Introduction to Biomaterials

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Module No. # 01

Lecture No. # 38

Understanding Design Concepts of Dental-implants (Tooth Replacement)

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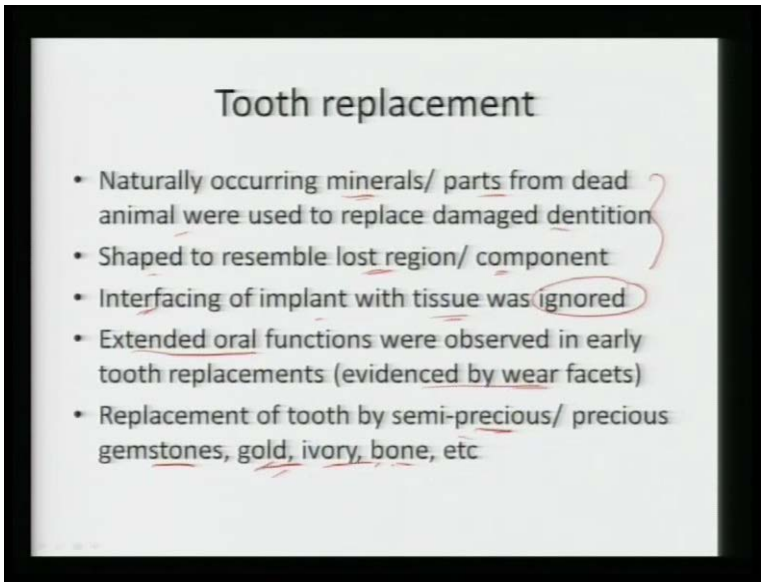

In this lecture we learn about understanding the design concepts of dental implants. Generally, for the tooth replacement, historically, there were naturally occurring materials or minerals which were actually being utilized for replacing any damages which were occurring in the bone. So, certain minerals which are naturally occurring minerals, or even parts from the dead animals were being utilized to replace the damaged dentitions in past in the history. So, that is how it started developing since very long time before. And again, but the main thing was that the shape, the shape of that particular resemblance, or that particular component was similar to that which was there in the lost region, or the component. So, particular entity which was being replaced possesses

similarity with the part which was to be replaced, and those parts which were being utilized for replacement were either minerals or parts from the dead animals.

And, but during that time, during the early stage when we utilized something just for replacing we did not care much about interfacing of that implant with that tissue in which it was in contact with so, that interfacing part was basically ignored in the early history. But again the extended oral functions were observed in the early tooth replacements and, which were basically being evidenced by wear facets; it means that the implant which were utilized they did show some wear, it means they were being there, they were being utilized for quite some time successfully while they were being implanted- so, those extended oral functionality was observed in the early tooth replacement. And again, history has also shown that some of the excavation, they have shown that the replacement of the tooth by semi precious or precious gemstones, or by gold, ivory, bone, etcetera, was indeed existing even in the prehistoric era. So, that part was being rendered, being enforced that indeed we can apply gemstones, gold, ivory, bone for replacing the tooth.

So, we can see that earlier the minerals or the parts from dead animals being were being utilized for replacing the damaged dentitions, and those parts mimicked, or they have behaved similar in shape to the natural parts which were being damaged or being replaced. And the interfacing part of the implant, the tissue was not really being considered. And the functionality of those oral implants was indeed to some extent successful because it did show some wear facets. And the replacement of this particular precious stone, of this tooth by precious stones or gold or ivory was being done in the, quite in that era.

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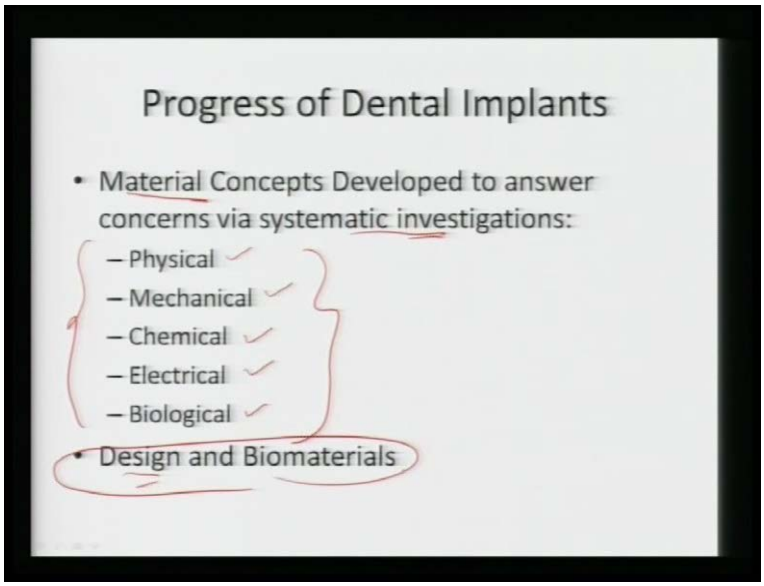

But as soon as the development occurs certain material concepts were introduced, and it became the requirement to answers certain issues which were basically coming again and again, and which again required certain systematic investigation- those were some physical concerns, mechanical concerns, chemical, electro chemical, biological. So, these all concepts starts creeping in, because when a particular entity, or a bone, anything is getting, overtaking the part of the natural bone, it needs to survive certain, it needs to survive the mechanical forces which are acting on it, even the chemical reaction, which is that particular entity or the environment which is undergoing because there are changes in p H, there are changes in the chemistry of the food what we eat. So, again, those all entities were very, very essential.

Again, biological concerns are also very, very important because the way the particular devices getting interfaced with that of a surrounding tissue, that also is a very, very critical issue, or how the transfer of stress occurs from the natural tissue, natural tissue to the artificial body and back to the natural material. So, the design concepts and evolution of biomaterials became very, very critical in the progress of the dental implants.

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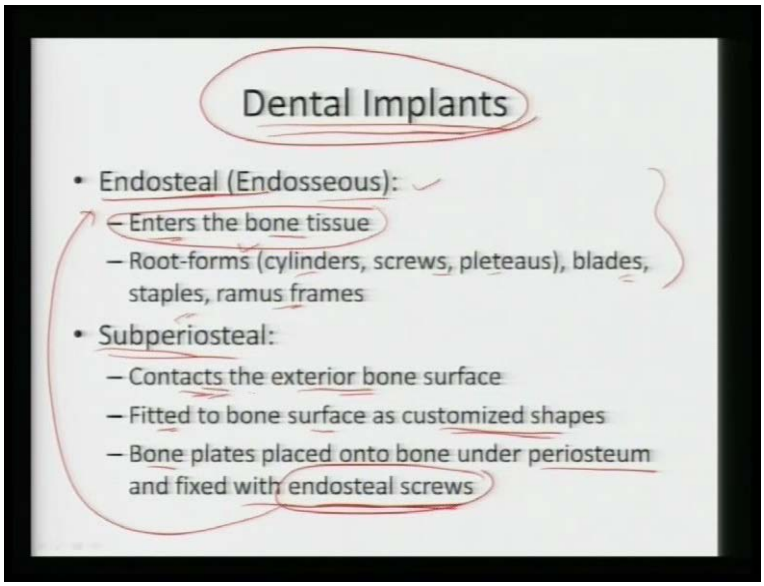

Dental implants can be divided into two categories. One is endosteal or endosseous- so, that basically is an entity which can enter the bone tissue, if you have certain implant which is somehow entering the bone tissue, we call it endosteal. Certain examples include root forms which can be cylinders, screws or pleteaus, or it can even be blades staples or ramus frames, so, they these are nothing but the, these from the endosteal device or dental implants.

Or they can again be subperiosteal, it means it is just in contact with the external bone surface. So, they have, are basically are fitted on to the bone surface, but then it could be customized, because depending on the arch, depending on the conformity of a particular bone we need to somehow give some support and that support has to be customized to the shape which is persistent in a particular patient's bone. So, those bone plates are placed into bone under periosteum and fixed with certain endosteal screws, endosteal screws. So, once we provide the support it needs to be fixed via certain endosteal products, which are again nothing but the screws, but endosteal screws.

