Oral Biology
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Lecture - 24
Biomaterials - Metals

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So, now we move on to the next material Biomaterial that is your metallic biomaterial. We all know that metals are again very commonly known well-known and we cannot just ignore their importance mainly because of this strength which they can offer. So, this metal and metal alloys are used for medical requirements, especially which are used are your stainless steel. In stainless steel metallic biomaterial we use 316 L titanium and alloys chromium alloys, aluminium alloys, zirconia, niobium, tungsten heavy alloys.

And then where are they used? They are used in dental implants craniofacial plates and screws, artificial hearts, pacemakers, clips, valves, balloon catheters, medical devices equipments bone fixation devices, dental materials, medical radiation shielding products, prosthetic and orthodontic devices. So, they have a huge range of applications and all these pictorial representations are predominantly aimed in strengthening the skeletal system most of them.

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So, and we have other applications as well the advantages as well known is that they offer a huge advantage of strength. So, the mechanical properties, which they are offering is very high. So, they are biocompatible, the only disadvantage is they are not bio active; they are bio compatible and there is good corrosion resistance in metallic alloys

So, as the material becomes more stronger as the material becomes more with high strength it can be used in applications of load bearing regions. We know that the hip jaw bones the entire body weight is actually resting on the long bones of the legs. So, the hip bones are the ones which require lot of strength and not only the hip bones we have the femur the tibia the all the leg bones legs and hip are the ones which require strongest material to be replaced.

So, metals play a very big role in that. And for load bearing regions the metals preferred are your cobalt chromium molybdenum alloy. So, that has to be remembered. So, how are they useful?

They are they have a very high tensile strength and fatigue limit of the metals; because they can carry huge mechanical loads when compared to ceramics and polymer material. So, in comparison polymer then ceramics and above all your metals are the ones which would give very high tensile strength.

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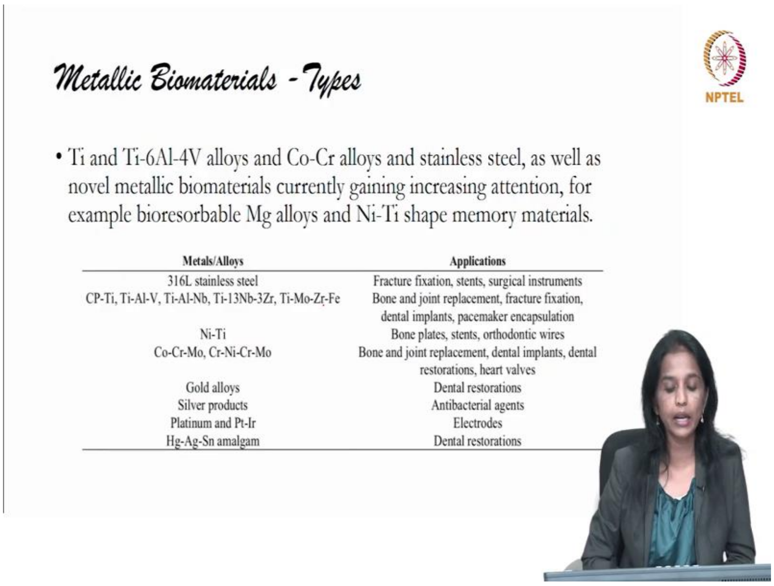

And further these metal metallic biomaterials the most commonly used or the preferred ones are your titanium alloys also in addition to cobalt chromium alloys. The advantage of titanium based alloys is that, they are more light weighted. And as it is more light weighted the difficulty in carrying the implant if it is going to be a larger replacement then it becomes easier for the patient.

So, it is advised to use titanium or titanium is more preferred than even cobalt and chromium. So, again as already mentioned in the pictorial representation, the application of these metallic biomaterials mostly relates to bone and bone replacements mostly.

