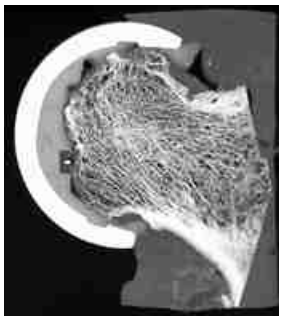
History of the prostheses of hips 1920-1980

> "Tantalum was used for the Gods the members of his Pelops son. The made indignant Gods ressuscitèrent Pelops. A shoulder already eaten by Demeter was replaced by an ivory articulation"
> (Ovide, Métamorphose, deliver 6, towards 410-415).

Bottom of mythology, the first endoprothèse had been born.

At the beginning of the twentieth century, the orthopedic surgeons are confronted with two types of attack of the Hanche: the osteoarthritis and fractures it Col of the femur. The consequences of osteoarthritis are known. With the wear of the cartilage this invaluable coating disappears which allows the harmonious slip of the head of the Fémur inside the cavity cotyloïdienne. To replace the lost cartilage of many materials are interposed between the head of the femur and the Cotyle: plaster, boxwood, rubber, lead, zinc, copper, gold, money or fragment of bladder of pig….
Aucune of these interfaces is not appropriate: too much fragile, too soft, too toxic.

The first convincing results are obtained, in 1923, by **Smith-Petersen**. This young surgeon of Boston already made speak about him by inventing at the beginning of his boarding school a new initially former way of the hip. At the time of its exercise it extirpates back of a patient a glare of glass remained in place one year and supported perfectly by the organization. The observation of this reaction gives him the idea of an orthopedic application. It makes build fine moulds of glass which it interposes between two surfaces of the hip. This lens of a few millimetres thickness "guides the repair work of nature". Except its brittleness the major disadvantage of this method remains the Nécrose femoral head related to the section of the vessels during the operation.



At the same time **Hey-Groves** (1922) proposes another particularly interesting approach in the fractures of the coll Indeed at the time of this Traumatisme the vitality of the femoral head is compromised by the shearing of the thin vessels which irrigate it. It thus replaces the head in its totality by an of the same ivory sphere gauges. Its fixing is ensured by a handle which crosses the femoral diaphyse. The prosthesis takes at the same time the place of the femoral head and the articular surface which it carries. This intervention remains an isolated case although the result is satisfying four years after the intervention.

Femoral prostheses

In spite of many research the solid ideal material and tolerated well by the organization is made wait. A solution is proposed in 1936 by **Dr. Venable**. After having tried out long years the effects of various metals on the bone this one concludes with the superiority of the Alliage Chromium-Cobalt-Molibdène for the orthopedic applications. It calls it Vitalium.

In 1939 **Harold Bohlman** resumes work of Venable and develops the first femoral prosthesis out of metal (Vitalium). This one replaces the head of the femur and the cartilage which recovers it. This solution makes disappear the risk from Nécrose met in the continuations of the cups of interposition. However a new question arises: how to make hold this prosthetic head? Bohlman chooses to fix the metal head at cortical external femoral collar by a nail. The first two operations show a failure what brings Bohlman to verticaliser the nail.

During the years which follow some attempts are born. The results are not very conclusive and the interventions far from many.

They are **the Judet brothers** who designed, in France, in 1946, the first prosthesis posed of number (the preceding attempts were < to 10). Jean Judet had never liked the blocking of the articulation (arthrodèse) suggested at the time to relieve severe osteoarthritides. He preferred réséquer the pathological femoral head and articulated the femoral collar in cotyle because “by arthrodèsant a painful hip you substitute an infirmity for another”. From 1946 the two surgeons replace the head withdrawn by an of the same sphere gauges out of more known methyl methacrylate under the name of Plexiglas. This one is fixed on a pivot crossing right through the collar of the femur. In all the cases the immediate results are good then disappointing as of medium term. These failures are due to an intolerance with the remains of wear of the acrylic resin which will be definitively abandoned in 1949.



Moore (1950)

Austin Moore already conceived with Bohlman in 1940 a méga metal prosthesis little posed. The revolutionary process of fixing that he proposes to maintain femoral the head goes back him to 1950: the metal head will be carried by a stem driven in the medullary canal of the femur. Since this date the near total of the femoral implants will take again this concept.