So, we can see the dental implants are now been classified into two- endosteal and subperiosteal; endosteal which is nothing but entering the bone tissues whereas, subperiosteal just remains in the contact of the exterior bone surface. So, that is how we can divide these two entities.

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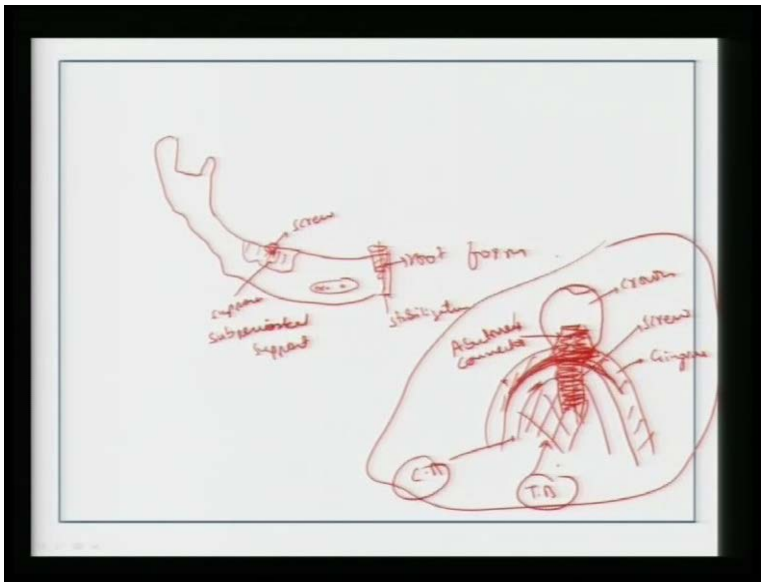

So, essentially seeing the overall edentulous mandible, so, we can see that we have, the overall structure basically appears more like this, so, we have the overall support, and I will just show the half part of the endo, edentulous mandible. So, we can has, we will require certain screws, so, we have certain screws which are basically being impregnated into the bone itself; so, this is nothing but the a kind of a root form, so, this is now piercing into the bone material; then, we have also have some bone plates for providing certain support; we can also have some exoskeleton type of a structure, which is nothing but placed on to this particular edentulous mandible- so, for some support, so, that part is now being just provided as a support- but now this thing is to be fixed with certain screws, endosteal screws.

We can see this is nothing but a screw, but now this is some sort of a support, and this support is a subperiosteal support- so, this is how we can see that how it is coming. We can also utilize certain stabilizer, which basically goes to the root canal for further stabilization. So, again, this particular, this particular stabilizer is again sort of an endosteal material. So, overall seeing, overall seeing a schematic, we can see that ones we have a tubercular bone, so, we have some sort of a tubercular bone over that we have compact bone and then, over that we will put some like, we will have gingiva. So, we can again see we have some gingiva over this particular compact bone. So, in this part we have tubercular bone, this thing is nothing but compact bone, this is nothing but gingiva and over that which we can see that we can introduce this particular screw, so,

we can introduce this particular screw. And then this is nothing but a screw and this is nothing but a crown. So, we have crown, which is shaped more like a tooth. So, we have this particular crown and then, we have certain abatement connectors, so, this is basically, it flows over the area between the gingiva and the compact bones- so, we have some support with basically goes like this, so, we have this particular material which goes as a support.

So, we can see that we have a crown, we have some sort of abatement, abatement connector and then, this is nothing but the tubercular bone, we have the contact bone, we have the gingiva, and this sort of an implant body, this is nothing but a screw, and crown. So, we can see how basically can take the support while keeping the screw in. So, we need both the entities of endosteal and the subperiosteal system to basically replace or to renovate the functionality of the bones. So, that is how we can see it out here.

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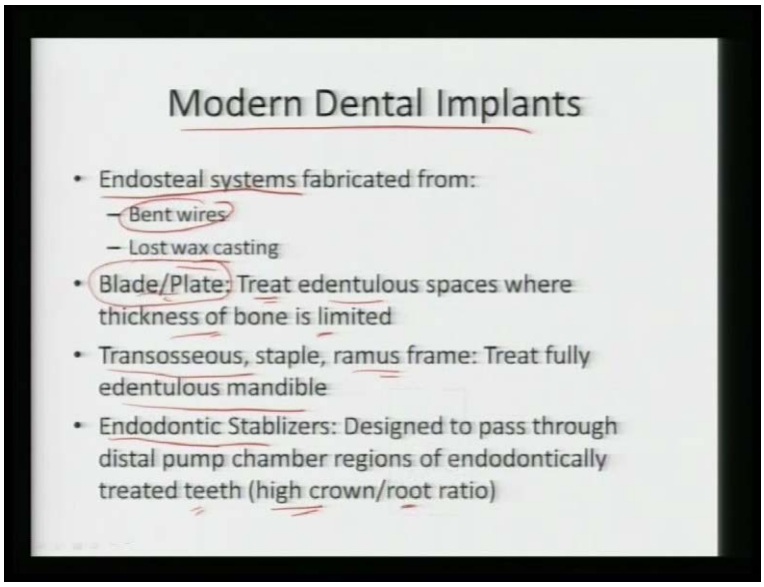

Again, the, modern dental implants basically, initially, the endosteal systems are basically being fabricated from either the bent wires, or even as lost wax casting; and these include certain blades and plates, and these are required for treating the edentulous spaces where the thickness of bone is basically being limited, so, we can support by utilizing certain blades and plates- they are called so because the shape is also very similar to that of a edge of a knife or edge of a knife, or like a wedge shape- and again, this is required where thickness of bone is limited, so, we can use it as a support.

And then, the transosseous, staple, or ramus frame, they are basically utilized for treating the edentulous mandible. So, again, we require certain shape to confirm to the arch of the edentulous mandible, so we require such features, or to provide support between the two tooths; again, there is something called endodontic stabilizers, those are basically designed to pass through distal pump chamber region of endodontically treated teeth- so, basically, for procuring high crown to the root ratio, so, that is how we require, that we require high crown to root ratio, so for that we can utilize this endodontic stabilizers.

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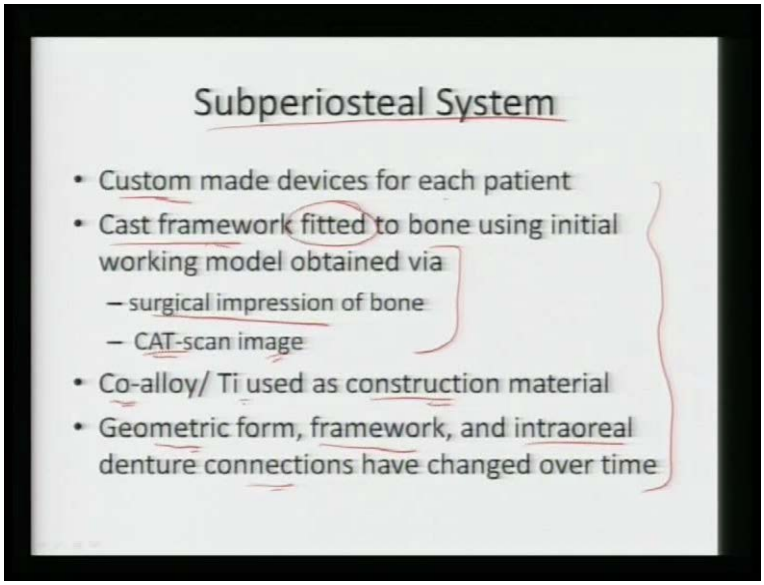

And again, in the subperiosteal systems, these again are to be custom made because these are, this confirmative of this particular entities vary from patient to patient, so, these subperiosteal systems are now being custom made for each patient. So, we require to form a some sort of a cast framework which is now fitted on to the bone using some initial working model, and to get this particular model, because the bone the overall bone conformities different from person to person, so, this particular framework is now being grabbed either by using, getting a surgical impression of the bone or getting a radiology or even by doing certain tomography, or computed assist tomography, from that we can get a scanned image. So, once, we have this particular, overall out line of this particular model we can frame the, we can cast the frame and will achieve this particular device for specifically for each and every patient.

