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DYNAMIC
STABILIZATION

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Part from the pain caused by the overt reasons such as the accidents, infections, tumoral spine invasions, they also cause neurologic damages at the same time. The cause of the pain is degenerative diseases, which also form the largest group. In this group, we can count the painful black disc, degenerative spondylosis, lumbar spinal stenosis, and degenerative scoliosis. The other important group was the group of patients, who had lumbar discectomy operations but ended up having recurrence or no good results; that is to say, the pain in the leg recovered or not, yet lumbal back pain remained. Although they had an operation, the patients in this group who could walk around, but do the daily activities with pain, were not different from the degenerative instability group which occurs typically spontaneously and need surgical support were included within this group.

The solution for stopping the pain is to eliminate the movement, that is to say, to fix in other words, doing the fusion on the segment which causes the problem which has been a general basic rule since Hibbs²⁹ and Albee.¹ In fact, it was the solution found for overt instabilities, but in the chronic instabilities too as degenerative diseases began to be used with the hope of effectiveness,¹⁶ it actually worked and became the golden standard. But to be able to call a solution 'the golden standard', there should be alternative solutions. However, there is not another solution, so the term of golden standard should be discussed.

There were some suggestions, even practical adaptations, that were ever so weak. As the simple discectomy which could not be a solution, everytime this came across with the confession of the surgeons who did the first operation.^{8,14,22,40,41} Cloward¹⁶ suggested fusion after the discectomy, but in 1956, Van Steenbrugghe⁵⁶ designed the first artificial disc model that could replace the natural disk, which could move like a real one; however, he did not apply it. Fernström thought of protecting, but not fixing the movement by replacing intervertebral discs interspace with a steel ball in a group of the patients after the discectomy.²¹

In 1992, Henry Graff²⁵ took a stand that in the degenerative events of the spine, the pains are based on the rotational strength, and to support the segment with artificial ligaments, which keeps it flexion by preventing the rotation instead of fixing the spine. He developed the Graf's ligaments which is named after him. Those ligaments are applied to the transpedicle screws keeping them under compression. This is the concept which presents that a spine can be stabilised without fixing from the posterior at the first time.

Fusion and Problems

To deny the necessity of the fusion surgery is out of the question. Yet, it is inevitable to essentially discuss the causes of applying it. As an antibiotic, which is useful for one infection, cannot be applied for every infection, the fusion surgery which is suitable for

some spine pathologies can not be used in every spine disease whenever it flashes into our minds. Whereas, fusion surgery is a very incredibly powerful method, which provides the spine continuity, with a formal logic, fixing the moving parts of this structure does not make any sense. In that case, there should be a restriction of using this treatment method.

In short, the answer to the question of what this restriction is, can be that the pathologies cause the overt instability. Besides, it is incontrovertable that it has a place in the surgery treatment of multi-level pathologies, which cause the sagittal and coronal imbalance in the spine.

What are the reasons for avoiding fusion surgery? Even if the operations are segmental, there is not another antidote to take the risk of the surgery treatment of overt instabilities when the rate is high against complications such as bleeding, nerve injury, infection, the most crucial one, pseudoarthrosis; but, in the treatment of one painful degenerative disc disease or recurrent disc herniation you should think twice (a thousand times). To increase the chance of fusion with the aim of replacing a bone graft, the intervertebral disc interspace is completely cleared up and the vertebral endplates are removed. If a cage device is used, one or double sided facet should be taken in order not to injure the nerve roots. That is to say, first with the doctor's hand the patient is thoroughly destabilised, then with the help of the screws they are stabilised and fusion development is accepted in a three month period. If it develops, there is no problem, however if it does not develop, to see the patient's situation before the operation remains a memory in the past.³¹

If an infection develops too, the situation is the same, because there is a direct proportion between the infection development and the surgical period. The ratio of pseudoarthrosis after the fusion operations is 26% and this ratio increases more due to the bone degradation of the patients who are osteoporotic, use cortisone or anti-inflammatory, or smoke.

Moreover, even though in the last years the ratios of the fusion related to the development in the fusion technologies has risen up to 98%, the patient satisfaction remains at 60%.⁵

The other important problem is adjacent segment diseases in spite of discussions, it is expressed that in the following years of fusion its ratio shall come out at 20%.^{30,45}

The other important reasons for pain are the location of donor, usage of a corset for a long time, the long period of rehabilitations which will be accepted and it is certain that the period of job loss will be longer for these patients. The period of total disability is a crucial cause of the income loss in the industrial communities.