At that time, Moore is the surgeon of the Psychiatric hospital of the state of Columbia, which has 7000 beds. The fractures of the collar of the femur are frequent among patients in general old, often in bad general state. The forecast of this lesion is transformed. A few days after the operation operated evolve/move in the corridors of the hospital what is very new. At the time the fracture of the collar of the femur was a cause of frequent death at the old man. The prosthesis of Moore is in Vitallium. A window is practiced in the prosthetic tail to allow pushes back it os. A hole is placed at the upper part of the coll It will be used, if necessary, to extract the prosthesis.

At the beginning the installations are carried out by former way of access. The operation is difficult and the poor results: the luxation are frequent. Moore thus modifies the procedure. It uses an increasingly posterior access which one will call in wink “the access of the South” or *way of Moore* . The simple femoral prosthesis deals with pathologies related to the femoral head. This solution is very useful for the treatment of the fractures of the collar of the femur.

However in osteoarthritis, vis-a-vis the metal head, the worn cartilage of cotyle remains unchanged. This treatment requires a total prosthesis or the femoral head and the cotyle are replaced.

Prostheses total of hip

Mac Kee (1951) Norwitch, England.

On the other side of the Atlantic Mac Kee seeks to solve the double problem arising from the osteoarthritis of hip. The wear of the cartilage is bilateral. Two surfaces must be changed. Its choice is made on metal. The new femoral head will roll in osseous cotyle covered with a metal hull. According to its example the couple of *slip metal against metal* between head and cotyle will become the solution suggested during many years by the originators of prostheses .

Mac Kee designs a first prototype in 1941 later follow-up of a first installation… 10 years. Its research will continue 40 years. Dice its *beginnings fixing with the bone* remains the principal problem. The part cotyloïdienne is fixed by a large posterior screw inspired of the screws of arthrodèses of the time. The femoral part is fixed at cortical the diaphysaire by a plate.

In 1951 Mac Kee established for the first time three of these total prostheses of hip. In two cases the prosthesis is out of stainless steel and is loosened in less than one year. Third is in **Vitalium** , recommended by Venable since 1936. This alloy does not present this tendency so common to “seizing”. The prosthesis remained in place more than three years, before the prosthetic collar does not break, which gives again the hope with the surgeon after all these years of work.

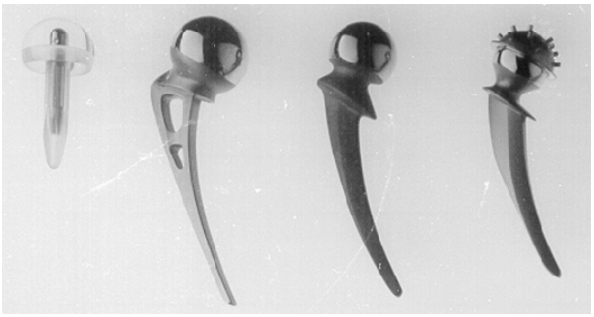
In 1953, Mac Kee meets its American fellow-member, the media Thompson. This one proposes, since 1952, a model resembling the prosthesis of Moore but without window. It was appropriate it of the reliability of the fixing of the femoral prosthesis by a *stem will intra medullary* . The following model thus comprises a femoral part standard Thompson with a head a little smaller to be able to articulate itself inside metal prosthetic cotyle.

This model is used of 1956 to 1960. 26 people will be operated. The results are rather satisfactory with more than 10 years. But in 10 cases out of 26 it is a failure by unsealing. At the time Mac Kee allots this bad behavior of the implants to the frictions repeated of a metal part on the other. To resist this request, he seeks has to improve the attachment unit of the implants. The true cause of these unsealings will be included/understood only well later.

Until 1960 Mac Kee proposes as solution with the problem arising:

- Stem in Vitalium carrying a femoral famous person articulating itself in a metal cotyle in Vitalium.
- Held of the two components by mechanical fixing: femoral stem and large screw cotyloïdienne.

evolution



The results of this type of prosthesis are unequal. In spite of the improvements made by Mac Kee It persists in a great number of cases of early unsealings. At the time the cause is allotted by it to friction or “seizing” between the two metal parts too constraining for the method of fixing mechanical of the implants.
It is only well later, in 1974, that one will include/understand the true reason of these unsealings: the human organism reacts vis-a-vis the remains of wear salted out in the new articulation. The macrophage eliminate the foreign particles and are attacked, in same time, with the surrounding bone: it is the Ostéolyse which corrodes the bone and weakens prosthetic fixing.

Cemented total prostheses

Charnley (1960)

The professor John Charnley is at the origin of a true revolution in the field of the prosthesis of hip.