In this particular case we make this particular frames using either cobalt alloy or titanium alloy, it can be pure titanium or titanium alloy, which is utilized as the construction materials, and it confirms to the overall geometric form. And again, this geometric form of this particular subperiosteal systems, the frame work which is required to hold this particular system in place, or intraoral denture connections- so, the overall design of all this have been changed from time to time, so again, that makes it very, very complicated because something, always there is something better, or some better design which can be really incorporated.

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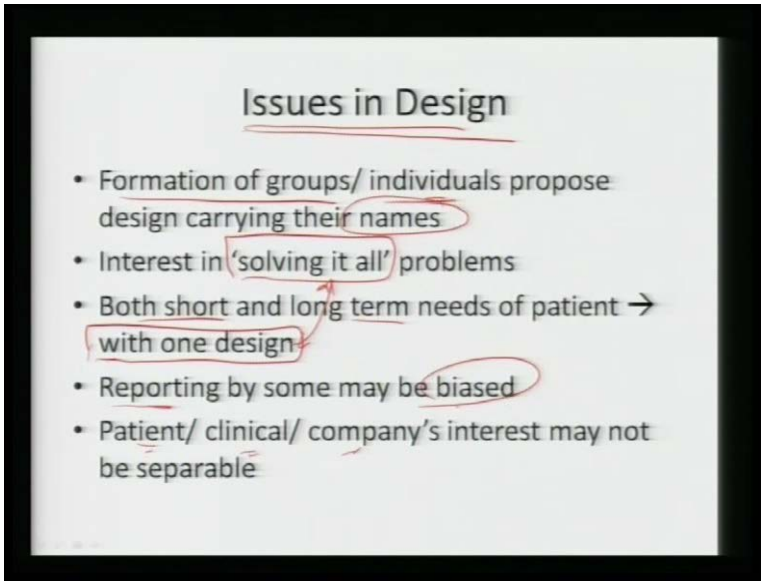

And again, there are certain issues, which basically develop with time. So, there are certain issues in the design part such as there is some formation of certain groups or individuals which tend to propose certain designs which carry their own name- so, they basically, now, propagate the overall, they overall, they are publicizing their own group or individual designs into the market. And basically, the overall problems also arise that there is an inherent tendency to design something which can solve it all, so, but that is not so true, or that that should not be done in that way, why because there are two issues, one is the short term and the long term needs of the patient and one design cannot fix it all. So, again, we require certain design which can challenge, or conquer the challenge piece by piece, so it should not be tried that we can confirm everything in one design. So, both short and long term needs of the patient need to be satisfied. So, the overall solving it all methodology should not be really tried, it should be tried piece by piece being able

to satisfy the long term as well as the short term requirements of the bone replacement or the bone repair.

Again, the reporting by some people, it may be again biased. Because sometimes what happens is the patient's or the clinical or the company's interest, they get club together- if one person is working for a certain company, they will somehow try to suit that particular design to a particular patient. So, that again becomes a problem because the overall a concern which are associated with either the company or the individual or the surgeon or the patient, they should be separable, that what is the requirement of a patient should be understood by that of a surgeon and according design should be taken care, taken or adopted from a particular company, and the tailored design has to be now implanted on to the patient, but that may not be really feasible, or that may not be really occurring in reality. So, these are certain issues which are related to the design of this, of this particular devices, or particular fixtures.

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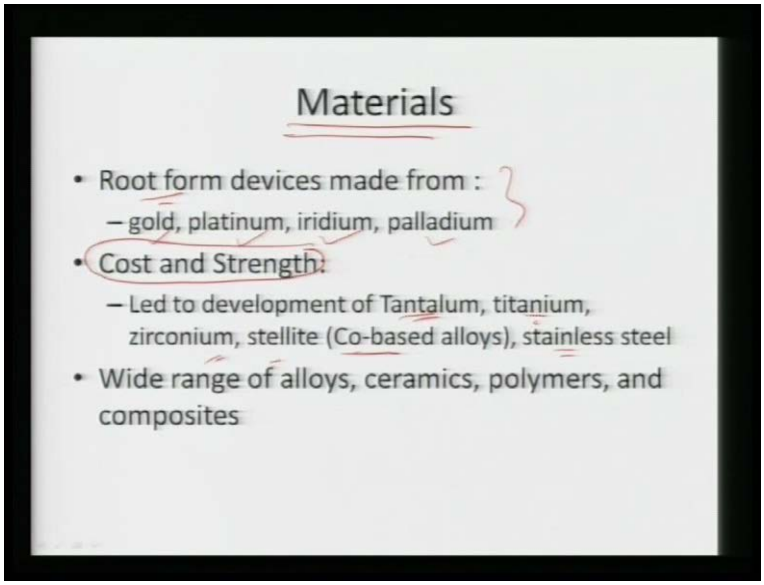

Again, if the materials which are being utilized for the root form, they are generally made from either gold, platinum, iridium, or palladium. They were very, very costly materials; so, again, the strength part is also very, very low. So, the cost and strength requirement I have again, lead to development of certain other materials, which are can, which can be either be active such as tantalum, titanium, zirconium, even satellite(cobalt

based), stainless steel; and again, wide range of alloys, ceramics, polymers and composites, also have been developed based on that.

So, to replace all this costly materials again which have a low strength requirement, certain new materials have been developed later on. So, those are tantalum, titanium, zirconium, satellite, which are nothing but cobalt based, or even stainless steel. Even wide range of alloys, ceramics, polymers and even composites, or Carbon based materials have also been developed.

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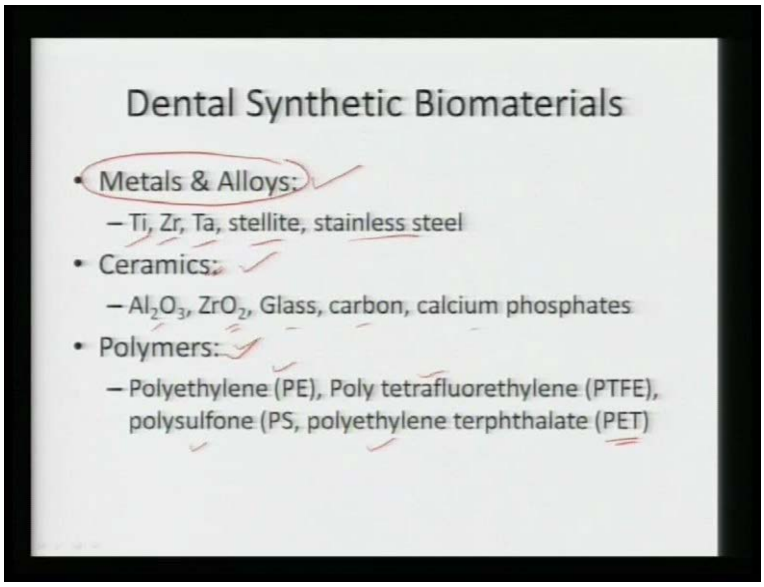

Dental synthetic biomaterials, in metals and alloys we can see that we have titanium, zirconium, tantalum, stellite of the cobalt based or iron based, stainless steel. It can be again ceramics which is aluminum oxide, zirconium oxide, glass, carbon, or calcium phosphates. Those can also be polymers, including polyethylene, PTFE that is, poly tetrafluorethylene, polysulfone, or polyethylene terphthahlate, so, that is nothing but PET, which is normally used for the bottles. So, we can see we have metals and alloys, ceramics and polymers again, which can be again utilized for the, utilized as a dental synthetic biomaterial.

