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学位論文名	ORBITAL FLOOR RECONSTRUCTION USING CALCIUM PHOSPHATE CEMENT PASTE : An Animal Study （リン酸カルシウムセメント糊を使用する眼窩下壁の再建：動物研究）
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論文内容の要旨

[Introduction]

Calcium phosphate is a widely acceptable alloplastic bone substitute particularly in the form of ceramic blocks and granulated forms. Difficulties in handling and fitting at the implantation site, though, are some of its disadvantages. The development of calcium phosphate in cement paste form has made its application simplified and easy. In this study we used an a-tricalcium phosphate (a-TCP)/dicalcium phosphate dibasic (DCPD)/tetracalcium phosphate monoxide (TeCP)/Hydroxyappatite (HA) cement system which is commercially available as an injectable calcium phosphate cement (CPC) paste. Its clinical evaluation in orthopedic surgery indicates that it is highly safe and effective. Encouraged by this clinical success, we intend to investigate the potential for application of an injectable CPC paste in orbital floor fracture with direct communication to the maxillary sinus.

[Methods]

This experiment was conducted under sterile condition at the animal laboratory of the Institute of Animal Experimental Sciences, Osaka University. Ten white New Zealand rabbits weighing 2.5-3 kgs were used in the study. The left orbit of each rabbit was assigned in the control group and the right to the study group.

Following a subciliary incision, the areolar and muscle tissues were dissected down to the orbital floor with subsequent elevation of the periosteum. A defect of 10 mm diameter was created in each orbit using a sterile rotating burr. In the study group, the defect was patched with a freshly prepared injectable calcium phosphate paste with the aid of a thin aluminum sheet 0.24 mm thick. This sheet was temporarily placed at the orbital floor defect and was removed soon after the paste had set. The other orbit for the control group was left open. The periosteum, muscle and skin were carefully sutured in layers using a 6-O nylon.

Post-operatively, the animals were observed daily for sign of infection, extrusion or migration of the implant,

and any post-operative complication. Force duction test was similarly noted preoperatively and postoperatively. Subdivided into groups of 2-3, the animals were sacrificed with an overdose of sodium pentobarbital at 2, 4, 8, and 12 months after implantation. In each orbit, tissue samples consisting of implant, bone, and soft tissues were harvested, and studied for gross morphology, histology and microradiography.

[Results]

Grossly, implants were found to be adherent to the floor and covered with fibrous tissues. There was no sign of infection, extrusion, or migration of implant within the orbit and maxilla. The orbital floor was completely restored. Histological examination showed that there is active new bone formation that encroached within the implant and which gradually increased density with time. Maxillary mucosa and glands were likewise reconstituted. Thin fibrovascular tissues were seen on top and within the surface of the implant, and few to slight inflammatory cells were seen. Microradiography showed direct apposition between the new bone and the implant.

The orbital floor defect in the control group was noted to be diminished and partly obliterated by thin opaque wall separating the orbit and the antrum, with its central portion noticeably translucent. Two samples in the control group have also shown accessory lacrimal glands within the floor defect.

[Discussion]

Fundamental studies on calcium phosphate cement were previously reported and indicated its good biocompatibility and osteoconductivity. It was shown that it is a hydroxyapatite-producing cement that can maintain a high compressive strength of up to one year in simulated body fluid. This can prove to be important as the cement implant need to keep its strength at least until incorporation with the surrounding bone tissue occurs. Our findings compare favorably with previous studies showing biocompatibility and osteoconduction of calcium phosphate paste. There was neither inflammatory response beyond normal wound healing nor significant foreign body response, which is in accordance with previously reported biocompatibility property of calcium phosphate cement. Bone formation on the surface as well as within the implant indicates that the implant is capable of supporting its growth by serving as the scaffold within the defect. It has allowed vascular soft tissue and bone ingrowth that stabilizes the implant to the surrounding tissue and makes extrusion unlikely. The implanted cement body did not show clear change with time and may thus mean that the cement used can remain longer to keep the shape and volume of the reconstructed area.

While the defect in the control group was shown to heal spontaneously, it should be noted, however, that the floor recreated was apparently thin and in at least two orbits, has shown potential to herniate orbital contents.

[Conclusion]

The key requirements of an ideal implant would be : biocompatibility, promotion of tissue formation, mechanical properties, setting time, and ease of handling. These, we believe, were shown by the unique physical properties and biocompatibility of the CPC paste used in this study. The orbital plate implant provided by the cement paste provided a stable platform for orbital floor repair while affording ease of application. It assumed the contour of the orbital floor and afforded the advantages of biocompatibility, osteoconductivity, rapid setting, high compressive strength, slow resorption and radio-opacity. These results therefore indicate that bone substitute in the form of calcium phosphate paste can be useful in orbital floor reconstruction.

論文審査の結果の要旨

10羽のNew Zealand白ウサギの眼窩底に骨欠損を作成した後、その欠損をリン酸カルシウムペーストを用いて再建した。動物は術後2、4、8、12ケ月にて屠殺、眼窩部分を採取して本材料の生体親和性ならびに骨誘導能を検討した。

肉眼上、移植材料は眼窩底に密着、線維組織にて覆われており、眼窩側、上顎洞側ともに移植材料の感染、露出、変位は認めず、眼窩底は完全に再建されていた。

組織学的検討においても術後期間が経過するにつれて徐々に移植材料中に新生骨が侵入し、自家骨に置換されていく様子が観察され、移植材料が上顎洞に露出した部分の表面は薄い線維組織と共に粘膜上皮で覆われており、炎症細胞はほとんど認めなかった。

マイクロラジオグラフィーによる観察において、移植材料は完全に新生骨と癒合しており、良好な親和性が確認された。

同材料の優れた生体親和性ならびに骨誘導能に関してはすでに報告されているが、眼窩底の再建に用いた本実験においても同様の結果が得られ、その手技的な容易さや十分な強度など、眼窩底再建においてリン酸カルシウムペーストは優れた材料であると考えられた。

この研究はリン酸カルシウムペーストによる眼窩底骨折の治療に新たな道を開く有意義な実験的研究であり学位の授与に値すると考える。