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SPINAL SURGERY AND IMPLANTS : A SYSTEMATIC REVIEW AND UPDATE

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INTRODUCTION:

A variety of spine pathological conditions like Scoliosis, Spondylolisthesis, Disc Herniation, Degenerative spine disease, Traumatic spine injuries, spinal tumours, spinal canal stenosis etc are commonly get treated with Spinal implants. Spinal implants play major role in fusion and non- fusion spinal surgeries.(1,2)

Spinal surgery with implants and instrumentation include multiple types of implants for fusion and fixation of spine. In surgery, we can use them single or combination of multiple types of implants like plates, wires, rods screws, clamps, screws, single screws like odontoid, vertebral cages, intervertebral disc prostheses and disk cages etc.

After surgery, these implants work as support system of spine. They stabilize, loading share, strengthen the fixation and fusion and enhance movements with security against further damage.

Review Of Literature:

Cervical Spine Implants And Instrumentation

Monofilament Wire, Braided Wire Cables Spine Cables

For cervical spine posterior fusion, Gallie / modified Gallie technique, Brooks technique, occipitocervical fusion techniques are commonly used in neurosurgery practice since long time. In these techniques, wires and cables are used as wire with plate fixation, wire with bone graft, rod-fixation with wire, pin and wire strategies.(1-3)

1) Braided stainless steel or titanium or also known as Songer cables
2) Regular wiring with rods, plates and bone grafting
3) Inter-spinous process wiring
4) Sub-laminar wiring
5) Spine facet wiring

Screws

Screws like trans-pedicular screws, trans-articular screws can be used as stable implants in range of anterior and posterior spinal surgeries like transarticular screw fixation, odontoid screw fixation, plate-screw / rod-screw implants for spinal column stability or correction techniques.(2-4)

1) Unicortical and bicortical cortical screwsThreaded or double threaded or partially-threaded screws also known as thread-forming, self-tapping screws or cancellous spinal screws:- These screws are specially use for less dense cancellous bony areas in spine fixation.
2) Lateral mass screws, specially for cervical spine
3) Hollow or Cannulated screws
4) Laminar screws
5) Pedicle screws
6) Transarticular screws
7) Pars screws
8) Odontoid screws
9) Occipital screws

Spine Fixation Plates

Screws and, in certain situations, rod-screw interfaces are utilized in conjunction with plates. They are more frequently utilized in anterior fusion operations like fusion and anterior cervical discectomy.(1-3)

Few commonly used plates in cervical spine surgeries are Anterior cervical plate, Haid plate, Occipital plate, Odontoid plate, Restricted backout plate, Hook plate, Constrained plate, Semi-constrained plate-screw device, Tubular plates, Posterior cervical plates, Malleable reconstruction plates.

Spinal Fixation Rods

In occipitocervical fusion techniques, rods are typically observed as rod-screw constructs in various posterior cervical fusion procedures, including prebent and preshaped rod-systems such rod-screw-plate, rod-screw-clamp, rod-screw-cable, or inverted-hook-rod-screw interfaces.(4,6,8)

Traditional connecting rods,
Cervical rods that are pliable,
Pre-contoured rods for the occipitocervical region,
Ohio Loop for Medical Instruments,
Concave Hartshill-Ransford loop

Clamps

Pedicle clamp gets attach with pedicle and hold. These clamps are made of titanium or stainless steel. Their sizes, designs and shape varies as per requirement in different level of spinal surgeries. Spinous process clamp uses two plates to clamp and attach the upper vertebrae's spinous process with lower vertebrae's spinous processes. Mini screws or bolts with nuts keep attach these plates together. Universal clamps combine screws, wire and hooks together to correct the various spinal pathologies.(5,6)

Hooks

Fixation during posterior spinal fusion (PSF) can be accomplished with hooks. Transverse process hooks, supralaminar hooks, pedicle hooks, and sublaminar hooks are among the several kinds of hooks. Clamps and hooks can be used in conjunction with a pre-contoured rod-screw system for occipitocervical fusion or as a posterior cervical fusion approach in atlantoaxial fixation.