Total Disc Prosthesis

The total disc prosthesis is the replacement of a new artificial disc which keeps the segmental movements of the spine in the place of the discs removed which is the source of pain.

In the modern meaning, German Karin Büttner Janz and Kurt Schelnack⁹ carried out the replacement of a new artificial disc in the place of the discs removed in 1984. After the intensive bio-mechanic tests and the clinic applications, they made the first artificial discs prosthesis which belong to themselves and has three parts. The upper and lower parts of the prosthesis are made up of hard metal layer, and between them there was an elastic core which is adaptable to the movements with motion-segment that is formed with two vertebrae as well as it clings to the layers interspace. The roughened and jagged surface of the metal layers stick to the endplate cartilage and provides the prosthesis to cling to the vertebrae. Based on the occurrence of complications, by making the necessary corrections on the prosthesis, they twice formed the last shape with the name of Charité III. The name of Charité III was used in the Charité Hospital, which is related to the Humbolt University. Also, the artificial disc has begun to be called by the name of this hospital due to its use in that hospital. Karin Büttner Janz and Kurt Schelnack,⁹ in 1987, reported the first successful clinical results of TDP and said that from now on TDP has become another alternative treatment method to the fusion. Then, they also announced in their publication that by applying TDP for the second batch of patient group, the ratio of customer satisfaction was 98%.¹⁰ The usage of Charité III disc prosthesis became widespread in the whole world after that date. Marnay³⁷ designed "ProDisc" which has a polyethilen smooth structure and is called "Ball-Socket" and began to use it. He published the results of his 11 year positive follow ups. Disc prosthesis such as Prodisc i Maverick, Flexi Core, Mobidisc

ve Kineflex pursued. In terms of its being suited up to the bone, the prosthesis are designed as ceramics, clinging to the parts of the cartilage endplates. The new designs which have the effect of shockingly absorbing to be called a last generation are brought into question. (Figure 1 and 2)

This excitement in the disc prosthesis provided the prosthesis surgery to enter to the American markets. The prosthesis passed into other hands with top dollars. Their use have began to spread worldwide by wheting the others' appetite in the medical industry.

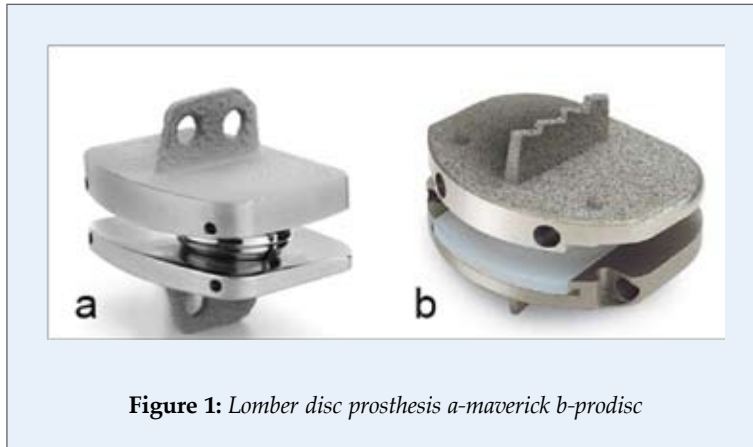


Figure 1: Lomber disc prosthesis a-maverick b-prodisc

Indications

The idea patient group for TDP; the patients who did not lose the bone due to the bone degradation of the patients who are healthy adults at the age of 20-40 and osteoporotic, who have no facet-joint problems, have a problem on especially L4-5 disc according to MR findings and whose disc height is not less than 5 mm.

Contraindications

The people who have to take cortisone, osteoporosis, have calcium metabolism disorders, are allergic to metals, immune deficient, have active infection, are morbidly obese and have degenerative facet joint, denegerative spondilosthesis and scolliosis, pursue the second gain on purpose or unintentionally, have personality disorders, major depression and psychosis, too, are not suitable to replace the TDP. Also, people who had an abdominal operation, iliac artery and the defraction of veins are just higher than the level required to make prosthesis, and are not suitable candidates.