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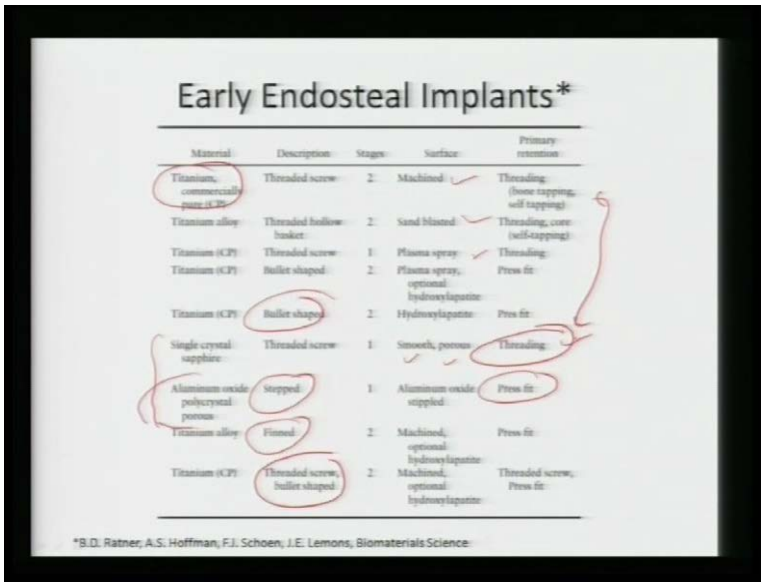

And the early endosteal implants were basically limited to titanium and aluminum oxide. So, we can see we have commercially pure titanium or titanium alloys, which were basically either machines and blasted or even plasma sprayed, certain ceramic calcium phosphate coating over it, they can be again smooth and porous, or again they can be again made up of sapphire or aluminum oxide, polycrystal or porous, and they can again be threaded or stepped or finned or bullet shaped. Basically, those are the certain geometries or descriptions which are being utilized for the titanium and the aluminum oxide. So, this again, there was threading, it was utilized for fitting them, or even it was press fit, so, depending on the overall location and the functionality, the overall fitting was in either by threading or by press fitting.

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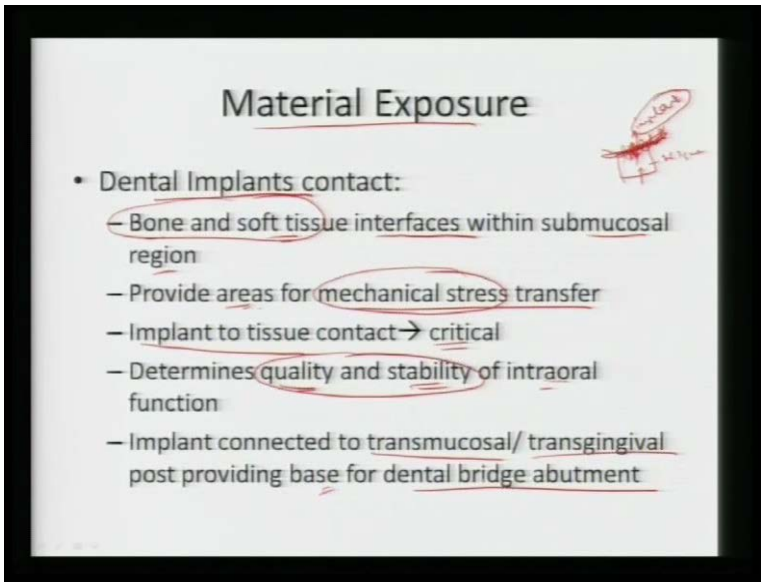

One more critical part with the dental implants is their exposure, or the how the material is being exposed to the surrounding tissues. So, we can see that dental implant comes in contact with the bone and the soft tissues, and that interfaces with the sub mucosal region. And now this provides area for certain mechanical stress transfer because of particular implant is been now been cemented, so, in this particular case we can see we have certain contact between the device, or the dental implant and the tissue. We require some sort of a area for mechanical transfer, so, the region between the device, or the implant and the tissues- so, we have tissue and that of a implant, there is certain region which needs to be developed so that the mechanical stress can be easily transferred. And this particular contact of implant tissues is very, very critical because this particular interface will decide whether the implant will be staying for a longer time in attachment with the tissue. If there is not strong anchoring between this implant and the tissue the device or the implant may just basically lose off. And that particular contact decides the overall quality and the stability of the intraoral function, because unless this implant is there the oral functionality of this, of this particular entity, or the intraoreal function may not be sufficient, so to balance that we need to have a very strong interface. So, the implant is connected with the transmucosal or transgingival post providing a base for certain dental bridge abutment. So, only once we have this particular implant which is being sitting out there it can further lead to the abutment, or even the support, which is required for the nice dental activity.

So, we can see that material is now being exposed to other bone and the soft tissue, and it has to know interface with sub mucosal region, which can provide a area for mechanical stress transfer and which is very, very, it is very essential in order to create the contact with the tissue and determine the stability in quality of the intraoral function. And also, it should connect to the transmucosal or trasgingival post, which can provide a area again for dental bridge abutment.

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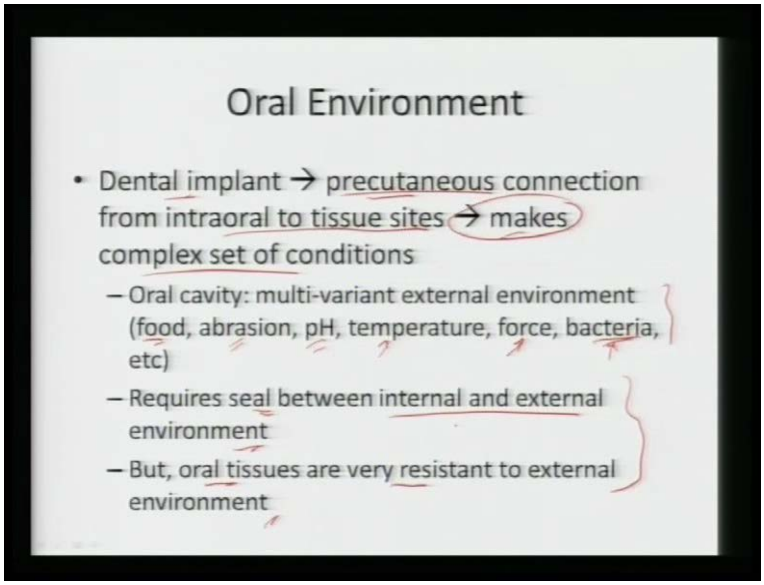

Again, the dental implants, it needs to have some precutaneous connection from intraoral to tissue sites, and that can render very complex set of conditions because the oral cavity itself, it undergoes certain multi-variant environments that includes eating food, so the way you have, the kind of food you eat, it can have different sort of chemical composition, it can also vary in terms of p H, from acid to base; the temperatures can vary from 5 to 55 degree Celsius depending on whether you are eating a ice cream or a if you are drinking hot coffee; again, the kind of abrasion, the kind of food you are eating, it can be nuts, which can be very hard, or it can be very, very soft materials as well; again the type of forces which are being encountered by the oral cavity; or even the bacterial which are being basically, come in contact with the set of the oral cavity.

So, basically, we require some sort of a seal, which is between the internal and external environment, but luckily the oral tissues are very, very resistant to the external environment, so, they can sustain a very strong forces or very strong anti friendly

environment, they can sustain. So, we can see the overall dental implant, it gets a precutaneous connection from the intraoral to the tissue sites, and this can basically, generate a very complex set of conditions because oral cavity undergoes very, very varying atmosphere or the varying external environment, which can vary from the type of food habits and abrasion of the tooth, the p H variation, temperature variation, force transfer, even the bacterias which can damage the oral cavity. So, essentially, we require a seal which can delineate the internal and external environment, but oral tissues they are very, very strong and stiffer, they are highly robust and they can survive anti hostile and the hostile conditions as well.

