Duello 2: Dynamic Instrumentation

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ABSTRACT
Dynamic stabilization is a new technology; more importantly, it is a new philosophy for the treatment of
the spine. Patients complain of pain but have no other major problems in degenerative instability. Dynamic
stabilization of the spine is the ideal treatment when pain negatively impacts quality of life. Treating fusion
in most of these patients should be viewed as unnecessary because mortality and morbidity rates are quite
high, especially in the elderly population, and satisfaction is not guaranteed. In cases of degenerative
instability, dynamic stabilization immobilizes the spine, is an easy operation, and the mortality and
morbidity rate is low. In my opinion, dynamic stabilization will take the place of rigid stabilization in the
treatment of degenerative spine, and indications of fusion will decrease in the future.

KEY WORDS: Degenerative disc disease, Degenerative instability, Dynamic stabilization

To be or not to be part of evolution:

It is said that life has existed on the earth for nearly
3.5 billion years. During this period, an estimated 15
million species of animals and plants have emerged; some
of these species have disappeared, never to exist again.
These species disappeared because the world gradually
changed, and some living things that could not adapt to the
new living conditions could no longer survive. In contrast,
other species that could adapt to the new conditions
survived. Evolution is also an indispensable concept for
science. Knowledge combines with experience, and so
new theories, along with new discoveries, ensue.

When we come to our own field and examine the
evolution of spine surgery, bed rest takes the first place.
Following bed rest, there is traction, manipulation, fusion
after decompression, and decompression and fusion with
instrumentation to increase the chances of fusion. With
the development of technology, complicated fusion and
instrumentation occur, followed by dynamic stabilization.
The concept of dynamic stabilization is to stabilize the
spine while one is in motion. Dynamic stabilization has at
least fifty years of history since Fernström. The concept of
posterior system dynamism started with Graf and spans a
period of thirty years.

Fusion surgery is the sine qua non for spine surgery,
but currently it is not a panacea. Dynamic stabilization
does not denote the complete rejection of fusion surgery
but rather narrows the indication limitations of the fusion.
Inevitably, the solution for all cases of overt instability
is fusion surgery. However, fusion has no place in the
treatment of chronic degenerative instability as pain is
the main problem that brings patients to the physician.
Spine wear, which damages the nervous system's natural
anatomical spaces, leads to the emergence of neurological
findings, as in foraminal and canal stenosis. However, the
main problem is pain, which eventually spoils quality of
life.

Pain theories:

We can establish two theories to explain this pain. The
first theory is ‘the stone in the shoe’: the pain related to the
spine oppression. As we know, a healthy disc is isotropic.
Therefore, pressure is transmitted equally between the
cartilage end plates and the annulus. However, the isotropic
structure of the disk is disrupted as disk degeneration
progresses. With the load on the end plates and nucleus,
non-homogenous structures with rich nerve endings that
are formed by condensed and fragmented collagen may
press on some points of the end plates, ultimately causing
the emergence of pain (Figure 1 A,B).
The second theory to explain this pain is lumbar motion segment instability. Although the spine generally has some ability to shift movement during flexion and extension, the pathological state of hyperactivity has been claimed to be the cause of pain. In particular, the abnormal sliding movement caused by injury of the annulus and capsular ligaments is thought to be the source of pain (Figure 2).

There are valid criticisms against both theories. For example, spondylolisthesis is not always seen together with pain despite the continuity of the disk degeneration. In addition, patients are painless between the pain episodes. Unexplained pain relief occurs in some patients as a result of manipulation by chiropractors, although the current pathology continues to exist. Despite all these unexplained examples we know that both theories play a role in the mechanisms responsible for pain.

Although instability is a clinical term, the biomechanical viewpoint considers instability as an abnormal movement of a surface and holds that freezing the joint will stop the pain. Spinal fusion may remove the pain if the pain is caused by instability or abnormal movement of the vertebrae; however, clinical experience does not support this view. In the 1990s, success rates appeared to reach 98% with 360º fusion; however, the rates of clinical success do not match these observations. Many studies have shown that the success rate of fusion is not as expected (3).

**Fusion problems:**

**Resistance pain:** A metallic cage is placed between vertebral cartilages, increasing the load that oppresses the cartilage end plate to a value 5 times greater than the load on the normal end plate. This mechanism is thought

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**Figure 1:**
A) A normal disc constitutes an isotropic structure. The disc spreads the load equally towards the annulus and cartilage end plate.  
B) Conglomerate nucleus materials compress to the cartilage end plate, point to point, from the nucleus (stone in the shoe).