TDP Biomechanics

Disc prosthesis turns the disc height to its normal size and provides openings in foraminas in this way. By providing the tension of posterior anulus, where mechanofeceptors are so dense, also supports improving the proprioceptive capacity, which is one of the most important ones

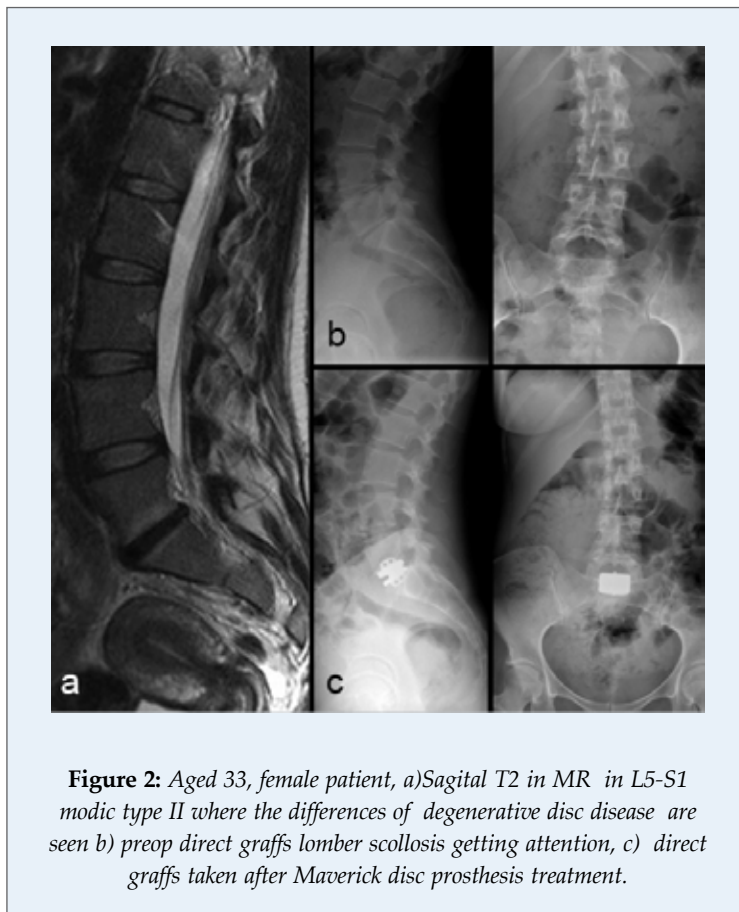


Figure 2: Aged 33, female patient, a)Sagittal T2 in MR in L5-S1 modic type II where the differences of degenerative disc disease are seen b) preop direct graffs lumbar scolliosis getting attention, c) direct graffs taken after Maverick disc prosthesis treatment.

of spine balance. The point to be careful about is to provide the normal disc height, not more or less. The most problematic space is the fifth lumbar and the first sacral (L5-S1) vertebral space. Because of the sacral inclination, the front part of the disc height is more than the back side, and the disk angle to be replaced in this space is as important as choosing the suitable prosthesis. By providing the load off the center and turning the degenerative disc hyperacidity, or on the contrary, the less active moves to its normal motions to protect the tissue around from the abnormal load.

When the disc prosthesis was replaced, it is placed at a location deemed suitable by the firm which manufactures the prosthesis. The ideal location is that the prosthesis rotation center should be slightly behind the medial line of the spine in the sagittal plan and slightly under the cartilage endplate of vertebra. All the disc prosthesis allow the flexion, extension and rotation movements. All those motions and ligaments are controlled by proprioceptive nerve system and muscles. While the hyperacidities are stopped due to the anatomic structure of the disc itself, the device itself provides this limit in the disc prosthesis.

Disc prosthesis in the damaged segment has a positive effect on the spine balance as the load and movements, which became normal, will regulate the posture.

The Current Situation in the Total Disc Prosthesis:

An important study was made on TDP, which had two parts, made in the custody of Food and Drug Administration (FDA) before they entered the American market. The first part was multi centered and randomized and compared fusion with TDP. The results of the study proved that TDP was more effective than fusion.⁴ In the second part of the study, disc prosthesis regulated the range of motion (ROM) with respect to the preoperative period. When it became normalised, it was found to have less subsidence according to the cages in the vertebral interspace. Based on these studies, Charité disc obtained the approval of FDA for common use in America.^{4,15,17,23}

While many positive results were reported with publications, Putzier study published in 2006 became very disappointing.⁴⁶ Putzier enunciated that fusion surgery is better than TDP by reporting that very large number of patients with Charité I, II and III