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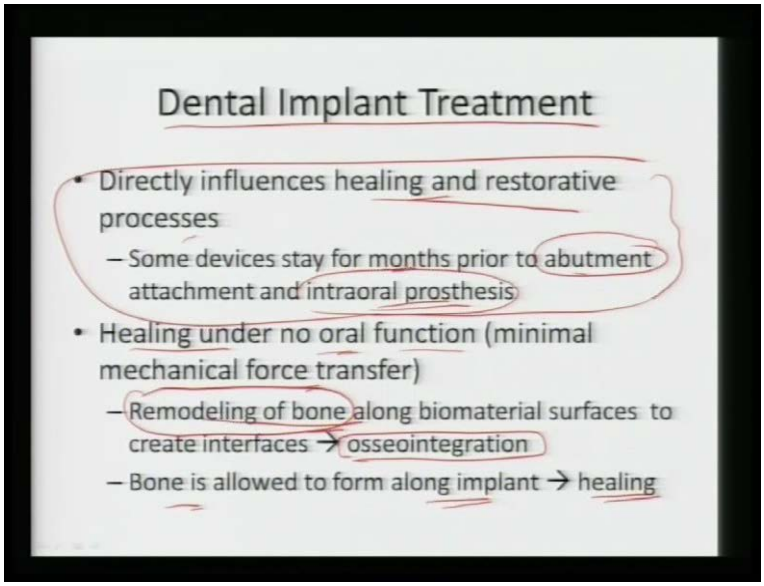

And after surgery it becomes essential to treat those dental implants because that dental implants they directly influence the healing and the restorative processes. And in some cases, some devices, they have to stay for months prior to abutment attachment. So, if we need to have the abutment attachment and intraoral attach intraoral prosthesis some devices may have to sustain very long stay in the in the edentulous mandible. So, it becomes a requirement that the particular implant can sustain such harsh conditions for a prolonged duration. And again, the healing is occurring under no oral function, or mechanical force transfer in this particular case, the device will stay inside, under no mechanical force transfer if the device will stay here. So accordingly, what happens is there is some remodeling of bone which can occur along this particular biomaterial surface, and that that is nothing but, it will create certain interface, biological interface

and then, it will allow the gulfing of the device as a part of the bone itself, and that it is nothing but osseointegration. So, bone is allowed to form along the implant and lead to eventual healing.

So, we can see close surgery dental implant treatment can also become highly essential because it directly influences the healing and the restorative process. And some devices they have to stay in for months before the abutment can really occur, or the intraoral prosthesis can be attached. So, healing is occurring under no oral function and to avoid the, so, to basically control the remodeling of the bone and allowing it to grow along the implant surface and allow it to heal and osseointegrate. So, these again has to be tailored accordingly.

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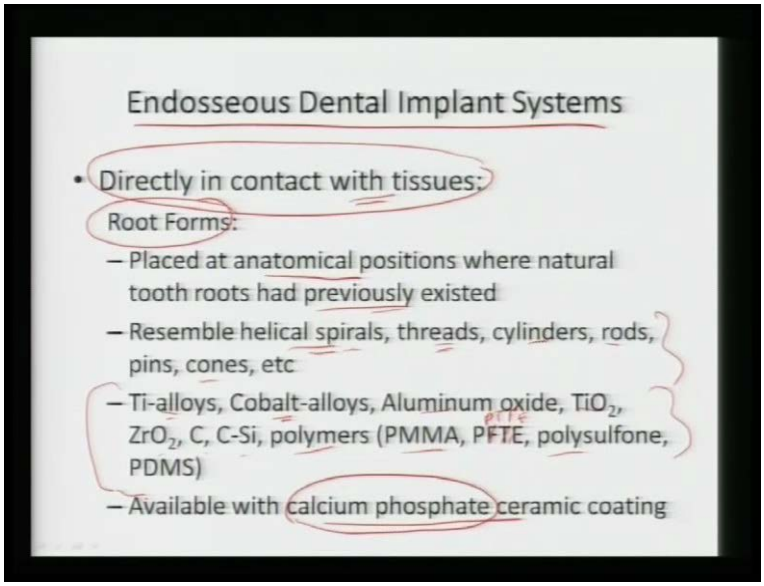

Endosseous dental implant system, now, again, they remain in direct contact with the tissues. So, certain examples include root forms. And root forms, basically, they are placed at the anatomical positions where natural tooth roots had previously existed. And again, they, root forms resemble conformities such as helical springs, threads, cylinders, rods, pins and cones. So, this endosseous dental implant, they come in direct contact with the bone itself, and now they are being placed at anatomical positions where actually the natural tooth roots had previously existed; and again, they resemble geometries of spirals, threads, pins, cylinders, rods, etcetera.

And these are basically being made from certain stiffer materials such as titanium alloys, cobalt alloys, even aluminum oxide, titanium oxide, Zrirconia, Carbon, Carbon silicon, polymers, polymethylemethocrylate, polytetrafluroethylene(PTFE), polysulfone or polyydimethylesiloxins. So, we have certain examples which are basically, which are basically being utilized. So, we have so many materials, which are available for the endosseous dental implants.

And again, these particular materials are coated with certain calcium phosphate ceramic to enhance the weight turbology, or even enhance the biological contact with the nearby tissues. So, these are ones which come in direct contact with tissues, to enhance this particular tissue attachment they have a particular ceramic coating of calcium phosphate is also done, and these are now placed at anatomical positions where initially were certain tooth roots; and they have certain conformities or geometries which are associated like, pins, cones, spiral threads, and these are made from very stiffer materials, titanium, cobalt, aluminum oxide, titanium oxide, Zrirconia, etcetera.

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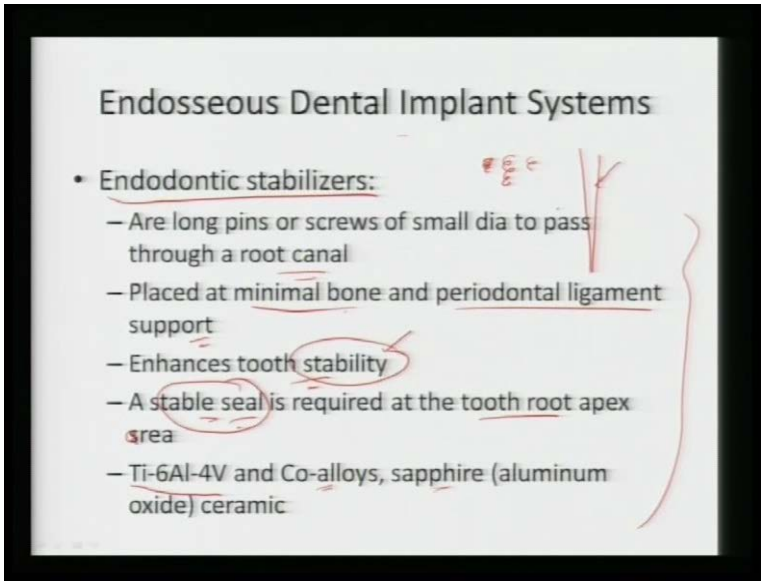

Again, there are certain categories of endogenous dental implants, which are called endodontic stabilizers- this is somewhat very long pins. So, in the previous case for the root forms we have certain kind of screws or spirals, which were available, but in this case endodontic stabilizers, we have very, very long pins, so, very, very long pins, or screws of small diameter to pass through a root canal. So, we have this, we need to have

this particular pin, diameter of this pins small enough so that it can pass through a root canal. And these are not placed at the minimal bone and periodontal ligaments of, periodontal ligaments for support. So, those are not placed at the minimal bone and they are used as a periodontical ligament support. What it does is, it does increase the stability of the tooth. So, if we implant certain crown or a particular tooth, we can basically put this pair inside and it can enhance the overall tooth stability. And there is a stable seal is required to the tooth root apex. So, the tip of the tooth root, we need to, we need to basically attach a stable seal so that it can sustain there for very long time.

So, we, particular, takes this particular endodontic stabilizer, this some sort of very long pin, it passes through the root canal, and again it is now placed at minimal bone and periodontic ligament for support, and this does nothing but increases the overall tooth stability. And a seal is required at the tooth root apex area for basically enhancing or limiting its movement. And these particular dental implants for endodontic stabilizers are made from T I- 6 A l- 4 V, titanium 6 aluminum 4 vanadium, and even cobalt alloys, or aluminum oxide ceramics. So, we can see this applicability of the root forms- those are more of spirals or pin shape, but these ones are very long pins or screws to support the periodontal ligament support, acts as a periodontal ligament support, or support the area where we have a minimal bone or the some bone lose in that particular area, for enhancing the overall tooth stability.