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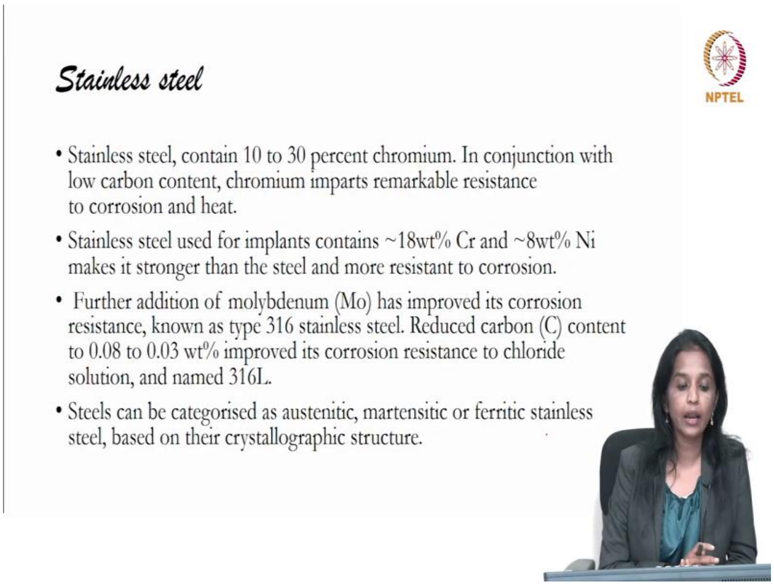

And again, the most common ones cannot be forgotten. So, the stainless steel metal biomaterial has to be known. Stainless steel again is widely used. The name stainless steel is derived because it does not it has very high corrosion resistance because of the low carbon content and the percentage of chromium.

So, this particular composition makes stainless steel a more sought-after material more sought after biomaterial. Addition of molybdenum to this particular alloy makes it even stronger and more durable. And stainless steel the moment we read stainless steel we need to quickly understand that stainless steel exits exit I mean exists in three forms; austenite, martensite and ferritic stainless steel based on their crystallographic structures.

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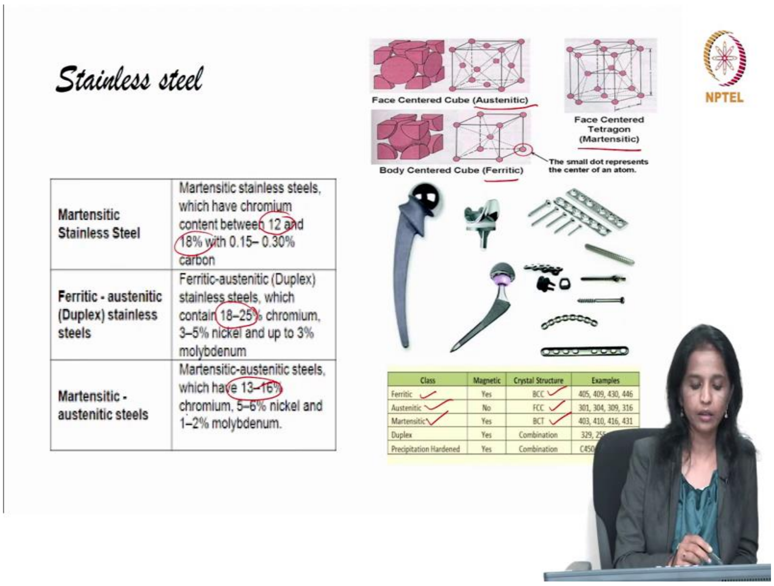

Study on metals does not get complete without reading these crystallographic structures. So, we have the face centered cube that is austenitic face body centered cube that is your body centered crystallographic structure that is the ferritic. And then we have the face centered tetragon the martensitic a quick look at the tabulation over here. So, ferritic is your body centered, austenitic is your face centered and martensitic is the face centered tetragon.