disc that he followed up for seventeen years gave unsatisfactory results. Following this important study, FDA reported that five year results indicated no definite statistical difference in the radiographic ROM and clinical findings of TDP as a fusion surgery.²⁸ Another study was published by Berg and his colleagues in which the patients who had one or two level painful degenerative disc disease were divided in two groups. They applied Charité, Prodisc and Maverick disc prosthesis in one group and made posterolateral or posterior intervertebral fusion (PLIF) to the other group and followed them up for two years. They informed at the end of the first year that the patients who had disc prosthesis and became more mobile earlier, regained their independent life earlier, whereas, in the end of the second year follow-up, they had no definite statistical difference with fusion group. In another study, Eerenneent and his colleagues compared the clinical results of TDP and fusion reported in the literature and revealed that TDP was not superior to fusion. In this study, when the results of fusion which was made with Charité disc prosthesis and BAK cages, was compared with two and five year clinical study reports, they signified that the result they reached was based on weak evidences. They also stated that similar findings were invalid for Prodisc and the data was insufficient to conclude that TDR was superior in the long period follow ups in the treatment of one level degenerative disc disease.⁵⁵ These studies, and the reports of complications by many centres, notably the USA, and dis-incline among surgeons from TDP due to difficulty in revision leading to mortality and morbidity, the insurance companies in the USA declared that they would not provide coverage for TDP operations. In the end, the process, which entered with great hopes, became a great disappointment, and the numbers of TDP operations hit the bottom very fast.

TDP surgery was a great attempt, and in spite of pausing, doubtlessly with human intelligence and ingenuity, it will go on its way again.

With different designs and operation techniques there will be new developments and the non-periodical motion of the development will go on in this technology.

Posterior Pedicle Dynamic Systems

The first person, which came up with the concept of posterior dynamic system, is Henry Graff.²⁵ Graff believed that rotational strengths caused the backache in chronic instability. That is the reason why he thought that the pain would pass when the rotation was restricted; he limited the movements by stabilising the spine in compression by inserting the screw instead of the rod to the artificial ligament named after him. (figure 3) Graff ligament was used by many surgeons who believed in this concept in various countries in the world. From 10-year study results of 59 case study series in which he applied Graff ligament, Kanayama concluded that there is a definite recovery.³² However, there were no biomechanic studies related to this, so the evaluation was made with the results of clinical studies. Some other successful results were reported which said that it was equivalent to fusion.^{7,36,42}

With time, this became weak in hypertension and caused foraminal stenosis owing to destabilising the spine in compression. Moreover, dissepimental between two screws caused distraction, resulting in development of fault spine deformity, for which it was widely criticized and its use, could not become widespread.^{26,42}



Figure 3: Graff ligament technique which is applied in a way of Posterior transpedicle

Later, Dynesys system was developed by Dubois in order to close the gaps of this system. (Figure 4 and 5) The most crucial difference is replacing a very strong dissepimental on an artificial ligament to withstand the hypertension and compression. Dynesys is very dynamic system, which is mostly widely used in the world today. It was shown that neutral zone turned to normal biomechanically, and brought the pathological mobilisation under control.^{2,43,54} Prospective clinical trial studies were used in the treatment of the degenerative disc disease^{48,53} spinal canal stenosis and the degenerative spondilolisthesis,^{11,13,35,47,48,50,51,53} and the successful results were published. Especially, in Ricard's clinical trial with 25 patients and in the evaluation of all the patients who could benefit from the surgery, are very good.⁴⁷ Cakir, in his retrospective study, compared the groups in which fusion and dynamic stabilisation were made, and found that the dynamic stabilisation in the cases where Dynesys system used, is a very strong alternative to fusion.¹³

Dynamic systems are tried in the degenerative scoliosis too. The first person to use Graff's ligament is Kanayama.³² It was reported that the results of the patients were very good. Di Silvestre *et al.*¹⁸ made the surgery treatment to the degenerative scoliosis with Dynesys system. In approximately 54 month follow up, it gave a good result and he did not mention any major complication.

There are three studies, which show that fusion is not superior than Dynesys.^{12,27,61} In fact, this indicates the superiority of dynamic system because its mortality and morbidity is lower than fusion.

Dynesys system's problem is the difficulty in arranging the tension rod, which depends on separator's locking of distraction and the waist is forced to kyphosis. In addition to use of multiple levels, it causes flat back syndrome. When tension rod standardization is not made in proper way,



Figure 4: Dynesys system dynamic rod are used a very strong alternative to fusion(13)

the rod almost behave like a rigid system. In addition, compromising compressive loads on separator can cause breakage and loosening on separator by bending movements.³¹

Other than Dynesys, another rod system in clinical practice is reported in literature. Balance C rod came into market after *Agile rod* results were unhealthy. However, it is used for a single distance; hybrid fusion models are also designed. In addition, the Korea and China market have similar dynamic rod systems. Again in literature, there exists another dynamic rod system, called “Biofleks”, which has been reported to give positive results in the biomechanical and clinical studies.^{44,63}