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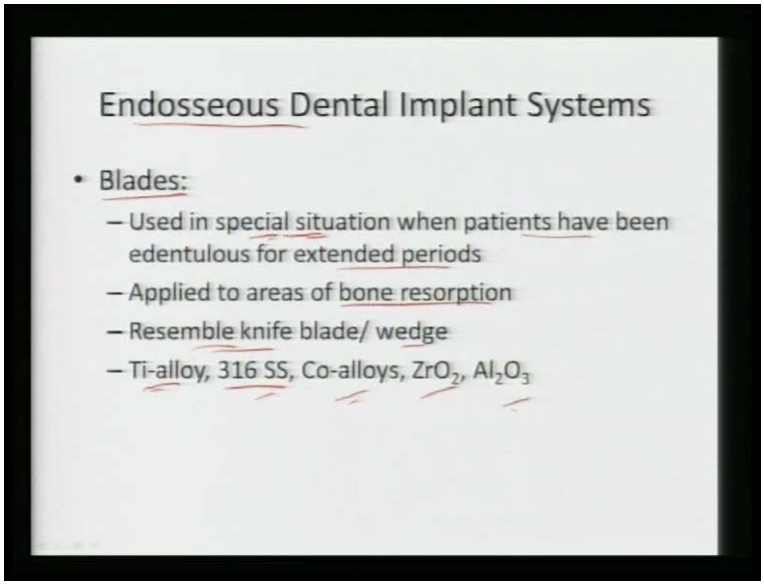

There can also be certain blades. So, in certain area where we require certain support, so, we can have these endosseous dental implant systems. So, we can, again, get certain blades, which are basically using special situation where patients have been edentulous for extended periods- so, in case there is some sort of a bone loss. So, these are applied to various bone resorption has already occurred. And these are called blades because they resemble knife blade or wedge shaped conformity. And these are being basically made from titanium alloy, 3 1 6 stainless steel, cobalt alloys, Zrirconia, or alumina. So, we can see the first thing is a root form through certain geometry. Again, we have longer pins for again for the support of the endosseous ligament, or even when the bone loss is already occurred. And third thing is the blade which is utilized in special situation when patients have undergone some bone resorption. So, it will basically, support the overall structure, and resembles knife or blade wedge type structure, and basically, made up of titanium alloy, 3 1 6 stainless steel, cobalt alloy, Zrirconia, or even alumina.

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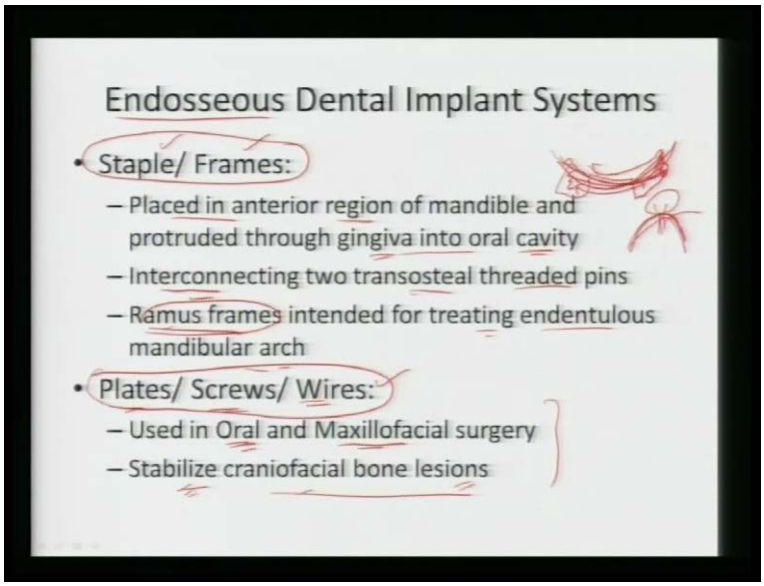

So, we can also see that the endosseous dental implant system, they can also be made from, they can also encounter certain staples and frames. And these staples and frames, there are placed in the anterior region of mandible and protruded through the gingiva into the oral cavity. So, we can see that particular, these particular frames, these are now extended to a very large, to a very extent life. In the overall, endosseous mandible, you have certain overall structure, and in order to maintain a particular structure we add certain frames to it. So, we have certain frame structure to support where the bone loss is

already occured. So, this particular support is now utilized for maintaining the arch of this endosseous mandible. And they are now placed on the anterior region of the mandible and protruded through the gingiva into the oral cavity.

So, and this, basically, do nothing but interconnecting two transosteal threaded pins. So, all the pins which are now being inserted into the overall cavity, they basically are now being joined by the staples or certain frames. And this ramus frames are basically intended for treating edentulous mandible arch. So, in order to maintain this particular arch, or to give confirmatory to the mandible edentulous mandibular arch we require this ramus frames. And again, we can utilize certain plates, screws, or even wires for which are, these particular entities, plates, screws and wires, they are similar to that what is being utilized in the oral and the maxillofacial surgery. These all are, these are basically utilized first stabilizing the craniofacial bone lesions, so if there are lesions, that will try to stabilize those particular structures. So, we can see again in the endosseous dental implant systems we have certain staples, frames, and these are placed on the anterior region of the mandible, edentulous mandible, which again, these are protruded through the gingiva into the oral cavity as we saw earlier.

So, we have this particular gingivalur cavity out here and then, we had certain supports which can go pierce through the particular gingiva, and they go through the oral cavity. So, we have the oral cavity out here and this interconnects to transosteal threaded pins. So, even when we require, we need to have some transosteal threaded pins, so, we can again, get them connected using this particular staple and frame. So, using the staple we can get the interconnection, and the frames are required basically for treating the edentulous mandibular arch. So, in case there is no support we can either tailor the arch or we can support the structure by this ramus frames. And again, we utilized plates, screws and wires, which are again, have to be pierced into the bone, and these are basically utilized in the oral and maxillofacial surgery. These are basically being utilized for the stabilization of the craniofacial bone lesions. So, these are now the similar entities which are utilizing surgery for stabilizing the bone lesions.

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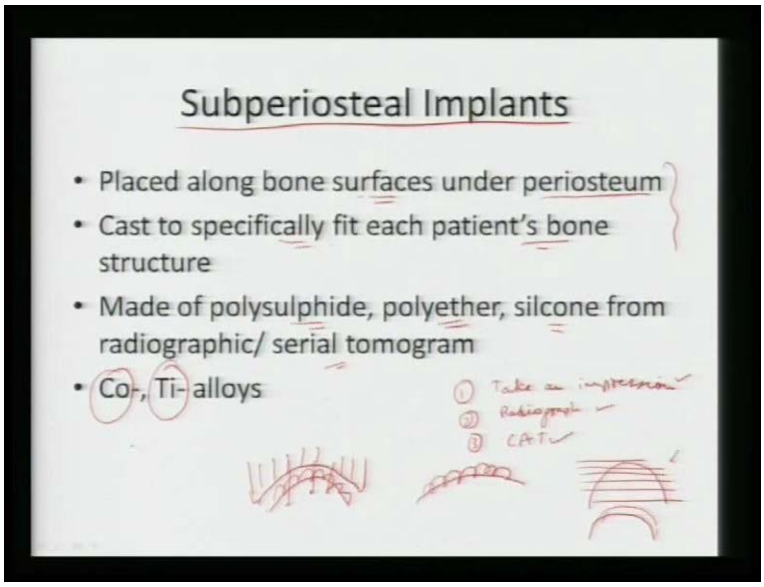

Then, there is a second category which is called subperiostesl implants. These are placed along the bones surfaces. So, these basically, are not inserted into the tissue, but they are placed over the, along the bone surfaces under periosteum. And basic thing is we have to be cast to specifically fit each patient's bone structure; so, if particular bone structure is very different for the two patients, the overall structure needs to be captured first so that this particular implants can be posted over this particular bone surface- and how that is done? There are there are two, there are couple of ways in which it can be done. First of all we can take an impression. So, surgically an impression has been taken of these particular surfaces. So, once we take a particular impression on a particular moldable ceramic or it can be even certain polymer, so, once we take an impression now, this particular entity is not (( )) in a negative shape of this can be, basically, made to confirm to a particular surface of this particular bone.