And the these are different the crystallographic structures are different here because of the composition present here. So, martensitic stainless steel has a content of 12 to 18 percent here it is 12 to 25 percent of chromium in ferritic and then we have martensitic again austenitic martensitic it is 13 to 16 percent.

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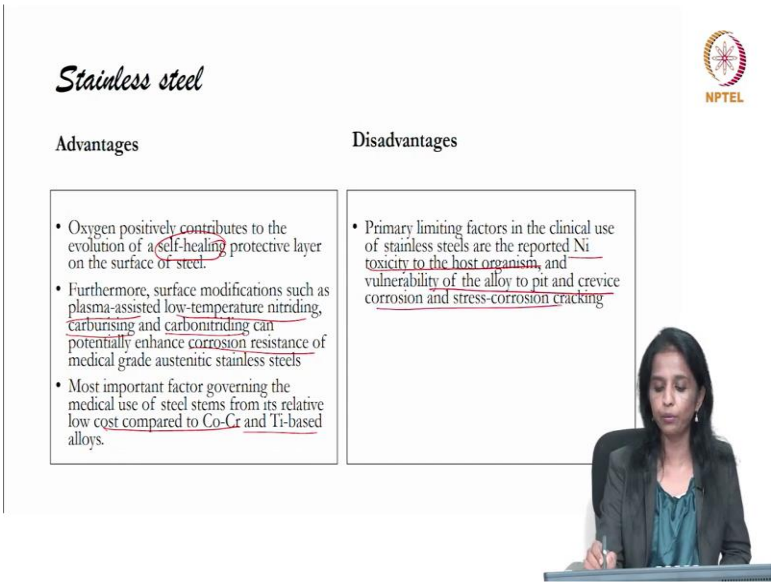

So, the what are the advantages of stainless steels? Stainless steel the most important advantage is the oxygen contributes there is a self healing protective layer on the surface of the steel. And it can also be further modified the surface can be further modified by a variety of methods like plasma assisted, low temperature nitriding carburising carbonitriding and so on, which will enhance the corrosion resistance.

And the other important things are it can be actually important factor is that the medical use of stainless steel is almost similar to cobalt chromium and titanium based alloys. To that extent though it is cost effective it is equivalent to these two alloys.

The disadvantage of stainless steel is that we know that there is a particular percentage of nickel inside and this nickel toxicity if the host is nickel allergic then it cannot be used. So, this makes it toxic to the host tissue. And in addition they are also vulnerable to pit and crevice corrosion and stress corrosion cracking.

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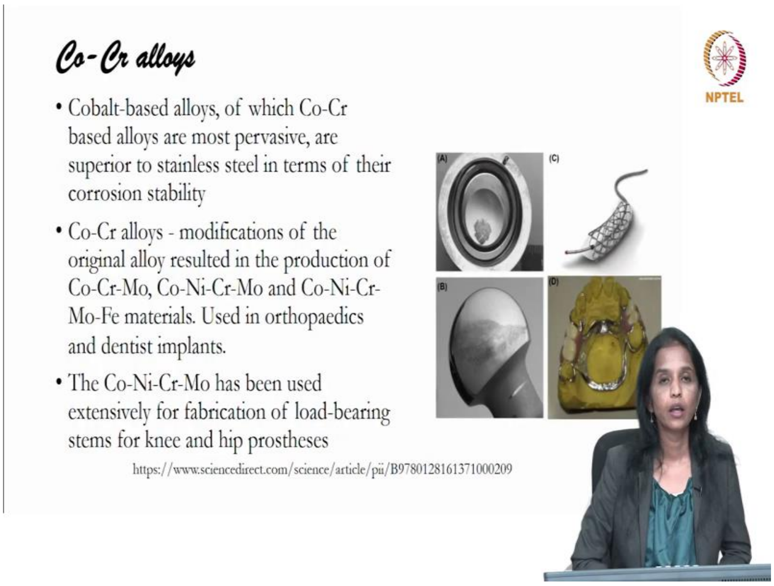

And further we have the cobalt chromium alloys. So, these cobalt based alloys or your cobalt chromium are most pervasive and superior to stainless steel and as already mentioned it is used in load bearing areas. So, we can see that this is the hip joint and this is the socket. So, this is the ball and socket.