After some hesitations the concept suggested is based on several complementary principles and completely innovating: new materials, fixing with cement, news cuts prosthetic head, new way initially. As from 1970 **more than one million** its prostheses will be posed and it is still posed some.

For Charnley the key of the success depends on the *reduction in friction* between two articular surfaces person in charge of “seizing” so prejudicial to the prostheses metal-metal. In 1959 it measures the coefficient of friction of a normal articulation and compares it with that “of a shoe slipping on ice”. Of course, the man cannot manufacture parts articulated with so low coefficients of friction, especially for slow pendular motions and in full load. In parallel the experiments of Charnley confirm that the fabulous mechanical properties of the articulation come from the articular cartilage and not from the synovial liquid.

Initially Charnley thus will seek a material to replace the cartilage destroys in the coxarthrose. This one must offer the smallest coefficient of possible friction and be perfectly tolerated by the organization. At the time it is polytetrafluoroethylene or *Téflon* which fills these criteria. Charnley thus develops the concept of articular cartilage synthetic and recovers reorganized articular surfaces of a fine film of this plastic. These thin cups give spectacular immediate results. Alas, very quickly, the luxated femoral head then planed to receive the " cockle " of Teflon, the same complication as with the cups of Smith-Petersen undergoes: necroses ischemic. The results are not with return Charnley however have just made the experiment of a new material: plastic.

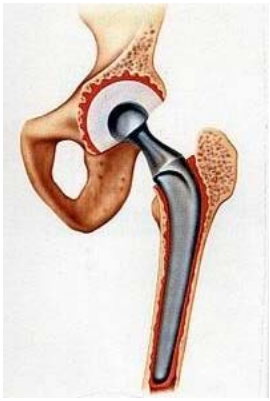
Charnley is interested then in the prostheses of Moore which eliminate this risk by replacing the femoral head. But those have the same defect as the prostheses of the Judet brothers: they are loosened. While being based on work of Doctor Wiltse published in 1957, Charnley retains the possibility of using the acrylic resin autodurci like method of fixing prosthetic. This technique is already used by the dentists. Starting from 1959 its prostheses of Moore will be fixed with polymethylmethacrylate which it will call “cement with bone”. Tens of patients are operated and, as envisaged, the results are much better than those obtained with the same prosthesis without cement. Charnley thus proposes to cement its prostheses.

In the second time, in order to protect cotyle while decreasing the coefficient of friction further, it will not make any more rub the prostheses of Moore on the damaged cartilage but on Téflon. Its prosthesis becomes total. Side cotyloïdien it then takes again its first Teflon cotyles and poses prostheses which one can describe as hybrids, made up of a standard cotyle “artificial cartilage” of its invention opposite a femoral element out of metal, standard Moore, fixed at “cement with bone”. The results are rather good… but the very fine cotyle quickly wears and continuous to be loosened in a great number of cases.

In 1960 Charnley then decides to further decrease the risk of unsealing by decreasing friction between the femoral part and the part cotyloïdienne. It will move away from the natural diameter of a head of the femur passing from 41 millimetres to 22 millimetres. The demonstration is mathematical: the smaller the femoral head is and the less important friction is. It is famous “the prosthesis with weak friction” (low-friction arthroplasty). This small diameter of femoral head has another advantage: it leaves more place for Teflon cotyle inside the bone cotyloïdien. The thickness of cotyle can thus be increased. But however after a few years the small head imposes an unbearable pressure on the cup which wears quickly.

The surgeon does not retrogress. Attached to the principle of the small head he prefers a plastic more solid than Teflon. He chooses in 1962 the polyethylene of high molecular weight. This one has a coefficient of friction against steel 5 times higher than Teflon but its wear resistance is 500 to 1000 times higher.

The prosthesis of Charnley will thus be cemented with a small metal head of 22 mm travelling in a cotyle in Polyéthylène.



Charnley is close to its solution however, among operated patients, a new disadvantage is presented: the small femoral heads are luxated more easily. Charnley thus changes its way initially and proposes a specific solution: the Trochanterotomie. The incision is side, the great trochanter is divided to release the articulation. This one will have to be ringed with metal wire at the end of the intervention what retightens the muscles glutei, stabilizing elements of the hip. This technique largely decreases the risks of luxation with a resumption of the support on the side operated five weeks after the operation.

Charnley thus proposes in the orthopedic world triple solution with the problem arising:

- Low friction and thus low level of wear per bearing of a metal head of small diameter in a thick plastic polyethylene cotyle.
- Fixing of the components by acrylic cement.
- Way initially by section of the bone trochantérien to retighten the muscles glutei and to decrease the risks of luxations due to the small diameter of the prosthetic femoral head.