**Figure 2:**
A) Anterior sliding is limited while cervical flexion appears normal.  
B) Anterior sliding up to 2 mm accepts abnormal movement.
to be the source of the pain. Therefore, covering all of the lower and upper cartilage fusion is less painful due to equal load distribution. Although fusion formation is well contained, the benefit to the patient is suboptimal (Figure 3A,B). There is therefore no correlation between fusion formation and pain (8,10).

Adjacent segment disease: Adjacent segment disease is a major problem after fusion surgery (Figure 4). Although adjacent segment disease is claimed to be a natural process, it is known to be common after fusion surgery. In addition, it has been shown biomechanically that an upper segment is extremely mobile (9,14,16,21,25,27).

Pseudoarthrosis: The success rate of fusion is reported to be between 15% and 95%, and the mean success rate is 68% in the literature. As a result, fusion has a 32% risk of failure due to pseudoarthrosis (10), which means that the spine becomes more unstable than it was before the surgery. The fusion success rate is higher in healthy young adults than that in elderly patients because osteoporosis is a serious problem for the formation of fusion (Figure 5a,b) (1,7,22). Although long construction has been established to distribute the load, it is still likely that fusion is not achieved. In addition to deterioration in the local functional unit, an imbalance may develop in the sagittal and coronal spine.

Infection: Fusion surgery lasts longer, and the probability of an infection developing is relatively high. Long operation time increases the incidence of infection (Figure 6) (23).

Donor place pain: The pain in the bone graft taken to provide the fusion can be unbearable and can last for days.

Restriction in social life: The patient should wear a corset for a minimum of three months after the operation for the formation of fusion and continuously wearing a corset decreases quality of life.

Dynamic Stabilization:
Creating a normal load pattern on the spine to relieve pain is a more reasonable idea than ending the movement (i.e., stabilize but do not freeze). The concept of dynamic
stabilization has emerged as a result. The dynamic stabilization system is based on load sharing rather than carrying. Dynamic stabilization, or semi-rigid stabilization, has been used to control abnormal movement while leaving the spinal segment mobile. Because dynamic stabilization is a new concept, some questions remain to be answered. To what extent must the movement be controlled? How much of the weight should be shared by the system? Can dynamic stabilization be standardized, or is patient selection more fitting? Which dynamic stabilization system is more appropriate for physiological movement? These questions indicate that there is a new area to be explored.

**Dynamic stabilization systems:**

**Graf’s Ligament:** Henri Graf was the first person to propose that strengthening the posterior tension band and blocking rotation may solve pain in chronic instability cases. The Graf concept strengthens the posterior tension band, which is a common feature of ligament systems, and it shifts the load on the spine to the spinal posterior column (Figure 7). The Graf system has found supporters in Europe and the Far East, and some successful results have been reported. Many disadvantages of Graf ligamentoplasty have emerged over time. For instance, Graf ligamentoplasty locks the posterior column in compression and may cause foraminal stenosis. With the effect of compressive power, the posterior part of the annulus becomes curved, and the spinal canal narrows. The system relaxes in hyperextension and loses its protective features (5,17,18).

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**Figure 3:** A) A patient with symptomatic lumbar stenosis. B) Screw loosening after long segment stabilization. C) Fixed sagittal balance that developed nine months after the operation.

**Figure 5:** A) A patient with symptomatic lumbar stenosis. B) Screw loosening after long segment stabilization. C) Fixed sagittal balance that developed nine months after the operation.

**Figure 6:** The infection rate is high after long operation times, as observed in the instrumentation with fusion.

**Figure 7:** Graft ligaments behave as a dynamic rod.
Dynesys: The Dynesys system was developed by Giles Dubois in 1994. It was designed to eliminate the missing features of the Graf ligamentoplasty (Figure 8). A polyester tape separator (spacer) is passed over a polycarbonatetane separator. Dynesys has a modular structure that is fastened with titanium screws. Biomechanically, it allows some of the load to move from the anterior to the posterior column. The polycarbonatetane separator (spacer) blocks the effects of compressive power, interrupts the spinal canal, and may cause foraminal stenosis. Dynesys is used for spinal stenosis, degenerative discopathy, disc herniation, spondyloolisthesis, and revision surgery and successful results have been reported. There are also disadvantages of the Dynesys system. The separators (spacers) obstruct the lordosis, and when used in excessive compression, the separators force the segment to undergo kyphosis. In compressive loadings, the separators (spacers) may cause a bending motion in the pedicle that leads to loosening or fracture of the pedicle screws. In compressive loadings, the separators (spacers) are compressed and function as a nearly rigid implant (2,19).