And then we can see that it can also be used as a reinforcing agents in the stent tubes and we also use it as cast partial frameworks in denture placements. So, it is got that extreme tough extreme strength extreme tensile strength and very favourite material to be used by orthopedicians and dental surgeons.

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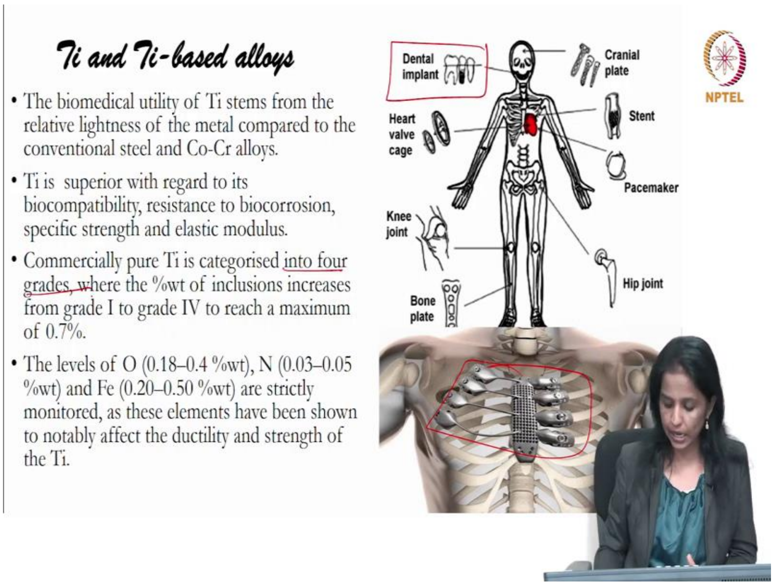

And then we have titanium and titanium based alloys as already mentioned. Titanium is a most sought after material because of its biocompatibility and because of its light weight. You can see the pictorial representation there is again a huge list of applications over there.

The most frequently represented titanium based biomaterial is used in dental implants we know that dental implants are being very widely used; nowadays for replacement of missing teeth and in addition it is also used as heart wave replacement it is also used as the rib gauge replacement because they are very light.

And in case if there is a fracture it can be used as a bone a replacement agent and then it can be used as a plate it can be used as a joint it can be used as a pacemaker as a stent. So, because of it is light weightedness and biocompatibility resistance to biocorrosion. So, this is the highest biocompatible material or the most sought after biomaterial in relation to the term biocompatibility.

So, having said that, we need to understand that commercial titanium is available in four grades. So, while choosing titanium you will have to choose between the grades of titanium based on how much of other alloy molecules are there. So, depending on that the characteristics of titanium would differ.

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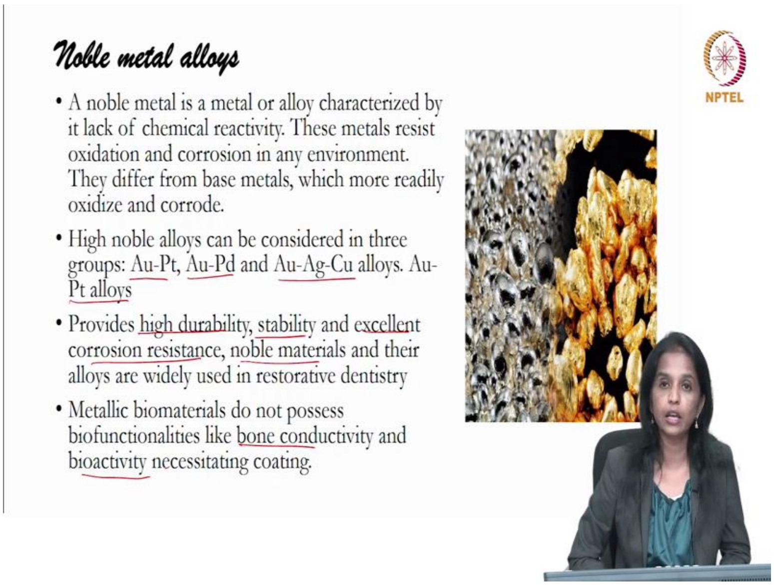