This tripod established a right balance between the three risks: wear, unsealing and luxation

Mac Kee - Farrar (1960)

In front of the impressive results of its Charnley fellow-citizen, Mac Kee starts to cement to him also its prostheses in 1960. It uses same the Ciment. It fixes the femoral element and the element cotyloïdien, which Charnley at the beginning does not do. The prosthesis used is metal-metal associating a femoral component of Thomson type with a cotyle which loses its large posterior screw because of fixing with cement.

It is at that time that Farrar joined Mac Kee. The principal problem with which they are confronted is the conflict between the broad collar of the prosthesis of Thomson and the edge of metal cotyle in the movements of great amplitude. In 1961 the collar is refined. In 1965 the femoral element is redrawn with a narrow collar as on the femoral stem of Charnley.

In 1974, the persistence of unsealings is finally included/understood: it is not the shape of the prosthesis which is in question, nor cement, but the metal remains which had with frictions metal on metal. This Métallose induces a reaction of the organization source of unsealing. Like Charnley, Mac Kee and Farrar thus decide to give up the couple metal-metal to use a cotyle polyethylene with high density. After 35 years of honest services the couple metal-metal disappears from the orthopedic landscape in waiting of the progress of materials.

However this change of couple of friction will not be enough. Vis-a-vis the prosthetic heads of large diameter the polyethylene cotyles remain fine. Wear is much more important. Those are pulverized in a few years. The small femoral heads of Charnley type allow a greater thickness of plastic.

McKee commented with spirit in 1982: "***we always learn more from our failures than our successes"***

Müller (1966)

Switzerland Maurice Müller does not wish to use the way initially suggested by Charnley. He prefers with the section of the bone trochantérien a posterior way of Moore. This way allows its patients a resumption of the immediate support whereas the trochanterotomy recommended by Charnley induces one period of nonsupport of more than one month.

In against part, the risk of luxation increases with the posterior way. To cure it Müller initially increases the diameter of the femoral head of 22 Misters with 32 Misters the rate of luxation decreases but the wear of the cotyle polyethylene is then more important. The tripod proposed by Charnley must find a new balance. Starting from the posterior way considered as less aggressive one new consensus is established between luxation and wear. The diameter of the femoral head will be of 28 Misters.

The shape of the cemented stem proposed by Müller is also different. This stem will be called the prosthesis "banana" because of its form. The cotyle is also out of polyethylene.

Muller proposes an alternative with triple solution suggested by Charnley:

- weak Friction by bearing of a metal head with a diameter 28 mm in a thick plastic polyethylene cotyle. However the attrition rate will be more important than with a head of 22mm.
- Fixing of the two components by acrylic cement as for Charnley.
- initially posterior Voie what allows an immediate resumption of the support.

THE SEVENTIES

With the beginning of the year 1970 the world of orthopedy knows and analyzes with a certain passing, as well temporal as numerical, the results of the technique of Charnley. They are good and even very good.

Fixing by cement solves the problem of the behavior of the prostheses of hip so much so that it becomes obligatory in the United States as from 1972. In association the low level of friction between small metal head and cotyle makes it possible to decrease the wear of the couple of friction.

Before Charnley a prosthesis was to last 5 even 10 years, which held it to the oldest people. With Charnley, the prostheses last often more than 15 years. Time passes. With the beginning of the year the 1980 first unsealings occur.

In occident, hundreds of thousands of total prostheses of hip are posed each year. Blackbird of Aubigné takes part in the diffusion of this type of prosthesis in France at the Cochin Hospital where it are always posed today consequently way initially: trochanterotomy.

However certain elements gradually will modify the systematic use of cement. The patients changed. It becomes less and less acceptable to suffer from a disease of the hip and operated are increasingly young people. The work requested from the artificial articulation is increasingly close to a normal articulation with renewal of activity in even sporting force.

"Acrylic cement is thus little adapted to these new conditions. The human bone, especially at the young subject, is an evolutionary structure in perpetual activity of replanning according to the biomechanical constraints with walk and the effort. " Jean-Alain Epinette.

Continuation of the prostheses without cement between 1970 and 1980

During this period the prevalence of the techniques suggested by Charnley is such as the initiatives to move away some are very few and the fact of outstanding personalities.