So, secondly, we can also get the radio graph. So, once we take, once we can take a radio graph we can find the overall features of this particular entity, snd again we can recreate this particular implant. Or third thing can also be computed assisted tomography, in this particular case a layer by layer sectioning is done, for this particular surface. So, we have particular, we have particular surface and now this layer by layer construction is now being visualizing in 3 dimension, so we can get a 3 dimension conformity surface. And now this can be again modeled to fit a particular patient's bone structure. So, we can either take an impression, we can also do radiography, this is nothing but sending x rays

or even gamma rays if required for getting the overall conformity of a particular bone, or doing completed assisted tomography- and this is basically being utilized for specifically fitting each patient's bone structure. And this particular material utilizes either polysulphides, polyether or silicone from radiographic, or serial tomography, again, cobalt alloys or titanium alloys are also utilized in this particular subperiosteal implants.

So, again, we can see that subperiosteal implants, they just confirm along the bone boundary. So, the bone boundary has to be exactly matching with that of the bone structure of the patient. So, in this particular case they have to fit exactly, and this has to be custom tailored to each patient's needs. And this is done by either taking an impression of that particular surface or by doing some computer assisted tomography, or even by taking a radiograph in a certain materials such as polymers, polysulphides, polyether, silicones again, or utilizing cobalt or titanium alloys by certain techniques.

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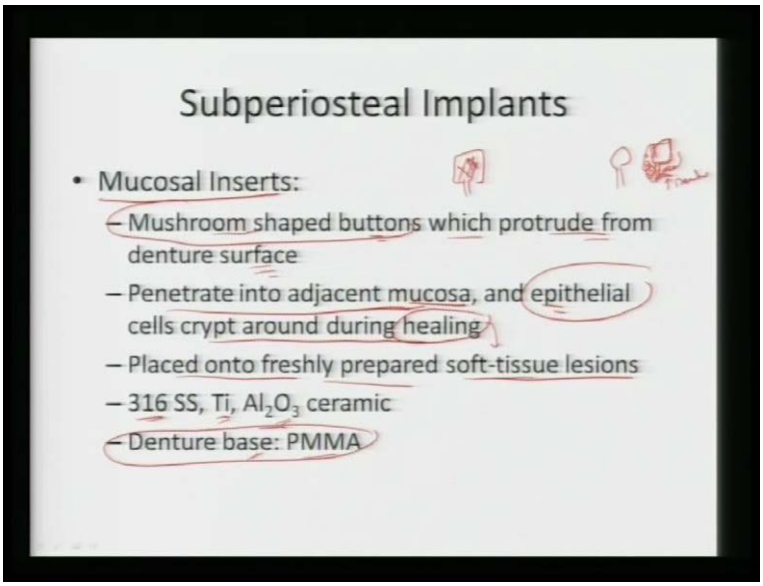

And there are also some mucosal inserts, and this mucosal inserts are nothing but some sort of mushrooms shaped buttons which protrude from the denture surfaces. So, we have a denture surface and this is some sort of a mushroom shaped entity, mushroom shape entity which is protruding from the denture surface, and they penetrate into the adjacent mucosa, and epithelial cells start crypting around this particular implant while healing is occurring.

So, we have this particular mushroom shaped entity or the button which is now protruding out from the denture surface of once we have a denture. We have this particular entity which is sitting on to the denture surface, and what happens is the epithelial cell start forming around it during the healing, and this is now placed onto a freshly prepared soft tissue lesions. So, now, this particular entities sitting near the soft tissues lesions, which are being basically being freshly prepared, and these particular mushrooms entity is made up of 3 1 6 stainless steel, titanium alloys, or even alumina ceramic, and the denture based is made from the polymethyl methacrylate. So, once we made the denture base of polymethyl methacrylate we can have this inserts, mucosal inserts.

Mucosal inserts are nothing but mushroom shaped buttons. So, this (( )) highly porous as well which basically protrudes from the denture surface. And these particular mushroom shaped buttons, they penetrate into the adjacent mucosa and then epithelial cells starts crypting around it when the healing is occurring. And this particular mucosal inserts after this epithelial cells started forming on to it, we are now sitting on to a freshly prepared soft tissue lesions. And these are, mucosal inserts have formed from the 3 1 6 stainless steel, titanium, or alumina ceramic, and the denture base is basically being made from the polymethyl methacrylate.

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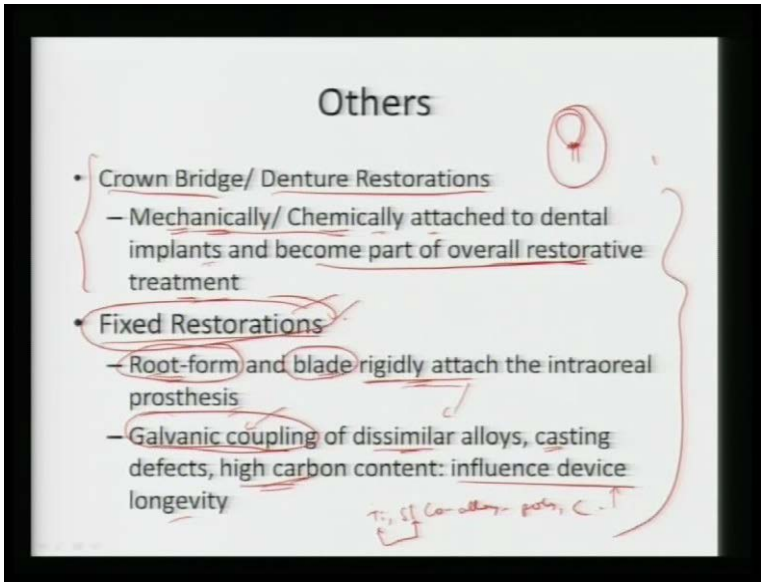

And there can be certain other fixture which can also be, which are also required- some of these are called crown bridges or even denture restorations. So, basically this have to be chemically, these have to be mechanically or chemically attached to the dental implants- so, either we can have just mechanical fixation by press fitting or even by applying certain cement to chemically attach to the dental implants. And this overall structure becomes the overall part of the restorative treatment. So, we have this particular crown bridge or denture restorations eventually, they become attached, they get attached by either mechanically, by press fitting, or by some cementation, but now they have to become overall part of the resorted treatment, so they can overtake the functionality of this particular replaced part.

So, eventually we are doing nothing but mechanical or chemically we are attaching to dental implants, and they overall become the part of the restorative treatment. And again, there can be some fixed, fix restorations such as root forms and blade, they have to, they have to remain rigidly attached to the intraoreal prosthesis. So, there are certain restorations which need not be removed later on, or they have to stay for much longer time throughout the life of this particular implant, so those are nothing but root forms. And again, certain blades which basically remain rigidly attached at the intraoreal prosthesis. And again, but the problem with this particular fixations which remain in the body for a very long time that there are some sort of a galvanic coupling, because we have variety of materials such as titanium alloy, stainless steel, cobalt alloy, or certain polymers, Carbon based materials, so, there are so many different sort of, sorts of alloys, so, what happens is they can have a galvanic coupling, it means the difference in the material can lead to certain development made of certain EMF or electro motive force, so, it will make one material to act as anode another material to act as a cathode and there is some flow of charge between them, and one material will start eating the other because you have you already have difference in p H and you have presence of certain electrolyte, which can occur from the saliva-so, we can have some galvanic coupling which can occur between the two materials. So, that is the biggest problem once we have, once you utilizing dissimilar materials.