And then further we have the noble metal alloys, which is been there in practise from prehistoric times. So, gold and silver have been in use for very long times as the human mankind can remember. So, high noble alloys are your gold platinum gold palladium gold silver copper gold platinum alloys.

They are very frequently used because of their high durability stability and excellent corrosion resistance and they are considered noble because of this excellent corrosion resistance. So, metallic biomaterials in general do not process bone conductivity and if the material has to be made as a bio-functional element there has to be an additional bone conductivity and bone activity which has to be added.

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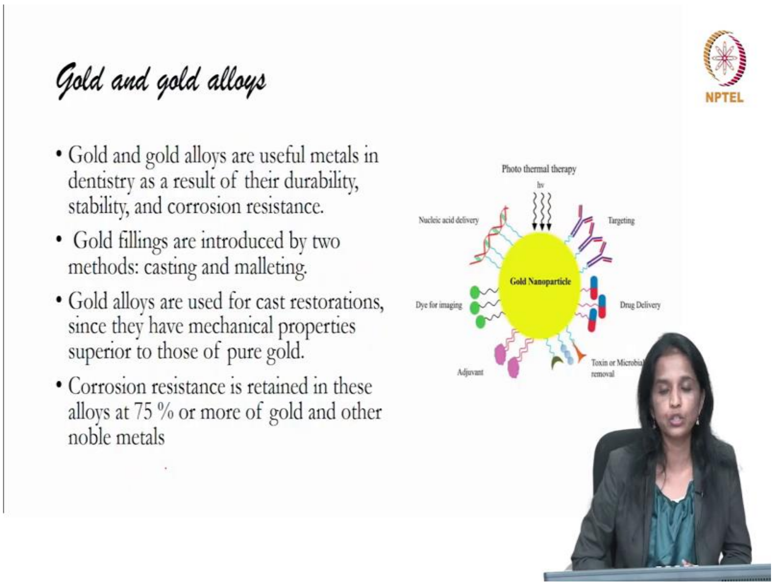

So, these gold alloys are already known that they are very durable and they are corrosion resistant and they are actually used as a filling material. So, when they used as a filling material they can either be casted and then fitted onto it or there can they can be malleted onto the defective area where they can be used as a filling material. Corrosion resistance again is very high for gold, but if the amount of gold is below 75 percent then the corrosion resistance decreases.

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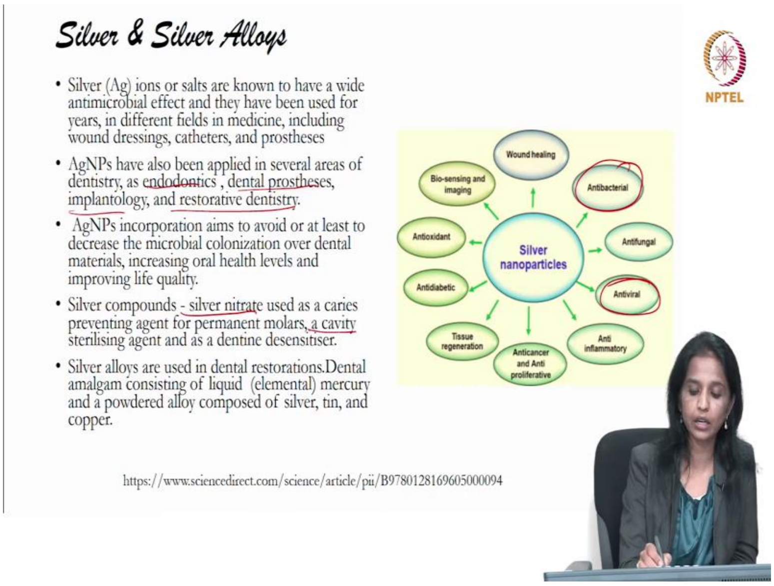