Inverted occipital hook clamp system technique: - Using this method, the bone hooks are positioned away from the dural venous sinuses and on the squamous portion of the occipital bone.(7,10)

Halifax interlaminar clamps: - Attached to the adjacent laminae, the Halifax clamp is a posterior cervical stabilization technique that is tightened until there is no more mobility between the concerned vertebrae.(8,9)

Cages

The anterior fusion discectomy and fusion treatment involves the use of interbody fusion cages in addition to an anterior cervical plate.(2,5,9)

Few devices are beveled, whereas others include interlocking features.
Artificial cages (PEEK)

Cages made of carbon composite (PLDLLA, for example)
Metal cages made of tantalum, stainless steel, or titanium
Implants that are cylindrical
Mesh cages

Cervical Artificial Disc Replacements

Artificial cervical discs provide some mobility maintenance at the single-level disease and are used in cervical disc replacement. There are many cobalt-chrome and titanium implants, either lined with polyethylene or not.(2,7)

Spine fixation Hardware for thoracolumbar spine instrumentation

Cables and wires

These days, it is uncommon to instrument the thoracic lumbar spine using wires and cables. Together with other implants, such as Hartshill rectangles, they have been utilized.

Screws are frequently utilized in the thoracolumbar spine in combination with other implants, such as screw-plate interfaces, interconnecting rods, or interbody cages.(2-6)

Pedicle screws
Facet or translaminar screws
Spinopelvic screws
Screws that interlock
Similar to rods, plates are more frequently employed as connecting elements in spine procedures that involve anterior, oblique, or lateral approaches and a fusion of fewer levels.

Spine Fixation Rods
Rods serve as connecting components for scoliosis surgery (2,3,4) as well as for posterolateral thoracic, lumbar, lumbosacral, and spino-pelvic fusion procedures (such as PLIF and TLIF).(5,6,7)

Connecting rods
Rods with threads
Constructions using rods and screws **with or without a tandem interconnect**

Expanding rods
Conventional growth rods
Growing rods under magnetic control
Harrington rods, which were utilized from the 1960s until the 1990s, are extendable rods that are attached to the laminar surface of the concave side of scoliosis.(9,10)

Luque rod (no longer in use; posterior thoracolumbar stabilization with sublaminar wires)

Vertebral body replacements and interbody spacers
Cages and solid tapered structures are examples of interbody spacers and vertebral body replacements. There are several types of implants, such as stackable, expandable, and stiff devices that can be used in conjunction with rod-screw or plate-screw constructions. (2,4,7)

Some of them have built-in fixing or interlocking mechanisms.(6-9)
Cages made of stiff mesh
Cages that can be expanded
Cages that can be stacked with or without connecting rods
Implants that are cylindrical
Implants with tapered ends

Man-made discs:- When degenerative disk disease symptoms are present but there is no severe facet joint arthritis, spondylolisthesis, or instability, artificial discs are used in lumbar disc replacements.(2,5)

There are unconstrained and semiconstrained ball-and-socket devices. Some of them feature a metal-on-metal contact, whereas others have polyethene liner (7,8) and metal endplates.

Devices For Dynamic Stabilization: - For patients experiencing low back discomfort as a result of chronic degenerative changes, dynamic stabilization devices offer an alternative to rigid fusion devices(4) and exist in several versions.(8)

Equipment for hybrid stabilization
Synthetic ligament structures
Methods for replacing the facet or posterior element

Interspinous devices:- By preventing spinal extension, interspinous devices lessen the strain on the facet joints and reduce the symptoms of spinal canal stenosis (5) :
1) Coflex (a titanium implant in the shape of a U with vertical wings)
2) Wallis (Dacron-band-fixed interspinous PEEK spacer)
3) X-Stop (a spacer connecting two parallel wings)

CONCLUSION:
Significant progress has been made in the design and operation of spinal implants in recent years. By creating biomaterials and implant biologics, preserving motion in spinal segments, using personalized implants, creating less invasive surgical techniques, and enhancing patient safety, these advancements have aimed to improve spinal fusion. The creation of newer alloys and tweaks to old substrates has both led to advancements in the use of biomaterials. Disc arthroplasty and the creation of non-fusion implants are two examples of motion preservation. The integration of three dimensional printing into spinal implants, coupled with advancements in tissue engineering, has revolutionized implant personalization.

The morbidity of spine surgery has decreased thanks to newer implant designs for less invasive spinal surgery. Overall, advancements in robotics, navigation, and intraoperative neuro-monitoring have increased patient safety. Since spine surgery is a dynamic profession, any advancement must be closely watched for their potential as well as their usefulness and cost-effectiveness.

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