Over that we have certain casting defects which can arise in, during the processing of various alloys. And again, the high Carbon content can also lead to this problem because Carbon can act as a cathode and it will start eating away the other materials. So, that

overall influences the overall longevity of the implant. So, we can see there are certain materials which like, crown bridge or denture restoration, they have to be mechanically or chemically attached to the dental implants, and eventually, they over take the, over take the functionality of the entire region and they become the part of overall restorative treatment. There are certain implants which needs to stay there for very long time, which occur as a fixed restorations such as root form or blades, which remain rigidly attached to the intraoreal prosthesis. But the utilization of these dissimilar alloys in different regions of this particular implant material, it can lead to either galvanonic coupling when we have dissimilar alloys, or they can, it can generate certain casting defects such as porosity. And again, once we have porosity we have high surface area which is available and then, it can again get degraded as a flow of the fluid around it starts increasing or the abrasion starts increasing, they can have some high Carbon content.

So, the overall functionality, or the longevity of devices is basically being compromised by utilizing this. The design has to be very, very proper in order to encompass all these problems which might exist in the particular, in the design of this particular entity. So, that is how that is how we can see the overall functionality is dependent on how the long term and the short term requirements of dental implants need to be taken care.

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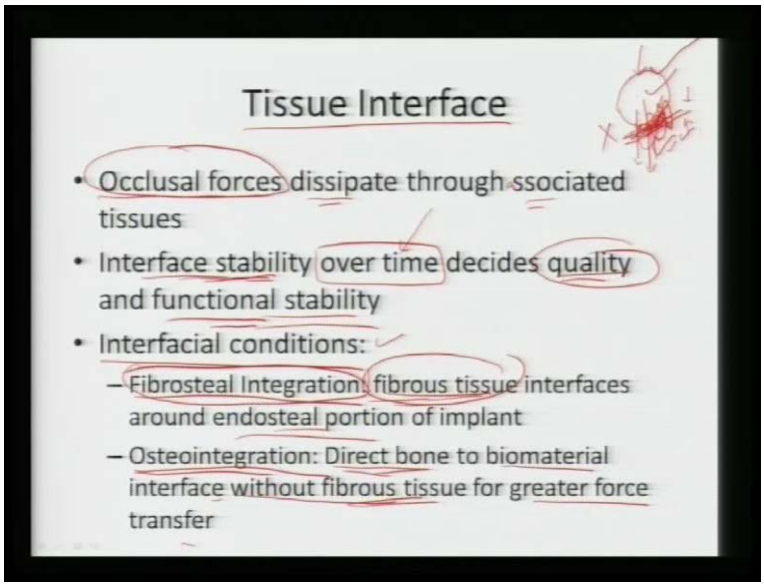

There is one more very important issues interfacing with the tissues. Because, once, we are forming interface with the tissue there are some occlusal forces, those have to be

dissipated through associated tissues. So, we can see, there are certain occlusal forces, they have to be, they have to dissipate the force through them which are now attached to the implants. So, the interfacial stability is very, very strong concern because that is the one which over time will decide the overall quality as well as the functionality of the device, because if you have certain device implant which is now being, which is now forming with nearby tissue, so, we have a crown and certain tissue which is beneath it, so, unless interface is very, very strong and it has now confirmed to the restorative part, it has been restored, if this particular interface say, is gone weak, the cementation or the mechanical fitting, or even the interfacing the tissue interface is gone weak, this material will not survive, or this device implant material will not survive.

So, the interface stability is very, very critical, that has to be estimated over time to define to, to basically confirm to the quality and the functional stability of a particular function. And there are certain interfacial conditions, there can be two interfacial conditions which can arise: one is the fibrosteal integration and second thing is the osteointegration. In the first case, fibro steal integration, the fibrous tissue starts interfacing around the endosteal portion of the implant. So, in fibrous steal we have generation of certain fibrous tissues whereas, in osteointegration there is no fibrous tissue, but there is direct bone to biomaterial interface so that a greater force can be transferred. So, we can see for a tissue biomaterial interface there are certain occlusal forces, they have to be now dissipated through the associated tissues.

So, the forces which are now being overtaken by the implant, those now have to be transferred through these interfacial tissues as. So, the interface stability between this implant and the tissues is very, very critical because the stability, quality and the functional stability is decided by the interface. And the interface can be basically divided into the overall response at the interface, and it can have two conditions: one is the fibrosteal integration, so, the fibrosteal integration, the overall device, it basically is interfacing with certain fibrous tissues around the endosteal portion of the implant; and second thing is osteointegration, in this particular case there is a direct bone to biomaterial interface without any fibrous tissue, so, we do not have any fibrous tissue which is forming between the device and the tissue surrounding it so that a greater force can be basically transferred to the tissues.

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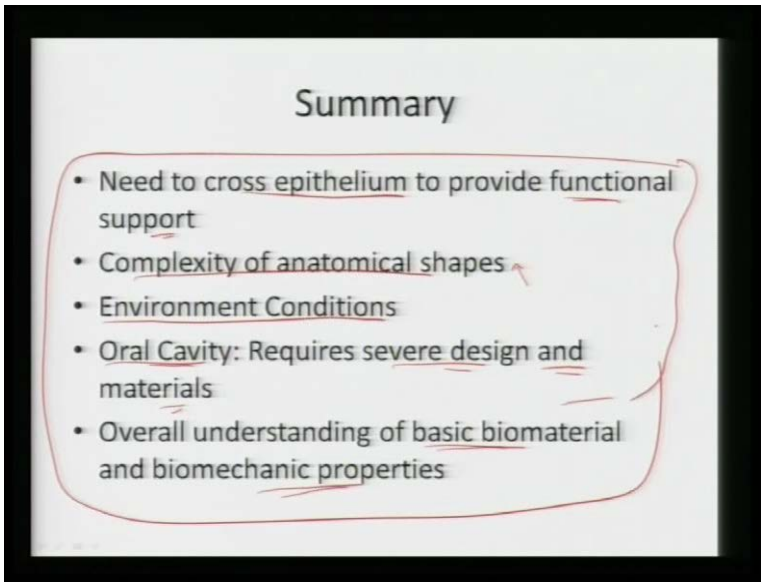

So, in summary we can see that the overall, overall there is some need to cross the epithelium to provide certain functional support. So, we have certain root forms or pins, which basically help, or bone plates to basically, support the edentulous mandible, and they basically, overtake the overall functional, they can provide the overall functional support to the edentulous mandible. I will again, there is much more complexity which is associated with the anatomical shapes. So we need to either get an impression by the radiology or computer edit tomography to suit the conformity of the bone for each and every patient, so, as soon as a patient is coming we need to cast that particular implant depending on the conformity of a particular patient, so, that has to be specific to a particular patient.

So, that can, that can provide us certain challenges, and, you know, that basically, is opening certain challenges and opportunities for the engineering of this particular shape, even in terms of choosing a particular material; the variety of materials can be ceramics, metals, polymers, which are being utilized regularly, titanium, cobalt chromium, stainless steel, PTFE, PMMA, PDMS, so, there are variety of materials, or even Zrirconia, titania, alumina, which are routinel utilized for serving as a bio, as an implant material for the dental surgery. Again, there are variety of environmental conditions, depending from the abrasion, the kind of food we are eating, the, pH, even the temperature. So, these are, these make the overall environment very, very severe and

hostile. So, the particular material has to be compliant enough and stiff enough to take, to basically survive this hostile environment.

So, the oral cavity, it requires certain design challenges and even challenges with selecting a particular material. And these things basically come up, once we can understand a very, we can nicely understand what is the interaction happening between the surrounding tissue and the implant material, and able to also through light on the basic biomaterial and the biomechanics response, how the stress will get transfer, how the load will be borne by the particular implant, or how the overall response of this biomaterial will happen, how the interface, how stronger interface will be in terms of either forming the fibrous tissue or retaining a direct bone to implant contact for an efficient stress transfer.

So, the long term and the short term, in certain cases we require very long term such as pin and everything, they have to survive in the endodontous region for prolonged times and then only a crown will be attached to it. So, again the short term and the long term needs of a particular device or the implant has to be specifically accounted for, and if we require a particular geometry such as a particular, a particular conformity to anatomical shape is required, that also has to be confirmed to. So, that, so, these, certain complex set of criteria is required, is required for engineering the, for designing and understanding the dental implants. Basically, that is it. I will stop my lecture. Thanks a lot.