Then we further have silver and silver alloys the moment we speak of silver; the most important agent is the antibacterial antiviral agent which is why silvers silver is more preferred. So, silver nanoparticles are very widely used in wound dressing materials because of this antimicrobial properties.

And in addition, it is also used in dentistry in endodontics dental prostheses implantology and restorative dentistry. It has a very high antimicrobial effect and it is being implemented where and where necessary. Silver compounds especially silver nitrate is actually even used as a caries preventing agent as a solution applied on the teeth substance teeth caries tooth.

And so, that there is no further recurrence of caries and it is used as a cavity sterilising agent and a dentine desensitising agent. The only disadvantage of silver nitrate as for the properties mentioned above is that it would cause severe discolouration. Otherwise for its potent antimicrobial action it would really serve as a very good cavity sterilising agent. And then further we have dental amalgam consisting of liquid mercury and a powdered alloy composed of silver tin and copper.

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And then further we have shape memory alloys. So, these shape memory alloys are very important. So, those are the alloys which have the potency to remember their shape memory as what was before and what was there after deformation and then quickly coming back to its original state.

So, this shape memory describes the ability of a material to be plastically deformed below its transformation temperature and then bounce back recover back to its original shape. So, this particular shape memory alloys the examples of shape memory alloys the ones which we use in dentistry is N i T i in addition there are many shape memory alloys which are silver caladium, gold caladium.

Then you have copper aluminium nickel copper aluminium beryllium. We have copper tin, copper zinc, copper tantalum and then we have nickel aluminium, ferrous platinum and then we have ferrous palladium or iron palladium manganese copper ferrous manganese silicon.

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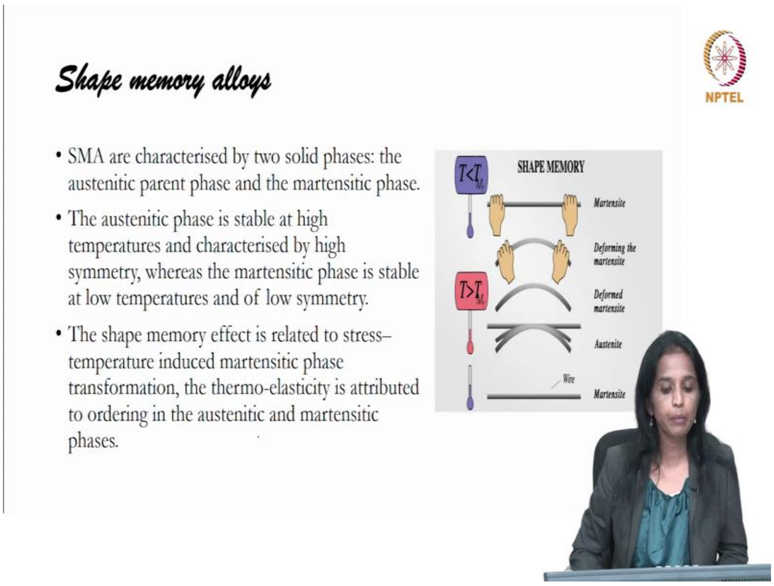

Shape memory alloys happen or the phenomenon of shape memory happens because of its ability to shift between the martensitic from the austenitic to the martensitic and then further back to the austenitic phase. We read in stainless steel that generally metals are available in three forms.