The designer has brought dynamism by putting Von Stempel to screw joint. (Figure 6 and 7) There is no need to work on facet replacement systems, which is great, of simple design, but expensive. In short level, this system is rigid or dynamic rod, but in more levels when it is used with dynamic rod, it will serve as a facet joint but will create posterior tension band and support it. Stempel has indicated his experience and indications for use of this system and has published successful results.⁵⁷⁻⁵⁹ There are studies, indicating articulating screw system made by the finite element system on the computer and



Figure 5: 35 year old, woman patient has a) Sagittal T2 of MR L4-5'de degenerative disc disease seen, b) draws attention to the direct loss of lordosis preoperative radiographs, c) plain radiographs obtained after application of Dynesys.

sharing pre column load.^{24,52} This idea was planned on the basis of argument by providing articulated screw system under the pressure of graft to develop better fusion. But at the end, fusion didn't develop



Figure 6: Cosmicmia screw head is hinged, allowing one action plan



Figure 7: 65-year-old male patient, a) Sagittal T2-L4-5 degenerative disc disease seen on MRI, b) preoperative radiographs directly observed a slight scoliosis, c) Cosmic plain radiographs obtained after administration.

well even in patients without fusion system well adapted to bones, especially in one distance. After that it's being used as non-fusion technology. These studies were works from that period. As a non-fusion technology, biomechanical tests were published in literature, which is conducted on human cadavers and shows Safinaz (figure 8) and Cosmic system's stabilization power. Both the studies revealed that dynamic screws has stabilization effect close to a rigid system.^{6,49}

When participating level increases, system becomes more rigid and we use the weak side of the dynamic screw system. This is the reason why the system is being known as a semi-rigid system. We thought that we could defeat this weak side by making the posterior tension band lively. In fact, we have used and published³³ Agile rod as a hybrid for the first time for dynamic system in rigid rod. However, we tried to use a system in long levels with all rods moving. Especially for young patient, who were operated by us with peek and carbon fiber dynamic, we gave up using them on two levels because of lack of insufficient flexibility of rod that behave rigid. We designed and tested on biomechanical tests, and we started to use flexible dynamic rod known as Talin. (Figure 9 and 10) In our biomechanical



Figure 8: Olive screw, the beginning of the hinge, and allows movement one



Figure 9: Flexible metallic rod: Talin



Figure 10: 37-year-old male patient, a) Sagittal T2 MRI, degenerative disc disease at multiple levels, b) the preoperative plain radiographs, c) dynamic screw (Olive, hinged screw head) and dynamic rod (Talin) plain radiographs obtained after application

studies, the dynamic rod, when used with the coil and screw, there was a decrease in the screw overlapping dynamic loading stress, and the loading of the screw rod decreases the possibility of complications. However, the system instead of semi-rigid becomes more dynamic. Surgery that uses moving screw and rod has excellent early results but in the long term, due to fracture of rods elastically, we have abandoned to use it. However, until the rods were broken, we have both excellent clinical sign, which later gave bad clinical signs after the rods became weaker. We observed clinically that the damaged segment is stabilized by the spine flexibility.

Technologically, the development of artificial facet joint systems, which will carry all the features of a great technological race has, began, but

there is still no any succesful system. TOPS, the pioneer of the total facet system have been introduced with great hopes to the market and have produced successful results for its first patient.^{38,60} However, later it didn't continue. Newly developed DSS and Stabilmax.⁶² system is a highly complex and even if laboratory studies showed facet joint movements, clinical results have not been very succesful. As a result, which system is more suitable for spine and its movement has not been determined yet. Today, the dynamical system has been into the development process, which is branching off rapidly. According to simple moving rods and a variety of complex systems in a multi-facet replacement, products have developed or continue to be developed.

Conclusion

In my opinion, it is time to push the fusion surgery in the surgical treatment of degenerative instability. Even if creating anterior disc prostheses is a big disappointment, it will be developed. User friendly and simple, more effective prosthesis or nucleus pulposus alternative system shall be final. After that surgical treatment of degenerative instability should be the first choice. There is almost no mortality and morbidity. Wound infection, cerebrospinal fluid leak in a few cases opened for the second time for comparison with the fusion, there is a small screw and rod breakage. Stabilization of rigid rod breakage of screws or pseudarthrosis often requires revision. If the patient has no complaint to the dynamic stabilization, no revision is needed. And its not understandable who blocked this system, which is more cheaper and has less complication and risk for patient. Instead of evidence based medicine, counting himself with "according to me" mentality, he tried to cut the front of dynamism, but there is no place for "according to me" mentality.

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