$ " center hole in the mounting plate open for injection of the silastic. (Figure 17)

The two half buckets were repositioned on the male mold and the silastic, consisting of a 25% 385 silastic and 75% 386 silastic mixture, was injected into each hip joint and seat area. (Figure 18)

After curing of the silastic the half buckets were removed, containing smooth seat pads. (Figure 19)

The hip joints as well as the finished stride control unit blocks were then installed. (Figure 20)

Dynamic Alignment of the Prosthetic Unit

The prosthetic foot was set up in a special way in relationship to the hip joint, so that from the lateral view a reference line from the hip joint anteriorly through the knee bolt would fall $2\frac{1}{2}$ " posterior of the heel of the shoe. This would give the patient maximum stability and stance phase. (Figure 21)

Since no adjustable knee units were used during the alignment procedure, surplus wood was kept on the ankle blocks as well as the knee blocks. (Figure 22)

During the dynamic alignment the stance phase reference line (hip joint, knee joint, posterior of heel) needed to be increased 3 inches posterior of the heel of the shoe.

Suspension of Prosthetic Bucket

A prelamated flexible plastic tongue (as shown in picture #10) provided a closure of the anterior opening of the bucket. Buckles and Dacron reinforced leather straps were used to hold the closure secure. In this case leather straps with holes have a more accurate closing point each time the prosthesis is used. A Velcro closing would be too inconsistent. (Figure 23)

The posterior opening of the bucket was provided with a 4" by 6" by $\frac{1}{8}$ " Ortholene flexible hinge. This hinge would allow the patient to operate the prosthesis with the very short stumps, using his semi-normal gait. (Figure 24)



FIGURE 20

The height of the prosthetic unit was determined by using a proper knee flexion height of the knee unit, so that the patient would be able to sit down comfortably in a normal chair with both feet flat on the floor. (Figure 25, 26)

Two cork seat blocks had to be added to the seat areas of the bucket, thus bringing the patient up to a normal and level sitting position.



FIGURE 21

Knee Locks

Cable extensions, complete with housing and retainers bilaterally, were brought up laterally within easy reach of the patient's hands, and, for unlocking, hooked into a small stainless steel hook. Unlocking of the knee units would only be used for sitting, and both knees were locked during ambulation. (Figure 27)

The stride control hip locks would lock automatically when the patient would rise to a standing position. (Figure 28)

The patient indeed is able to ambulate, using one foot after the other consecutively. (Figure 29)

Ascending and descending stairs was accomplished by the patient by hoisting himself, using bannisters. (Figure 30, 31)



FIGURE 22

After the patient became more skilled in ambulating with his prosthetic unit, and due to the extreme stability (see hip joint, knee joint, posterior of heel reference line), the hip stride control lock could be removed, giving the patient a somewhat larger step. (Figure 32, 33)

The stride control straps were attached three inches distal and 1" anterior of the knee center medially and laterally on each leg, brought up posteriorly to the plastic bucket and retained with a D-ring in the area slightly anterior of the ischial tuberosity. (Figure 34, 35)



FIGURE 23

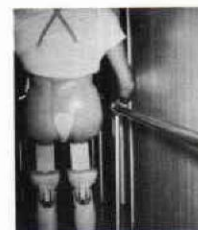


FIGURE 24



FIGURE 25



FIGURE 26



FIGURE 27



FIGURE 28



FIGURE 31



FIGURE 34



FIGURE 29



FIGURE 32



FIGURE 35



FIGURE 30



FIGURE 33



FIGURE 36