Biomechanics of the Dynesys ligamentous support: The ligamentous support reduces the stress due to increased loading on the anterior annulus. It corrects the Range of Motion (ROM), especially in axial rotation, and it restores the neutral zone. Helical Axis of Motion (HAM) slides to the posterior on both flexion and extension. The length of the separator (spacer) is also important. Long separators increase the ROM in all directions, while it may cause movements in the neutral zone.

Cosmic dynamic screw: The dynamic screw system was developed by Archibald von Strempel. The main goal of this system is to increase the fusion chance according to Lowe’s law. In patients who develop pseudoarthrosis, the dynamic screw system was found to be asymptomatic and hence was used without fusion. Biomechanically, construction with dynamic screws shares the load with the anterior and posterior columns and does not permit rotation. It has a joint between the screw head and body. Screw heads are attached to each other with rigid rods (Figure 9). The dynamic screw system is used in spinal stenosis, degenerative discopathy, disc herniation, spondyloolisthesis, and revision surgery. It is not suitable for use in soft disks because the system will be increasingly rigid over usage on two disc levels (12,26).

Biomechanical study of the cosmic screw: This study focused on human cadavers in which bisegmental decompression was performed. When compared with the normal specimen ROM, lateral bending and flexion and extension movements were decreased in bisegmental decompression cases (24). This system restores movement in cases of bisegmental decompression and more rotational instability; motion rates are reduced to within normal limits as in the intact segment.

Safinaz dynamic screw: The Safinaz screw has the same function as the cosmic screw but differs with respect to the hinge. In contrast to the cosmic screw, the Safinaz screw allows a rotation of 1 degree. The values obtained in biomechanical studies were close to rigid stabilization. The loading and bending moments are greater in the rigid screw system than in the dynamic screw system in flexion, lateral bending, and axial rotation. Biomechanically, dynamic stabilization has shown that ROM is protected within normal limits, which indicates that the patient can participate in daily activities without requiring an orthosis. Articulating screw systems (Cosmic, Safinaz) distribute the Instantaneous Axis of Rotation (IAR) to different locations; however, IAR remains on the posterior column in rigid systems (4).

A two-year follow-up study comparing the dynamic system with the rigid system has been published (20).

Stabilimax NZ: This system was developed by Panjabi and colleagues. Spinal degeneration or injury is known to be the cause of Neutral Zone (NZ) growth and pain. This system is based on restoring the NZ. A dual concentric spring ball and joint with sockets were combined on pedicle screws (Figure 10). The system tries to maximize ROM while also attempting to bring NZ within normal limits. It has a complicated structure, and the long-term clinical results are not yet clear (29).

Posterior facet Replacement Systems: TOPS: To restore a degraded segment, a functional interconnection of the unit was placed on artificial joints to prevent normal biomechanical motion. The clinical results were not successful (6,13,15,28).
**FASS (fulcrum-assisted soft stabilization):** A support was placed in front of the ligament, between the pedicle screws, to prevent buckling of the annulus. Four clinical studies did not find any significant improvement of the rigid system when compared to dynamic systems. When Grob and Wrügler-Hauri’s studies were reviewed, we observed unplanned heterogeneous groups. The first group was retrospective, whereas the other clinical studies were prospective. The other three studies were carried out with the Dynesys system, except for Korovesis (Twinflex)(6,13,28).

None of these studies can conclude that the dynamic system is worse than the rigid system. These studies only found that the dynamic system is not superior to the rigid system. These results show that dynamic systems should be preferred over rigid systems due to high mortality and morbidity in fusion surgery.

**Criticisms Against The Dynamic System Configurations:**

**Criticism 1:** There are no results in the literature concerning long-term follow-up.

**Answer 1:** So far, there is no significant opposition to the dynamic system in the literature. In our own experiences, which cover an eight-year period, good results have been published and others are in preparation for publication.

**Criticism 2:** The system is semi-dynamic; the distinction of being dynamic is therefore lost when the level increases.

**Answer 2:** Discussion of whether or not the system is dynamic is a secondary issue. The most important points are to stabilize the spine using a simple method and to eliminate the pain rather than the fusion. In contrast, dynamic rods can be used instead of rigid rods for stabilization above one level.

Decompression and dynamic stabilization should be performed, along with an examination of neurological deficits in the treatment of pain caused by degenerative spine problems. Fusion surgery has no place in this type of instability.

**REFERENCES**


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**COMMENT**

Ozer has made a compelling argument for the use of dynamic lumbar instrumentation in selected cases. Such a strategy has many theoretical advantages. Nevertheless, clinical confirmation is lacking for the management of back pain. Perhaps future research and improved implant designs will lead to more positive data. Until then, proponents of dynamic lumbar stabilization must base their clinical decisions on the logic presented by Ozer. For providing such, he is to be congratulated.

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