So, we saw the crystallographic structures how we have a face centered and a body centered and a tetragonal structure and so on. So, those are the austenitic structures and. So, one from there if it shifts back it we can revert back to austenite. So, austenite phase is actually stable at high temperatures whereas, martensitic phase is stable at low temperature of low symmetry. So, when there is an again a change then it reverts back to its austenitic phase.

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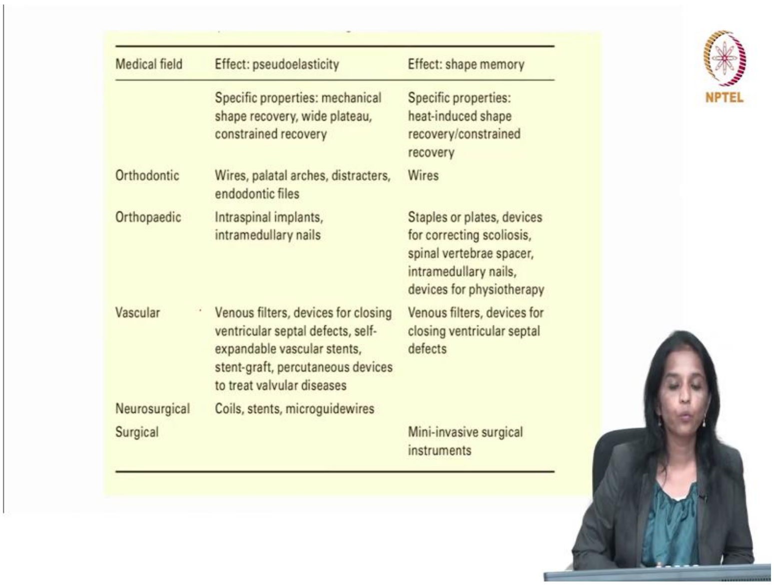

Medical field	Effect: pseudoelasticity	Effect: shape memory
	Specific properties: mechanical shape recovery, wide plateau, constrained recovery	Specific properties: heat-induced shape recovery/constrained recovery
Orthodontic	Wires, palatal arches, distracters, endodontic files	Wires
Orthopaedic	Intraspinal implants, intramedullary nails	Staples or plates, devices for correcting scoliosis, spinal vertebrae spacer, intramedullary nails, devices for physiotherapy
Vascular	Venous filters, devices for closing ventricular septal defects, self-expandable vascular stents, stent-graft, percutaneous devices to treat valvular diseases	Venous filters, devices for closing ventricular septal defects
Neurosurgical	Coils, stents, microguidewires	
Surgical		Mini-invasive surgical instruments

And where and how are these shape memory alloys are used. They are of great use in orthodontics where we have wires which have shape memory effect. And that is of great use to align mall align the tooth it can very quickly correct as the shape of the arch wire and can bring it into perfect alignment.

And then we also have it in orthopaedics vascular stents. So, those where you have a blocked artery or an arteriosclerotic plaques, if there is anything the stent which has a shape memory alloy can be pushed into and then it can be altered accordingly where and when required.

It also has numerical numerous efforts here neurosurgical field where it can be used as a coil stent and micro guide wires which are very crucial for neurosurgery. Because we know that neurosurgery is such a very critical technique sensitive procedure which involves the most sensitive part of our human body the human brain, where the wires have to be really small at the same time it should quickly bounce back to its normal size.

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Ceramics

- Ceramics are another class of materials used for designing biomaterials.
- Advantages of ceramics are their inertness, formability into a variety of shapes and porosities, high compressive strength, and excellent wear characteristics.
- Ceramics are used as parts of the musculoskeletal system, hip prostheses, artificial knees, bone grafts, dental and orthopedic implants, orbital and middle ear implants, cardiac valves, and coatings to improve the biocompatibility of metallic implants.
- Applications of ceramics are restricted due to brittleness and poor tensile strength.
- Bioceramics of phosphates are widely used to manufacture ideal biomaterials due to their high biocompatibility and bone integration.