Two research orientations are offered to these surgeons: the exploration of new types of fixing more powerful than cement and that of a new couple of friction. A new promising couple, ceramics-ceramics is proposed by French Boutin.

Fixing

In 1956, **Siwash,** a Soviet surgeon, develops in the USSR the first total prosthesis of hip with direct anchoring both for the stem cotyle. Very innovating surface external of the part cotyloïdienne comprises three crowns of asperities sharp and fenestrated in "petals" or "rosette" intended for direct osseous anchoring. Posed for the first time in 1956 this concept, worked out in Russia, will pass unperceived. He will be discovered in Europe fifteen later.

Between 1970 and 1980 various proposals for a fixing of the femoral stem without cement are born: by Judet in France (1971); Lord In France (1974); Engh in the United States (1977); Zweimüller in Austria (1979)

Judet proposes in 1971 a prosthesis with direct anchoring. It names this alloy containing cobalt the Porométal because the balls which recover it are separated by pores. It poses 1611 of these prostheses until 1975, but of many failures occur due to the bad mechanical and metallurgical characteristics of the implants. However the kickoff is given and from many models will develop in France.

In France, **Lord** proposes in 1974, its madreporic prosthesis which resembles the alive coral: the Madrepore. Its surface is made up of balls of 1mm. Unfortunately this stem presents several disadvantages: major difficulties of extraction and bad long-term adaptation bone-prosthesis what involves pains. These problems then caused a certain discredit upon this type of implant.

In the USA, the use of acrylic cement in surgery is interdict until 1967, then becomes obligatory as from 1972. It is into 1969 that Welsch and coll begin a considerable research task on fixing without cement. In 1971 is born a porous metal coating. It is into 1977 that **Engh** starts to use this “porous-coat” on the femoral stem of its prostheses.

In 1979 **Zweimüller** presents to Vienna a femoral prosthesis whose characteristic is its pyramidal form with rectangular section. The principle of fixing is the cortical self-locking. The titanium stem has a roughness from 3 to 5 microns what improves primary fixing on the bone. After 25 years of retreat this stem without cement very gives excellent results to long run and is always abundantly posed.

The couple of friction

Ceramics will be exploited for the quality of the ceramic friction on ceramics and for their biocompatibility which allows an macro-anchoring. It is **P. Boutin**, of Pau, which opens the way in 1970 with a total prosthesis of hip whose cotyle is out of ceramics and the femoral part in two parts: a ceramics head fixed on a steel body.

As for the preceding couples, metal-metal or metal-plastic, the fixing of the two components is a constant worry because the ceramic cotyle accepts cement badly and the fixing of the head on the metal stem, by joining or screwing, is dubious. In 1971 the cotyle becomes not

cemented. Anchoring is direct by macrogeometrical reliefs of 1 Misters Into 1975 of the folds of surface are practiced on the stem what allows an establishment without cement. In 1977 the ceramic head is fixed on the stem by a conical hafting.

An anecdote reports that this major innovation of P.Boutin would have been born from the observation of the system of rotation with weak friction of the turrets of the Leclerc tanks then based in the important military center of Pau close to its private clinic. This history summarizes the difficult course of the creative thought: complex wheels or simple blow of Pau?

At the conclusion of this decade opens the concept of fixing without cement by surface treatment like that of a new couple of friction known as hard-hard.

At the beginning of 2000

The techniques of fixing without cement develop. The femoral stem has a treated surface which allows its integration the bone. The solution chosen for cotyle is that of a metal shell impacted in the spongy bone: metal back. As for the femur, its external surface is treated by mini reliefs which allow its integration the bone of the basin. Surfaces of the stem and prosthetic cotyle are readily covered with a primary education component of the bone: Hydroxyhapatite. This fine coating accelerates the integration of the metal parts.

New couples of friction appear. The couple ceramics-ceramics takes its rise. The femoral head is fixed on a Morse taper, the cotyle is enchased in a hull metal back. Another couple has reappeared for a few years: metal-metal. Indeed thanks to progress of machining the wear of this couple is now very weak.

With the good resolution of the problems involved in the implant certain surgeons are interested in the **evolution of the way** initially. These invasive ways minis are carried out by mini incision (mini way invasive posterior: François Prigent). The articular muscles perished are respected. The rate of luxation is then decreased and faster functional recovery.

A new dimension is given to the **respect of the architecture** of the natural hip (concept of offset). The choice of the prosthesis is done on copies at the same time in length but also in width. These implants adapt to the anatomy of the patient in order to preserve the unchanged muscular tensions.